Programmer's Manual for CAMCON: Compliance Assessment Methodology Controller

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Abstract

CAMCON, the Compliance Assessment Methodology CONTroller, is an analysis system that assists in assessing the compliance of the Waste Isolation Pilot Plant (WIPP) with applicable long-term regulations of the U.S. Environmental Protection Agency, including Subpart B of the *Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes*, 40 CFR 191 and 40 CFR 268.6, which is the portion of the *Land Disposal Restrictions* implementing the Resource, Conservative, and Recovery Act of 1976, as amended that states the conditions for disposal of hazardous chemical wastes. This manual provides an architectural overview of the CAMCON system. Furthermore this manual presents guidelines and presents suggestions for programmers developing the many different types of software necessary to investigate various events and physical processes of the WIPP. These guidelines include user interface requirements, minimum quality assurance requirements, coding style suggestions, and the use of numerous software libraries developed specifically for or adapted for the CAMCON system.

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Preface

Software is fundamental to assessing the compliance of the Waste Isolation Pilot Plant (WIPP) with numerous environmental regulations: the task is impossible without it. The primary goals of this manual are to streamline software development for the CAMCON system and make future software modification easier. The high cost of code development and the higher cost of code maintenance and enhancements make these important goals. To meet these goals, this manual presents a set of development requirements and guidelines for software that will aid in producing well-structured (especially important for FORTRAN code) and sufficiently documented codes that are easily interfaced with other codes. The requirements are essentially those included in the software quality assurance (QA) procedures, documented elsewhere. As an aid to understanding this manual, the software QA procedures should be read first; although, a brief summary of the QA requirements is provided herein. The guidelines presented herein are essentially standard programming practices and are not intended to restrict individual programming styles. More importantly, this manual describes the use of the numerous FORTRAN libraries routinely used by the CAMCON system software. However, some of the libraries change over time. The most current information on any library is available from on-line documentation (help files) on the Sandia WIPP computer.

Related Documents

Several reports describe various other aspects of the CAMCON system and are listed below (i.e., user's reference manual, software QA procedures, proposed concepts in the CAMCON system prior to development, and documentation for a FORTRAN library, SUPES).

Rechard, R. P., ed. 1992. *User's Reference Manual for CAMCON: Compliance Assessment Methodology Controller, Version 3.0*. SAND90-1983. Albuquerque, NM: Sandia National Laboratories.

Rechard, R. P., P. J. Roache, R. L. Blaine, A. P. Gilkey, and D. K. Rudeen. 1991. *Quality Assurance Procedures for Computer Software Supporting Performance Assessments of the Waste Isolation Pilot Plant*. SAND90-1240. Albuquerque, NM: Sandia National Laboratories.

Rechard, R. P., 1989. *Review and Discussion of Code Linkage and Data Flow in Nuclear Waste Compliance Assessments*. SAND87-2833. Albuquerque, NM: Sandia National Laboratories.

Red-Horse, J. R., W. C. Mill-Curran, and D. P. Flanagan, 1990. *SUPES Version 2.1: A Software Utilities Package for the Engineering Sciences*. SAND90-0247. Albuquerque, NM: Sandia National Laboratories.

Acknowledgments

Several of the ideas and concepts presented herein are based on work performed while two of the authors were members of Sandia's Engineering Sciences Center. While many of the specifics have changed or been enhanced, some of the basic ideas remain. The foresight of the members of the Engineering Sciences Center who contributed to these basic ideas is acknowledged.

The authors also appreciate the time and suggestions supplied by the technical reviewers: M. E. Fewell, Sandia; R. L. Blaine, Ecodynamics, Inc., Albuquerque, NM; and J. D. Schreiber, SAIC, Albuquerque, NM. The text and illustrations were prepared by the artists, word processors, and production staff and edited by P. A. Oliver and D. L. Pulliam, of Tech Reps, Inc., Albuquerque, NM.

Contents

1. Introduction

1.1	The WIPP and CAMCON	1-1
1.2	About this Manual	1-1
1.2.1	Purpose	1-1
1.2.2	Organization	1-1
1.2.3	Use	1-3
1.3	CAMCON Software Development Project	1-4

2. The CAMCON System

2.1	Purpose of CAMCON	2-1
2.2	CAMCON Approach	2-2
2.3	Software Management System and System Architecture	2-3
2.4	Directory Structure and Protocols	2-5
2.5	Procedural Files (CAMCONexec)	2-6
2.5.1	Purpose	2-6
2.5.2	Language	2-6
2.6	Logicals and Symbols	2-7
2.7	Modules	2-7
2.8	Codes	2-9
2.8.1	Codes within Each Module	2-9
2.8.2	Code Directory Structure	2-10
2.8.3	Naming Conventions for Codes	2-10
2.9	Data Bases	2-10
2.9.1	Primary Data Bases	2-12
2.9.2	Secondary Data Bases	2-13
2.9.3	Computational Data Base, CAMDAT	2-15
2.10	Software Libraries	2-19
2.11	On-Line Documentation	2-22

3. Software Development Overview

3.1	Software Development Strategy	3-1
3.1.1	Multiple Passes through the Assessment	3-1
3.1.2	Incremental Improvements	3-1
3.1.3	Prototyping the System and Selecting Software	3-1
3.1.4	Prototyping Support Software	3-2
3.1.5	System Flexibility	3-2
3.1.6	Data Manipulation Software	3-2
3.1.7	Close Links Between Developers and Analysts	3-2
3.1.8	Analysis Efficiency	3-3
3.1.9	Training	3-3
3.1.10	Selection of Primary Coding Language and Computer Operating System	3-3

3.2	Software Quality Assurance Requirements	3-4
3.3	Software Classification	3-5
3.3.1	Description of the Four Software Classes	3-5
3.3.2	Proprietary Software	3-6
3.4	Software Development or Acquisition Procedures	3-9
3.4.1	Task Leader Establishes Need	3-9
3.4.2	QA Coordinator Assigns a Software Sponsor	3-9
3.4.3	Developer or Code Consultant Implements Development or Modifications	3-9
3.4.4	Inspection and Verification	3-9
3.4.5	Software Sponsor Enters Software into CAMCON as Class X	3-9
3.4.6	Software Sponsor Enters Software into CAMCON as Class C	3-10
3.4.7	Software Sponsor Enters Software into CAMCON as Class A	3-11
3.4.8	Writing CAMCONexec Procedural Files for Software	3-12
3.5	Modifying Software in the CAMCON System	3-13
3.5.1	Need Established	3-13
3.5.2	Downgrading Software	3-13
3.5.3	Inactive Software	3-15
3.6	Replacing Software Already in the CAMCON System	3-15
3.7	Verification	3-16
3.7.1	Definition	3-16
3.7.2	Examples of Verification Methods	3-16
3.7.3	Appropriate Verification Method Dependent on Complexity, Type, and QA Level	3-17
3.7.4	Determining Adequacy	3-17
3.7.5	Documenting Verification	3-17
3.8	Single-Analysis Software and Analysis-Specific Modifications	3-17

4. User Interface Guidelines

4.1	Traceability	4-1
4.1.1	Software Name, PA Version ID, Date Stamp	4-1
4.1.2	Author Names, Software Origin, Government Legal Disclaimer, and Proprietary Information	4-3
4.1.3	Using CAMCON_LIB Routines to Meet Traceability QA Requirements (Welcome and Exit)	4-3
4.2	Files and Entering File Names	4-4
4.2.1	File Types	4-4
4.2.2	Naming Conventions	4-4
4.2.3	Entering File Names	4-6
4.2.4	Example of File Reading	4-6
4.3	Parameter Input	4-7
4.3.1	Reading from Data Bases	4-7
4.3.2	Reading from ASCII Input Files	4-8
4.3.3	Reading Interactively	4-10
4.4	Code Operation	4-10
4.5	Error Messages	4-10
4.6	On-Line Documentation	4-10
4.6.1	QA Requirements for On-Line Documentation	4-10

4.6.2	General Help File Contents	4-11
4.6.3	Help File Structure	4-13
4.6.4	Entry-Level Text	4-13
4.6.5	Update History Subtopic	4-14
4.6.6	QA Information Suptopic	4-15
4.6.7	Execution Subtopic	4-17
4.6.8	Commands Suptopic	4-17
4.6.9	Data Subtopic	4-18
4.6.10	Example Subtopic	4-19
4.7	External Documentation	4-20
4.7.1	Software Notebooks	4-21
4.7.2	Software Abstract and Listings	4-22
4.7.3	Records	4-23
4.8	Formal Reports	4-23

5. General Programming Guidelines

5.1	Software Planning	5-1
5.2	Readability	5-3
5.2.1	General	5-3
5.2.2	Variable Naming	5-5
5.2.3	Declarations	5-5
5.2.4	Modularity	5-6
5.2.5	Example	5-6
5.3	Portability of Codes	5-10
5.3.1	Machine-Dependent Coding	5-10
5.4	Robustness	5-10
5.5	Efficiency	5-11
5.6	Internal Documentation	5-11
5.6.1	Minimum Internal Documentation	5-12
5.6.2	Enlightening Comments	5-12
5.6.3	Main Program Headers	5-12
5.6.4	Subroutine Headers	5-16
5.6.5	Include File Headers	5-16
5.6.6	DCL Procedure Headers	5-18
5.7	Interfacing C Codes to the CAMCON System	5-19
5.7.1	Compilation	5-19
5.7.2	Linking	5-19
5.7.3	Mixing FORTRAN and C	5-19

6. CAMDAT_LIB: Computational Data Base Interface Library

6.1	Background on the Selected Format	6-1
6.2	Correspondence Between Generic Computational Data Base and Data Entities in CAMDAT File	6-2
6.2.1	Heading	6-4
6.2.2	Quality Assurance Information	6-4

6.2.3	Optional Text	6-4
6.2.4	Data Base Version and Model Size	6-5
6.2.5	Nodal Point Coordinates	6-5
6.2.6	Element Map	6-5
6.2.7	Material Block Information	6-5
6.2.8	Boundary Condition Data	6-7
6.2.9	Results	6-9
6.3	General Guidelines on the Use of CAMDAT_LIB Routines	6-10
6.3.1	Sponsorship and Version	6-10
6.3.2	Overview of CAMDAT_LIB	6-10
6.3.3	Error Messages	6-12
6.3.4	Linking	6-12
6.3.5	Summary of Routine Calls	6-12
6.3.6	Example	6-15
6.4	Description of Routine Calls	6-17
6.4.1	General Routines	6-17
6.4.2	Detailed Descriptions of File Initialization Routines	6-20
6.4.3	Detailed Descriptions of QA Information Routines	6-34
6.4.4	Detailed Descriptions of Model Description Routines	6-41
6.4.5	Detailed Descriptions of Analysis Results Routines	6-69

7. SDBREAD_LIB: Secondary Data Base Interface Library

7.1	General Description of the Secondary Data Base	7-1
7.1.1	Secondary Data Base Structure and Similar Data Entities	7-1
7.1.2	Storage of Conceptual Model Stratigraphy	7-1
7.1.3	Storage of Parameter Data	7-2
7.2	General Description of SDB Neutral Files	7-3
7.2.1	SDB Descriptor Records (Keywords)	7-3
7.2.2	Format of SDB Descriptor Records	7-3
7.2.3	Example of Descriptor Records	7-6
7.2.4	Identification of SDB Neutral Files	7-6
7.3	General Guidelines on the Use of SDBREAD_LIB Routines	7-7
7.3.1	Sponsorship and Version	7-7
7.3.2	Overview of Capabilities and Method	7-7
7.3.3	Linking	7-7
7.3.4	Error Messages	7-7
7.3.5	Summary	7-9
7.3.6	Examples	7-9
7.4	Description of Routine Calls	7-13
7.4.1	General Routines	7-13
7.4.2	Advanced Routines	7-32

8. CAMCON_LIB: Quality Assurance Routine Library

8.1	General Guidelines on Use	8-1
8.1.1	Sponsorship and Version	8-1

8.1.2	Linking	8-1
8.1.3	Error Messages	8-1
8.1.4	Summary	8-2
8.1.5	Example	8-4
8.2	Description of Routine Calls	8-6
8.2.1	QA and User Interface Routines	8-6
8.2.2	File Processing Routines	8-22
8.2.3	Free-Field Input	8-30
8.2.4	String Processing Routines	8-51
8.2.5	Common Internal Routines	8-58

9. CAMSUPES_LIB: Routines for Dynamic Memory Allocation and Other FORTRAN Extensions

9.1	General Description	9-1
9.1.1	Sponsorship and Version	9-1
9.1.2	Overview of CAMSUPES_LIB	9-1
9.1.3	Linking	9-1
9.1.4	Summary	9-2
9.2	Description of Routine Calls	9-3
9.2.1	System Queries	9-3
9.2.2	Memory Management Routines	9-11
9.2.3	Advanced Memory Management Routines	9-23
9.2.4	Memory Management Debugging Routines	9-34

10. Graphics Libraries: PLT_LIB and HJIPILOT_LIB

10.1	General Guidelines on the Use of PLT_LIB Routines	10-1
10.1.1	Sponsorship and Version	10-1
10.1.2	Overview of PLT_LIB	10-1
10.1.3	Linking	10-6
10.1.4	Summary of Routines	10-6
10.2	Description of Routine Calls	10-10
10.2.1	Plot Initialization and Control	10-10
10.2.2	Setting PLT_LIB Parameters	10-23
10.2.3	Hardware and Software Text	10-51
10.2.4	Two-Dimensional Graphing	10-57
10.2.5	Device Coordinate Plotting Primitives	10-71
10.2.6	Two- and Three-Dimensional Mapping Routines	10-84
10.2.7	Clipping of Two- and Three-Dimensional Points, Lines, and Polygons	10-117
10.2.8	Color Palette Routines	10-128
10.2.9	Obsolete Routines	10-136
10.3	General Guidelines on the Use of HJIPILOT_LIB Routines	10-147
10.3.1	Sponsorship and Version	10-147
10.3.2	Overview of HJIPILOT_LIB	10-147
10.3.3	Linking	10-147
10.3.4	Limitations	10-147

10.3.5	Error Messages	10-147
10.3.6	Summary of Routines	10-148
10.4	Description of Routine Calls	10-149

11. Graphic Device Interfaces: SVDI and DVDI

11.1	Sandia Virtual Device Interface Library	11-1
11.1.1	Sponsorship and Version	11-1
11.1.2	Overview of SVDI	11-1
11.1.3	Summary of Routines	11-1
11.2	Escape Codes for SVDI-Supported Devices	11-2
11.3	Description of Routine Calls	11-6
11.4	Dual Device Interface Extension	11-45
11.4.1	Sponsorship and Version	11-45
11.4.2	Overview of DVDI	11-45
11.4.3	Application Programming Guidelines	11-45
11.4.4	Linking	11-47
11.4.5	Device Selection and Execution	11-48
11.4.6	Adding a Device Driver	11-51

12. Software Development Utilities

12.1	Chapter Conventions	12-2
12.2	ABSGEN, Software Abstract Generation	12-3
12.2.1	Sponsorship and Version	12-3
12.2.2	Function	12-3
12.2.3	Execution	12-3
12.2.4	Required Identifiers and Headings	12-4
12.3	CHANGES, Error and Enhancement Reporting	12-5
12.3.1	Sponsorship and Version	12-5
12.3.2	Function	12-5
12.3.3	Execution	12-5
12.3.4	Special Mode, SCANCHANGES	12-5
12.3.5	Commands for CHANGES	12-6
12.4	CREATE_PROGRAM, Compile and Link a Program	12-9
12.4.1	Sponsorship and Version	12-9
12.4.2	Function	12-9
12.4.3	Execution	12-9
12.4.4	Preparation	12-9
12.4.5	Output	12-11
12.5	FLINT, FORTRAN Code Analyzer	12-12
12.5.1	Sponsorship and Version	12-12
12.5.2	Function	12-12
12.5.3	Execution	12-12
12.5.4	Source File Specification	12-12
12.5.5	Qualifiers	12-13
12.5.6	Library	12-17

12.6	FORMRENUM, Format and Renumber	12-19
12.6.1	Sponsorship and Version	12-19
12.6.2	Function	12-19
12.6.3	Execution	12-19
12.6.4	Overview	12-19
12.6.5	Qualifiers	12-20
12.6.6	In-Source Control	12-22
12.6.7	Errors and Restrictions	12-23
12.6.8	Example	12-24
12.7	HLPCHK, Check Format and Content of Software Help File	12-26
12.7.1	Sponsorship and Version	12-26
12.7.2	Function	12-26
12.7.3	Execution	12-26
12.7.4	Required Identifiers and Headings	12-26
12.8	LISTDCL, List DCL File	12-28
12.8.1	Sponsorship and Version	12-28
12.8.2	Function	12-28
12.8.3	Execution	12-28
12.8.4	Preparation	12-28
12.8.5	Output	12-29
12.9	LISTFORTRAN, List FORTRAN Source	12-30
12.9.1	Sponsorship and Version	12-30
12.9.2	Function	12-30
12.9.3	Execution	12-30
12.9.4	Preparation	12-30
12.9.5	Output	12-31
12.10	QA_PREP, Setup for QA_PRINT	12-32
12.10.1	Sponsorship and Version	12-32
12.10.2	Function	12-32
12.10.3	Execution	12-32
12.10.4	Limitations	12-32
12.10.5	Preparation	12-32
12.10.6	Example	12-32
12.11	QA_PRINT, Quality Assurance Notebook Print Procedure	12-33
12.11.1	Sponsorship and Version	12-33
12.11.2	Function	12-33
12.11.3	Execution	12-33
12.11.4	Limitations	12-34
12.11.5	Preparation	12-34
12.11.6	Example	12-35
12.12	UPDATE_PROGRAM, Compile, Update, and Link	12-36
12.12.1	Sponsorship and Version	12-36
12.12.2	Function	12-36
12.12.3	Execution	12-36
12.12.4	Preparation	12-36
12.13	VAX/VMS Debugger	12-37
12.13.1	Sponsorship and Version	12-37
12.13.2	Function	12-37

12.13.3 Reference	12-37
12.13.4 Execution	12-37
12.13.5 Commands	12-38

References

Appendix A: Assessing the Performance of the WIPP

A.1 Background on the WIPP	A-1
A.1.1 Purpose	A-1
A.1.2 Waste	A-1
A.1.3 Location	A-1
A.1.4 Repository	A-2
A.1.5 Sandia Role	A-2
A.2 Performance Assessment of the WIPP	A-2
A.2.1 Compliance Strategy	A-2
A.2.2 Six General Tasks of PA	A-3
A.2.3 Multiple Iterations through PA	A-7
A.3 Overview of Consequence Modeling	A-8
A.3.1 Model Subdomains in Consequence Modeling	A-8
A.3.2 Modeling Systems	A-10
A.4 Requirements for the PA Software	A-13
References	A-16

Appendix B: CAMCON System Personnel and Software Sponsors

B.1 WIPP Computer System Administrator	B-1
B.2 Performance Assessment QA Coordinator	B-1
B.3 Assistant to QA Coordinator for Software	B-2
B.4 CAMCON System Task Leader	B-2
B.5 CAMCON System Sponsors	B-3
References	B-4

Glossary

Index

Figures

1-1	CAMCON software development in the Sandia WIPP PA Department	1-5
2-1	The analysis system CAMCON	2-4
2-2	The [CAMCON] directory structure	2-5
2-3	Example of files in the [SYMBOLS] directory	2-8
2-4	Code directory structure	2-11
2-5	The investigator interprets data in the primary data base that is consistent with the use of a model parameter in the computational model	2-14
2-6	The six FORTRAN CAMCON libraries provide interfaces to the PA analysts, secondary data base, computational data base, graphic devices, and computer memory	2-21
3-1a	Steps followed to reach a Class X, C, or A software QA rating (part 1)	3-7
3-1b	Steps followed to reach a Class X, C, or A software QA rating (part 2)	3-8
3-2	Steps followed for modifying Class A or C software	3-14
6-1	Correspondence between generic computational data base and CAMDAT neutral file entities	6-3
6-2	Storage of WIPP finite-difference mesh in a CAMDAT file	6-6
7-1	SDBREAD_LIB typically accesses three SDB neutral files exported from the secondary data base tables	7-4
7-2	Example of data moving from the secondary data base to a CDB neutral file and the various possible identifiers for CAMCON SDB neutral files	7-8
11-1	Communication with graphic devices is accomplished through the Dual Virtual Device Interface (DVDI)	11-46
A-1	Sandia's method for assessing WIPP repository compliance involves six tasks	A-5
A-2	Major computational models (codes) and the physical features they simulate in the WIPP disposal system	A-6
A-3	Three model scales are typically used in compliance assessment	A-9
A-4	Overview of PA calculations	A-11
A-5	CAMDAT, a primary component of the CAMCON system, is the behind-the-scenes structure that supports the PA calculations depicted in Figure A-4	A-15

Tables

3-1	Relationship Between Software Class and Quality Assurance Requirements	3-5
11-1	Currently Supported Devices in SVDI	11-3
11-2	Escape Codes for CAMCON SVDI-Supported Devices	11-3
11-3	Communication Codes for the SVDI Routine, VDESCP	11-47
11-4	Communication Codes for the SVDI Routine, VDIQES	11-47
B-1	CAMCON System Sponsors	B-3

1. Introduction

1.1 The WIPP and CAMCON

The Waste Isolation Pilot Plant (WIPP) is a geologic repository being developed by the U.S. Department of Energy (DOE) as a research and development facility to demonstrate the safe storage, management, and disposal of defense-related transuranic (TRU) waste and, as such, must comply with several standards of the U.S. Environmental Protection Agency (EPA). The Compliance Assessment Methodology CONTroller, or CAMCON, is the analysis system used by the Performance Assessment (PA) Department of Sandia National Laboratories (Sandia) to assess the compliance of the WIPP with applicable long-term environmental regulations, including Subpart B of the EPA's *Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes*, 40 CFR 191 and 40 CFR 268.6, which is the portion of the *Land Disposal Restrictions* implementing the Resource Conservation and Recovery Act of 1976 (RCRA), as amended, that states the conditions for disposal of hazardous chemical wastes.

1.2 About this Manual

1.2.1 Purpose

This manual was written to assist programmers developing software for the CAMCON system. Specifically, the manual provides information on the following:

- An overview of the architecture of the CAMCON system
- Specific requirements for CAMCON software¹
- Programming guidelines and desired program features for CAMCON software
- CAMCON libraries²
- Software development utilities available within the CAMCON system
- Background on assessing the compliance of the WIPP

1.2.2 Organization

The following is an overview of the organization and content of the remainder of this manual:

Chapter 2 The CAMCON System. This chapter presents an overview of the CAMCON system.

Chapter 3 Software Development Overview. This chapter provides an overview of development strategy, verification, and placement of software into the CAMCON

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1. Minimum quality assurance requirements and procedures for the software were first presented in Rechar et al., 1991. Current QA requirements are found in the PAP02 (1993) and subsequent revisions.
 2. The most current information is available from on-line documentation.

system. It also summarizes pertinent software quality assurance (QA) requirements; however, a developer should review the complete QA procedures prior to coding.

- Chapter 4** **User Interface Guidelines.** This chapter discusses suggested software features for interfacing with the user (customer).
- Chapter 5** **General Programming Guidelines.** This chapter discusses guidelines and desired internal features of software developed specifically for performance assessment and the CAMCON system.
- Chapter 6** **CAMDAT_LIB: Computational Data Base Interface Library.** This chapter describes the computational data base, CAMDAT, and the calls to the routines in the CAMDAT_LIB library. CAMDAT_LIB contains subroutines that read from and write to a neutral file, which is a file to which codes in the CAMCON system are linked.
- Chapter 7** **SDBREAD_LIB: Secondary Data Base Interface Library.** This chapter describes the secondary data base and the calls to the routines in the SDBREAD_LIB library. SDBREAD_LIB contains subroutines that read from several neutral files, which are files that store parameter values pertinent to performance assessment calculations.
- Chapter 8** **CAMCON_LIB: Quality Assurance Routine Library.** This chapter provides a description of the calls to the routines in the CAMCON_LIB library, such as the QA headers required on output, which provide a common interface to the user.
- Chapter 9** **CAMSUPES_LIB: Routines for Dynamic Memory Allocation and Other FORTRAN Extensions.** This chapter describes the calls to the routines in the CAMSUPES_LIB library, which primarily allows programmers to dynamically dimension arrays in FORTRAN.
- Chapter 10** **Graphics Libraries: PLT_LIB and HJILOT_LIB.** This chapter describes Sandia graphics libraries used in CAMCON plot programs.
- Chapter 11** **Graphic Device Interfaces: SVDI and DVDI.** This chapter briefly describes the operation of the SVDI and DVDI libraries for the major CAMCON plot programs.
- Chapter 12** **Software Development Utilities.** This chapter describes twelve codes available to assist the software developer.

Appendix A Assessing the Performance of the WIPP. This appendix provides background information on performance assessment.

Appendix B CAMCON System Personnel and Software Sponsors. This appendix lists individuals to contact within the PA Department concerning various aspects of the CAMCON system.

A glossary of terms is found at the back of this manual.

1.2.3 Use

This report is a *reference* programmer's manual. As such, it contains extensive descriptions of CAMCON software libraries, software development utilities, and programming requirements and guidelines. However, the manual assumes

- Familiarity with computer programming in FORTRAN
- Familiarity with PA Department software quality assurance procedures
- Access to some currently existing CAMCON system software (but not necessarily an understanding of the software's purpose)
- A cursory understanding of the VAX/VMS operating system

Hence, this programming manual does not introduce a novice programmer to the CAMCON system. Furthermore, it does not describe the WIPP project or the mechanisms of performing a complete performance assessment (PA) except for the summary in Appendix A.

The following are some suggestions for using this manual based upon information sought and level of expertise:

1. *If you are an experienced programmer on the WIPP project and are familiar with performance assessments and the CAMCON system*

- Skim Chapters 2 and 3
- Read Chapters 4 and 5
- Use the Table of Contents and the Index to locate specific information to supplement the on-line documentation provided on the WIPP computer

2. *If you are a new programmer seeking an introduction to the CAMCON system*

- Refer to Appendix B for a list of people to contact for answering questions
- Browse through the current version of the CAMCON User's Manual (e.g., Rechar, 1992)
- Read Rechar et al. (1991) and the current revision of PAP02, Software QA Procedures for the PA Department
- Browse through a software notebook on any piece of software (contact the person listed in Appendix B) and/or access the CAMCON system on the WIPP computer and examine the on-line documentation for several pieces of software

- Obtain a listing of a piece of CAMCON software for reference
- Read Chapters 2 through 5 of this manual

3. *If you are seeking a description of the CAMCON system*

- Read the first few chapters of the current version of the CAMCON User's Manual (e.g., Rechard, 1992)
- Read Chapter 2 of this manual
- Skim Chapters 3, 4, and 5
- Skim Rechard (1989)

4. *If you are seeking information about performance assessments or the WIPP*

- Refer to Appendix A (or Rechard, 1989) for a cursory description of the mechanics of a performance assessment
- Refer to the extensive description in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* for the current year (e.g., WIPP Performance Assessment Division, 1991) and the list of references for more detailed descriptions.

1.3 CAMCON Software Development Project

Although software development is potentially a large effort, most of the development of each piece of software is best performed by one or two individuals because the development task is usually problem-driven, and quick responses to the needs of customers and software users are of paramount importance. Empowering only one or two individuals to respond to customer needs improves the response time.

Furthermore, the Sandia PA Department for the WIPP is not organized by software development categories, such as code definition, programming, or installation, but rather by modeling task assignments. These task assignments correspond to specific problem areas of the WIPP such as repository/shaft/borehole modeling and Culebra groundwater flow and transport modeling. Consequently, many specific software development needs are often defined by a task leader who may or may not be the CAMCON system coordinator. In addition, the software development responsibilities are not assigned to individuals performing software development only, but rather to individuals who may be working on specific problem modeling areas and thus have several other demands placed on them not directly related to software development. Therefore, communication and coordination of software development does not generally occur along the hierarchical stencil set up for the department (Figure 1-1). Nonetheless, the software developer is responsible for coordinating the development with the CAMCON system task leader. The purpose of this manual is to assist in the software development and coordination tasks. Refer to Appendix B for current personnel assignments.

TRI-6334-219-1

Figure 1-1. CAMCON software development in the Sandia WIPP PA Department.

2. The CAMCON System

This chapter describes the purposes of the CAMCON system and, in general, how the system accomplishes its functions.

2.1 Purpose of CAMCON

A performance assessment (PA) is the process of assessing whether a system meets a set of performance criteria. For the WIPP, the system is a computational model (which, in turn, is a composite of several models) that represents a deep, geologic, repository disposal system for waste contaminated with transuranic radionuclides and hazardous chemical constituents; the assessment is performed by computer simulation; and the performance criteria are various long-term environmental metrics in U.S. government regulations (not short-term operational safety issues). CAMCON, the analysis system for running the PA calculations, has two important functions. First, it provides the analyst with the necessary tools and flexibility to build and execute all or some of the many different types of software necessary to investigate various events and physical processes of the WIPP and present the final output for comparison with the environmental regulations (e.g., the probabilistically based release limits in *40 CFR 191*). Specifically it is flexible in use so that it can be used to

- Characterize the WIPP
- Model scenarios and evaluate regulatory performance metrics
- Evaluate uncertainties
- Evaluate parameter importance on a disposal system or subsystem level

It is flexible in capabilities so that

- Many types of data can be used even with large uncertainty
- Many types of software can be used, including both codes that are computationally efficient and codes that accurately model various phenomena

For example, it allows an analyst to quickly identify available software and the necessary information for using individual codes, enabling the analyst to select the code(s) best suited for a particular study.

Second, several of CAMCON's procedures, utility programs, and even the directory structure assist in implementing software QA procedures (Rechard et al., 1991; PAP02, 1993). This is important because

- Repetitive calculations are needed for propagating uncertainties with Monte Carlo techniques
- There is a potential need to recreate simulations
- Software is constantly being refined to improve capabilities

For example, CAMCON:

- Has the ability to read model parameters from one central secondary data base to ensure the same data are used throughout the analysis and that data changes have to be made only in one place
- Semiautomatically links codes, reducing errors in keying in data by using a computational data base that stores all data and results in one location

- Has codes available to algebraically manipulate and plot intermediate (and final) results for careful scrutiny
- Serves as a software management system, providing rudimentary configuration control
- Stores FORTRAN libraries of commonly used subroutines
- Has on-line documentation for each code and library, consisting of a description of the code and its capability, summary of user commands, update history, and examples

2.2 CAMCON Approach

Several software analysis systems have been built to meet the general requirements of a PA. One approach is to build one code with numerous submodels (see, for example, VANDAL [Unsworth, 1989], SYVAC [Goodwin et al., 1987; Sherman et al., 1985; Dormuth and Sherman, 1981] or LISA [Saltelli, 1990; Bertozzi, 1985; Saltelli, 1984]) or couple one analysis code with data preparation, Monte Carlo sampling, and results display (for example, NEFTRAN-S [Campbell et al., 1991]).

The Sandia PA Department for the WIPP chose to build an analysis “toolbox” (not one tool) by linking separate codes (either complex numerical or simple analytic codes) together. A performance assessment may or may not be rapid with the CAMCON system, however, because the difficulty and time required depend on the complexity and data requirements of the models (either analytic or numerical) chosen as components in the compliance evaluation. In a sense, the level of complexity of the models chosen determines how friendly the CAMCON system is to use. Hence, the CAMCON system can only approach the convenience of the other compliance assessment packages such as SYVAC (Sherman et al., 1985). Moreover, the use of individual codes in the CAMCON system requires that CAMCONexec, the executive package for CAMCON, be written using the computer system command language or using another language that makes extensive use of system routines.

However, these drawbacks are not always a shortcoming; the modular aspects of the CAMCON system and the WIPP compliance assessment methods make it easy for an analyst to

1. Directly make use of the interdisciplinary expertise residing in already existing codes as opposed to indirectly incorporating these concepts into one code,
2. Select the proper mathematical rigor from numerous existing codes, and
3. Use the same package for both the detailed examination of components as well as the overall disposal system (with the possible exception of substituting fast-running modules or modeling subdomains in the later analysis when desirable).

These points are especially important for nuclear waste repositories where the calculations are under intense scrutiny and sometimes elaborate procedures are necessary to justify that all steps taken in the analysis are defensible. For example, common engineering judgment in developing a simplified model, although frequently correct, is not always rigorously defensible; instead, detailed modeling must often

precede simplification. Hence, a PA system that is capable of handling both detailed and simplified models is important and prompted the development of the CAMCON system.

2.3 Software Management System and System Architecture

The CAMCON system acts as part of a Software Management System (SMS) for software within the WIPP Project. The CAMCON system consists of the following:

- A repository for current versions readily available to Sandia personnel working on the WIPP Project but with "execute only" access
- Computerized help files on procedures for using the software that are readily accessible to users, sponsors, and auditors

Other conventional parts of a software management system, such as

- A cache system for storing previously used versions of software
- Storage for all pertinent documents and records required by the software QA procedures (e.g., software abstracts, formal external documentation, and change request forms)

are currently performed outside the CAMCON system.

The name CAMCON alludes to the concept of linking major codes together as a computational system, but it has many parts which make this function possible. The primary parts of the CAMCON system consist of (Figure 2-1):

1. Directory structure and protocols for storing software for rudimentary configuration control.
2. Executive package (a suite of procedural files and symbols to set up the computer environment) written in DEC (Digital Equipment Corporation) Command Language (DCL) for ready access and execution (either batch or interactively) of the computational and support modules .
3. Code modules broken down into:
 - Seven computational modules (mesh generation, property assignment, etc.)
 - One support module (e.g., plotting and algebraic manipulation) (eighth module)
 - One utilities module for caching input files and results, listing programs, etc. (ninth module)
 - A data base module containing software for storing and/or manipulating the secondary and computational data bases (tenth module)
4. The computational data base (CAMDAT) and secondary data base
5. A collection of frequently used subroutines in FORTRAN object libraries (e.g., plot libraries)
6. Help files for on-line documentation.

TRI-6334-105-5

Figure 2-1. The analysis system CAMCON. The CAMCON system consists of (1) directory structures and protocols for storing software (not shown); (2) an executive package to access modules; (3) code modules consisting of seven computational modules, one support module, one utility module, and a data base module; (4) the computational data base (CAMDAT files) and secondary data base; (5) software libraries (not shown); and (6) help files for on-line documentation (not shown). (After Rechard, 1989, Figure 1.1.)

2.4 Directory Structure and Protocols

The specific purpose of CAMCON's directory structure is to collect software essential to the performance assessment in one location. Except for the CAMDAT files generated during a simulation and the relational data base program, the CAMCON system resides under its own user account name (but owned by the CAMCONexec sponsor) on the WIPP VAX/VMS computer. The CAMCONexec sponsor is responsible for, among other things, directory setup and giving write access privileges to the software sponsors in the appropriate directories, where *sponsor* is generally defined as the individual responsible for ushering a particular piece of software through the quality assurance procedures of the PA Department and other administrative tasks concerning the software (refer to the glossary for unfamiliar terms).

The main directory, [CAMCON], contains six categories of software divided into numerous code directories and five subdirectories that correspond to some of the CAMCON system parts (Figure 2-2):

TRI-6334-215-1

Figure 2-2. The [CAMCON] directory structure.

Except for the first category (codes), each category of software is stored in its own subdirectory. The first software category (codes) consists of all the codes in each of the ten modules. Although organizationally it might be desirable to have a code subdirectory which is then divided into ten modules and further subdivided for the individual codes, it was not desirable in a practical sense because the path name to the code quickly becomes long and unwieldy, a definite drawback for the calls in the procedural files. There are ways around this difficulty but the easiest solution was not to add a detailed directory structure for the codes.

Furthermore, and more importantly, several of the codes do not fit in only one module category. Several of the codes have multiple capabilities, such as fluid flow and contaminant transport, and thus, the categories are more of a convenience when describing the codes to users, rather than an intrinsic property of the codes themselves. A notable exception to this general practice was the grouping of the codes from the utilities module into their own subdirectory since these were usually run outside the CAMCON executive package. The codes in the utilities module are described in Chapter 11, "Software Utilities."

2.5 Procedural Files (CAMCONexec)

2.5.1 Purpose

The purpose of the collection of CAMCON system procedural files, CAMCONexec, is to act as the interface between separate codes, automating many steps in the modeling task, and thus freeing the analyst from tedious and repetitious tasks (e.g., numerous Monte Carlo simulations). Furthermore, it helps to ensure quality results by logging file information. Specifically, CAMCONexec does the following:

- Acts as user interface with the codes permitting either interactive or batch operation (e.g., generation of "macros" for later submission in background)
- Automatically names transfer files between codes, including the Monte Carlo run number, to avoid misinterpretation
- Traces the calculations so that they can be repeated
- Builds cache files

Some tasks are not automated by CAMCONexec so that the analyst can have more flexibility in how an analysis is performed. For example, CAMCONexec does not set up a secondary data base or automatically dictate which modules are to be run in what order. Furthermore, CAMCONexec cannot eliminate all user errors (intermediate results should still be examined).

2.5.2 Language

Although some routines do use C, CAMCONexec is mostly written in the operating system language, DEC Command Language (DCL), and is thus not directly portable to non-VMS systems. Even if a more

general language such as C had been used exclusively, the extensive need for access files and file attributes would have made the procedure quite specific to the VAX computer. CAMCON procedural files follow the same documentation requirements as all other software (e.g., FORTRAN), so they can be interpreted and translated to another computer system command language if necessary; although, the amount of translation may be large if all the capabilities in the DCL procedural files are wanted.

Specific instructions to the CAMCONexec sponsor are given in Section 3.4.8, "Writing CAMCONexec Procedural Files for Software."

2.6 Logicals and Symbols

Defining "logicals" and "symbols" frequently results in a much more friendly environment for the analyst. Under VAX/VMS, a logical is a name that can be used in place of a file specification (CAMCON\$ROOT is a logical name for *disk*: [CAMCON]). Logicals define the paths to directories storing the specific software such as codes and libraries. In contrast, a symbol is a name that represents a numeric, character, or logical value. A symbol can also be used as an abbreviation for a long command line, a command procedure, or to define a foreign command—a special symbol that can be used to execute a program by typing only the symbol name. Programs that use the command line to pass data (i.e., file names) must be defined as foreign commands. Most programs in CAMCON are defined as foreign commands.

The command procedures that set the CAMCON system environment reside in the CAMCON\$ROOT:[SYMBOLS] directory. The main command file, CAMCON_SYMS.COM, under the ownership of the CAMCONexec sponsor, controls the environment set up by executing supplementary command files. The software sponsors are responsible for defining symbols and logicals for their software in the supplementary command files, *sponsorname*_SYMS.COM. (The sponsor's name is used instead of the software name to reduce the number of supplementary command files since there are about ten sponsors versus over 80 pieces of software.) The last supplementary command file executed is PATCH_SYMS.COM, which can be modified by any analyst temporarily needing to redefine symbols or logicals. The analyst can define the CAMCON system environment by typing the system symbol CAMCON_SYMS at any time or by placing the symbol in his or her LOGIN.COM file. (See Figure 2-3 for an example of files on the [SYMBOLS] directory.)

2.7 Modules

When describing CAMCON codes, the PA Department groups them into modules (categories) as a convenient means to describe their use to PA analysts. The ten code modules of the CAMCON system are the (1) secondary data base module, (2) mesh generation module, (3) property assignment module,

TRI-6334-271-0

Figure 2-3. Example of files in the [SYMBOLS] directory. This DCL fragment eliminates several conditional statements for clarity. Also, to facilitate moving the CAMCON system to other disks or computer systems, the full path name is not used. Rather, a system logical, CAMCON\$ROOT, is used to define the disk location.

(4) groundwater flow module, (5) groundwater contaminant transport module, (6) repository module, (7) support module, (8) compliance module, (9) statistics module, and (10) utilities module.

- The Secondary Data Base Module inputs and manipulates the data collected during disposal system characterization.
- The Mesh Generation Module discretizes the model's domain (either the groundwater flow, groundwater transport, or repository model's domain) to assess consequences of release scenarios with the consequences analysis models.
- The Property Assignment Module places initial conditions, boundary conditions, and all model parameters needed by consequent analysis models into a CAMDAT file.
- The Groundwater Flow Module establishes regional and local fluid flow conditions within and directly surrounding the disposal system.
- The Groundwater Contaminant Transport Module predicts radionuclide migration from the repository source to the disposal system boundary.
- The Repository Module develops a source term for transport calculations by incorporating the complex processes in the waste container, disposal room drifts, and shafts.
- The Support Module contains codes that manipulate, list, and plot information in a CAMDAT file or codes to support other modules.
- The Compliance Module calculates various metrics (performance measures) to be used for evaluating compliance with environmental standards.
- The Statistics Module develops and plots regression models between various results (metrics) and parameters sampled.
- The Utilities Module contains codes that assist in the operation of the CAMCON system or specific codes within other modules and that do not interface with CAMDAT.

2.8 Codes

In most cases, a choice of computer codes is available within each module. For example, five codes are available in the groundwater flow module; the selection depends upon the type of problem under consideration.

2.8.1 Codes within Each Module

The codes available within each module are described in on-line documentation and in the current version of the CAMCON user's manual (e.g., Rechard, 1992).

2.8.2 Code Directory Structure

The directory structure for each code is arranged so that it can (1) store several active versions of a code, (2) store the help file directly with the source code files, (3) store the verification problems as a subdirectory to the source code files, and (4) store the previously working version of a code (desirable if the code is undergoing numerous modifications, i.e., a Class X or C code) as a subdirectory to the source code files (Figure 2-4). The previously working version is not necessarily the cached* (preliminary archive) version of the code, but remains on the system as a convenience to the analyst who may not be able to respond quickly to code changes, or who may discover a conflict (that needs to be corrected) with old and new capabilities. Having the old version remain on the system allows the analyst to continue working unaffected for a short period of time.

Only the software sponsor, responsible for ushering the code through the QA procedure, has write and delete privileges within the code directory. All other users have execute and read privileges only. In some cases, the read privilege is denied to all users, as in the case of proprietary codes or when desired by the software sponsor.

2.8.3 Naming Conventions for Codes

When several versions of the code exist within CAMCON (as frequently occurs), the software sponsor is responsible for defining which codes are available and the appropriate code designation. The usual designation for accessing these codes through CAMCON is as follows:

- *Codename* for current version
- *NEW_codename* for new version undergoing testing (source code resides in the sponsor's directory, not the CAMCON directory)
- *OLDmmmyy_codename* for previous working version (the three-letter month and two-digit year indicated by *mmmyy* are optional)
- *A_codename* when the version in the main code directory is something other than Class A software (e.g., the most recent version of a code is level C but a previous version was level A)
- *D_codename* when it is necessary to temporarily activate an obsolete version of a code (e.g., when a customer asks that comparisons be made between an obsolete and new code. A D class code can never be the sole basis of an analysis [PAP002, 1993]).

2.9 Data Bases

For the WIPP PA, the data bases are grouped into three general categories:

- Primary
- Secondary
- Computational

* Refer to the Glossary for definitions of unfamiliar terminology

TRI-6342-267-1

Figure 2-4. Code directory structure.

These categories correspond with the uncertainties in the data (e.g., measurement error—principally in the primary data base, conceptual model uncertainty—principally in the secondary data base, and computational model uncertainty—principally the models in the compliance assessment system). All the uncertainties combine to produce the uncertainty in the results. These three categories are discussed below.

2.9.1 Primary Data Bases

Requirements. Primary data bases contain the measured field, laboratory, and literature data gathered by investigators during disposal system and regional characterization (see Figure A-1 of this manual). Several requirements exist for the primary data base (Rechard et al., 1992b, Section 1.5; Rechard, 1989, p. 61):

- Contain high-quality data
- Serve as “memory” for the project or corporation
- Contain data applicable to the performance assessment
- Involve a minimum of subjective interpretation
- Possess a flexible, easily understood, and accessible structure

Furthermore, several general modeling difficulties affect the storage of data that must be addressed on a case-by-case basis. These include

- Spatial variability of parameters in a geologic medium
- Time varying parameters

The primary data base serves as a central repository of data for diverse disciplines and must be stored in a form readily understood by the various analysts. The data base must be readily accessible to the analysts, since varying conceptual models (embodied in the secondary data base) will be constructed from these data for the various scenarios as understanding about the disposal system changes.

Suggested Format. To accommodate these requirements and difficulties, a relational data base is suggested, but even within relational data bases, the contents of various tables can vary. Practical experience suggests that tables containing one parameter (e.g., hydraulic conductivity) or a group of closely related parameters (e.g., Young's modulus and Poisson's ratio) are best. The four proposed components of each relational table in the primary data base are

- Parameter location
- The parameter and units of measure
- Test conditions and supporting information
- References and miscellaneous information

Primary data bases are not a formal part of the CAMCON system (nor are they shown in Figure 2-1) and are not discussed further. Rather, all codes in the CAMCON modules access data from a secondary data base, which contains model parameters derived from interpreted data extracted from one or more primary data bases.

2.9.2 Secondary Data Bases

Although text and general scientific information on the assumed important physical processes for the scenario are not stored, the secondary data base stores all parameters necessary to define the conceptual model of the disposal system for the hypothetical release scenarios. The data base is termed a "secondary" data base since the model parameters are a compilation of "primary" data (field measurements, lab experiments, and other measurements of mechanical, chemical, geologic, and hydrologic parameters) that have been interpreted by investigators and experts. The level of interpretation can range from objective interpolation (i.e., well-known statistical techniques that are easily reproduced by others) to subjective extrapolation (i.e., techniques that are not easily reproduced unless well documented). To bridge any remaining gaps in data, knowledge derived from literature, individual professional judgment, and expert panel judgment are sometimes used so that a complete conceptual model is available.

Figure 2-5 illustrates the relationship between the primary and secondary data bases.

Although the interpretation and selection of the property data is a mentally engaging process involving professional judgment, experience, and, at times, consensus building, data entry into computer models is a tedious, error-prone process, especially when done many times for different models in the performance assessment of the WIPP. Storing parameter data in one location offers several advantages:

- By isolating the data entry in one place, a task leader can exercise more effective control. For example, when a decision is made on the value of a parameter, the value has to be relayed to only one or two individuals who enter the data into the data base rather than to all analysts who are using the parameter in their models. Also, changes to data can be made without verifying that all analysts make the necessary changes in the applied models.
- The use of consistent units for parameters throughout an analysis can be more easily enforced.
- Elaborate checks on the reasonableness of the data can be made when entering data. These checks might be too time-consuming to build separately into all codes.

The parameters for the conceptual models are divided into four file groups (Figure 2-5):

- Parameter distributions
- Stratigraphy
- Well location data
- Typical dimensions of the facility (drawings)

TRI-6334-20-2

Figure 2-5. The investigator interprets data in the primary data base that is consistent with the use of a model parameter in the computational model (after Rechar, 1989, Figure 5.1). This information is then stored in the PA secondary data base and made available to CAMCON codes via SDB neutral files and the SDBREAD_LIB routines.

Currently, data for the WIPP are compiled using the INGRES™ relational data base software. The use of INGRES™ is not a requirement since the CAMCON software reads an ASCII transfer file. In fact, R:BASE™, a personal computer relational data base, was used while the secondary data base was small. The data base could also be linked to a graphical information system (GIS), such as ArcInfo™, if desired. The WIPP project indirectly has a similar capability by moving data into the computational data base and then displaying the data spatially with the plotting package, BLOT (Rechard, 1992; Gilkey and Glick, 1989).

Some of the information stored in this data base is converted into neutral files and stored in the [SDBα] subdirectory of [CAMCON] (Figure 2-5). These files can then be read by software in the Property Assignment Module of the CAMCON system (see Figures 2-1 and 2-2). Initial software documents on the CAMCON system (e.g., Rechard et al., 1989) described in detail the formats used for writing the neutral files from the secondary data base. However, to facilitate rapid change in the file formats (sometimes necessary to accommodate new types of model parameters), codes now access the model parameters through the SDBREAD_LIB library mentioned in the previous section and fully described in Chapter 7 of this manual.

2.9.3 Computational Data Base, CAMDAT

The single most important method used to perform the complex tasks of the compliance assessment (i.e., linking codes, properly identifying Monte Carlo simulations, and controlling data flow) is requiring that all intermediate results of computer codes pass through a neutral file which is a part of the computational data base, or CAMDAT (Compliance Assessment Methodology Data Base). CAMDAT uses a neutral-file format so that a series of codes can be linked by a “zig-zag” connection rather than by the more common serial connection. For example, if the analyst wants to run a specific computational code, the analyst would use a data preparation code in the CAMCON system to first write the input file needed, execute the module, and then write the output file (i.e., results) to CAMDAT. These results could then be accessed by another module.

Neutral File Advantages. This method of using a neutral file offers six advantages, which are depicted on the next page and expanded in the paragraphs that follow:

- Only one plotting code is needed to display results
- Only one code is necessary for manipulating the data
- Analyses are easily changed to take advantage of a more precise code, a faster running code, or a subdomain of the model (a truly modular method)
- Order of applying codes is easily changed
- Coder interaction is feasible

TRI-6334-29-2

- Design of CAMCON, system to automate performance analysis, is facilitated
- Assuring quality is straightforward because all data are in one location

One Plotting and One Data Manipulation Code. As implied above, a distinct advantage of coupling codes through the computational data base (CAMDAT) neutral file is that the codes in modules can be used at any time. Two codes of particular interest for analysis are the plotting and algebraic manipulation codes, BLOT and ALGEBRA, respectively (Gilkey and Glick, 1989; Gilkey, 1988; Rechard, ed., 1992). For example, BLOT can display data input, such as the spatial distribution of transmissivity, or intermediate results, such as flow velocity. Furthermore, parameters or results can be algebraically manipulated at any time by combining parameters to create code input (e.g., storativity from rock porosity, rock compressibility, and fluid compressibility) or to examine results (e.g., evaluating fluid flux across a boundary given the discretized areas and velocities).

Codes Easily Changed. Using a computational data base permits codes to be easily replaced because when swapping codes, completely new translators with well-defined goals can be written; a programmer need not patch up previously existing software. To elaborate, an experienced programmer can save time by not needing to first understand a previously written translator to substitute a code; instead, the programmer writes completely new translators between the computational data base and new code.

The functional details of the translators will vary for each computational module of the compliance assessment. Potentially, a code module would be written so that it can read and write directly to the computational data base, entirely avoiding the need for a translator. When the code developer is responsible for both the physics and data manipulation, this approach is feasible; however, when the code is being developed by persons whose jobs vary between model physics, numerical solvers, and data and user interfaces, linking with pre- and post-processors as described below has worked well in practice.

In addition, for the WIPP, several major codes predate the computational data base. To avoid seriously complicating quality assurance by modifying coding, a translator is written that creates the ASCII input control cards by reading the data base and a supplemental program control file. Another translator is written to convert the ASCII output of the program module into the file format of the data base.

A distinct disadvantage of this approach is the limited ability to build a robust input translator to make use of all features of a general purpose code, especially if the code uses an archaic method of controlling features and lacks default values. However, only when a preexisting code is well understood have we modified a quality assured code (and quality assured again) to read the data base directly.

When examining the flow of data as described, it must be understood that the algorithm for assessing compliance of a disposal system has been made not only conceptually modular but modular in a practical sense also because the flexibility to replace codes is built in. Furthermore, if it makes sense to do so, the order of applying codes can easily be changed.

Code Iteration Feasible. Iterating between the results of two codes is more feasible, since the codes talk to each other through a data base. This greatly increases the flexibility of the performance evaluation algorithm. Apparent disadvantages to this are that processes may not be coupled, the computation may be inefficient, or numerical instability may occur; however, when these situations arise, the system will accommodate the introduction or development of a new code that does address these issues.

Controller Design Facilitated. Design of the executive package, CAMCONexec, to automate the analysis is facilitated when all information resides in one data base. By using a CAMDAT neutral file, building an executive package to couple the codes together, to control data flow carefully, and to run the codes is straightforward.

Assuring Quality More Easily. Assuring the repeatability and quality of the analysis is made easier when all data pass through one data base because information about all modifications of the data is recorded in a consistent format and stored in one location. These QA records are printed when results are plotted, a feature especially important when making numerous Monte Carlo runs (for propagating uncertainty of parameters) where results may vary only slightly and the analyst can easily misidentify and thus misinterpret a run.

In summary, the advantages of the CAMCON system center around efficient use of software development resources, analyst efficiency, management of code development when codes are replaced, and quality assurance of the analysis.

Information Stored in CAMDAT. Three types of information are stored in a CAMDAT neutral file:

- Quality assurance information, such as a record of the code name, version identification, and the date on which each code writes to a CAMDAT file
- Input data, such as finite-element or finite-difference geometry data; geologic, hydrologic, and chemical parameters; and model boundary conditions
- Output data, such as fluid flow results, concentrations from source term or transport modules, and particle pathways

Computational Data Base
(CAMDAT) Neutral File

	Heading
	QA Info
{	Mesh
	Material
	Boundary Conditions
{	Heads
	Velocity
	Path
	Concentrations

TRI-6334-272-1

Besides the general requirement to store these three categories of information, other requirements on the data base file format include the following:

- Ability to handle input and output, multiple element types, and boundary conditions for both fluid and mechanics codes
- Storage of either finite element and finite difference mesh and results
- Storage of array lengths so that the reading program can dynamically allocate memory
- Efficient use of storage and rapid access of data are also desirable, but have been sacrificed somewhat to meet the other requirements

Although the order of writing the data in a CAMDAT neutral file is conceptually correct in the preceding illustration, the actual manner of storage can constantly change as new requirements are placed on the data base; hence, codes do not directly access a data base neutral file but rather call subroutines which then access the data base. This greatly simplifies the process of changing the structure of the file. Thus, while earlier manuals on the CAMCON system had an extensive description of the manner of storage in a CAMDAT file, these descriptions have been replaced with descriptions of the calling subroutines in Chapter 6 of this manual.

A complicating factor of the computational data base is that several different model scales are necessary (see Appendix A): the regional, the repository, and the local. Furthermore, results from the regional, local, and repository models must be accessible to the other codes. To handle this problem, the computational data base is composed of separate files, all with the same format but with a file heading indicating the model scale. Furthermore, because uncertainty is propagated through the system by making numerous Monte Carlo runs, the number of files in CAMDAT is large. Currently, the CAMDAT is organized through the use of separate directories on the computer rather than through a relational data base system.

2.10 Software Libraries

A collection of subroutines has been placed in several object FORTRAN libraries within the CAMCON account, under the [LIBRARIES] subdirectory, to

- Simplify and speed up initial coding by reducing the amount of coding and subsequent errors
- Help to meet QA traceability standards
- Standardize the user interface
- Expand a code's capability
- Improve code maintainability (minimize the support effort)
- Isolate machine-dependent coding

Their use is strongly encouraged even though a programmer may dislike the use of "black boxes." The functions performed by these subroutines are usually quite simple, and source coding to understand the methods used is readily available in the software notebooks (see Section 4.7.1, "Software Notebooks").

The [LIBRARIES] subdirectory is owned by the [CAMCON] directory sponsor. The seven main libraries are:

- The [LIBRARIES] subdirectory is owned by the [CAMCON] directory sponsor.
- CAMCON_LIB contains standard subroutines used by codes developed specifically for CAMCON, including subroutines that write standard headers to the output to meet software QA requirements and subroutines that give all the codes a standard user interface.
- CAMDAT_LIB contains the subroutines used to read from and write to the computational data base file, CAMDAT, to standardize the interface between the codes and CAMDAT. This standard interface permits the sponsor of the data base file to change the data structure to meet the changing needs of the compliance calculations without affecting the operation of individual codes.
- SDBREAD_LIB contains the subroutines used to read from and write to the secondary data base file which stores parameter values. These routines standardize the interface between the code and the secondary data bases such that any necessary changes on the data structure do not affect the operation of individual codes.
- CAMSUPES_LIB contains the subroutines for dynamic dimensioning of FORTRAN arrays, and thus isolates this machine-dependent coding.
- DVDI_LIB contains the Sandia graphic device interface drivers for the plotting codes.
- PLT_LIB contains the Sandia graphics library.
- HELP_LIB contains the help library for all of the codes within CAMCON. HELP_LIB is created from all the individual text help files in the code and library directories and then is built as a standard VAX/VMS HELP file (DEC, 1989, 1990).

Because the routines are intended to be reliable and maintainable, most

- Are simple, not extremely sophisticated
- Do not necessarily maximize CPU speed
- Do not take advantage of extended system capabilities
- Are generally independent of the operating system
- Isolate any system-dependent functions

Figure 2-6 illustrates the interfaces provided by the seven FORTRAN CAMCON libraries (CAMCON_LIB, CAMDAT_LIB, SDBREAD_LIB, PLT_LIB, HJTPlot_LIB, CAMSUPES_LIB, and DVDI_LIB) to the PA analyst, secondary data base, computational data base, graphics devices, and computer memory, respectively:

TRI 6342 1912.0

Figure 2-6. The six FORTRAN CAMCON libraries provide interfaces to the PA analysts, secondary data base, computational data base, graphic devices, and computer memory.

The use of the CAMCON_LIB, CAMDAT_LIB, SDBREAD_LIB, CAMSUPES_LIB, and PLT_LIB are described in subsequent chapters of this manual.

2.11 On-Line Documentation

In the CAMCON system, on-line documentation is available for most pieces of software used. On-line documentation, or the help file (a computer file generated by the software sponsors), allows users and auditors to retrieve basic information about each code quickly. Consequently, the software sponsor and software coordinator spend less time answering routine questions on code availability and capabilities. In the CAMCON system, the help file is structured as a VAX/VMS HELP library (DEC, 1988) and is located in the [LIBRARY] subdirectory of [CAMCON]. (The individual text about each piece of software that makes up the help library is stored in the same directory as the software.)

A detailed description of the help file is given in Section 4.6, "On-Line Documentation."

3. Software Development Overview

3.1 Software Development Strategy

Software development for the CAMCON system is part of the complex interdisciplinary process alluded to in Chapter 2. What follows is a brief overview of the strategy used by the software development team. Although planning had been done, it was often minimal in the early phase of the project.¹ The demonstrated success of the software of the PA project has greatly depended upon software development strategies rather than planning the details of implementing the CAMCON system.

3.1.1 Multiple Passes through the Assessment

Although not a software development strategy, a very important project strategy that greatly effects software development is the commitment by PA to perform periodic assessments of the WIPP even though it was not initially a customer requirement (see for example, Rechard, 1989, p. 49; Bertram-Howery and Hunter, ed., 1989; Marietta et al., 1989). For software development, the benefit has been great from iterating through the entire compliance assessment methodology several times followed by peer review by outside groups such as the Board of Radionuclide Waste Management of the National Academy of Sciences, even though sufficient time for detailed planning has been unavailable. The cycles have helped project managers and more importantly the participants themselves (PA analysts and code developers), allocate software development resources as well as plan for overall project needs. In short, the iterative nature and peer review ensures that the software development and enhancement process is a series of small steps repeated many times.

3.1.2 Incremental Improvements

A direct benefit of the periodic assessment cycles is that the software development or modification process is a series of small steps; consequently, software discrepancies and deficiencies are discovered and corrected within the overall WIPP analysis. More importantly, the software product can continue to improve based on experience, and we can incrementally institute quality assurance procedures rather than attempt to design the software perfectly the first time.

3.1.3 Prototyping the System and Selecting Software

A distinct disadvantage of the annual cycles is the lack of time for passing through the early planning phases of software development. A strategy that was initially adopted and has been used several times is to form two groups: one either to develop or adopt software that approximately meets the needs of the analysis but more importantly meets critical schedule times, and another group to more systematically develop software. The first group provides valuable information of technique and approaches, even

¹ The proposal and planning document for the CAMCON system was Rechard, 1989.

though the software is eventually discarded. Versions 1 and 2 of the CAMCON system followed this approach. Version 1 was a thrown-together version (which worked amazingly well due to the diligence of the developers), while Version 2 was developed in parallel and served as a foundation for further development.

3.1.4 Prototyping Support Software

For support software, often time is lacking for clear problem definition, etc., so this software begins as a prototype or rough draft from which the actual code is designed or greatly enhanced.

3.1.5 System Flexibility

As mentioned several times, the flexibility of the overall analysis system is a very important strategy adopted by PA. It has allowed the system to easily accommodate the study of new phenomena (e.g., gas generation from corrosion of waste containers) as the needs arose. This is possible even though each individual piece of software is not necessarily flexible.

3.1.6 Data Manipulation Software

ALGEBRA. Although actually a part of the CAMCON system, a code deserving special mention is the ALGEBRA code (Rechard, 1992; Gilkey, 1988). ALGEBRA algebraically manipulates data within a CAMDAT file. Its function is to transpose data for use by other codes. This code greatly diminished the planning necessary to have codes exchange results between each other — important when time is short and/or the usefulness of a code(s) is only being explored.

RELATE. Another code deserving special mention is the RELATE code. RELATE interpolates models, parameters, or results described at the nodes or elements of one mesh onto another mesh. This code greatly increased the flexibility in developing modeling scales.

3.1.7 Close Links Between Developers and Analysts

An important strategy has been the close association of the analysts with the developers. Because much of the software development is driven by events and discoveries of complex phenomena, this close association between analysts modeling the phenomena and the developer creating tools to aid in its analysis is essential. This close relationship also serves to ensure that the software does what it is supposed to do.

In several cases, the analyst and developer are one and the same. This situation can cause problems in that the apparent drudgery of planning and prototyping is skipped over, and the software is perceived as a tool to be used once to get at a solution. While a definite problem in short-term projects, the repetitive use of the same software in annual cycles tends to diminish this tendency. However, the WIPP PA

Department must often respond rapidly to analyze perceived problems; hence, patches to codes can and do creep in. This can necessitate the formation of two groups, the users and developers, to allow progress in code enhancements, not just continual patches. Another option previously mentioned in Section 3.1.3 was forming two groups, one for early customer requirements and the other for long-term customer requirements.

3.1.8 Analysis Efficiency

Because thousands of runs through the system are necessary, computational efficiency is necessary. Thus, software development has centered not just on linking existing codes together or developing new codes with standard solvers, but has included supporting research and the adoption of new methods as a way to make dramatic improvements in the CAMCON system model. These tasks have not been under the supervision of the overall CAMCON system developer, but under a task leader, directly affected by the improvements to maintain a tight link between the developer and analysts.

3.1.9 Training

Throughout the project some informal training has occurred. This has included discussions of programming style, subroutine use, and QA requirements. As the project has grown, the need to present more formally the PA Department's programming "culture" has precipitated the need for the programmer's manual.

3.1.10 Selection of Primary Coding Language and Computer Operating System

FORTTRAN 77. As mentioned earlier, in the introduction, the CAMCON project is not individuals solely performing software development in development groups, but rather individuals performing other tasks such as analysis. The coding language of these individuals was predominantly FORTRAN. Furthermore, existing scientific and engineering software (SES) was predominantly FORTRAN; thus, it was selected. However, the selection of only one programming language is unnecessary since codes can be easily linked through the neutral files of CAMDAT.

Operating System. The primary criterion for selecting the operating system was the availability of an excellent debugging package for FORTRAN.

Mainframe Computer. As alluded to several times, assessment of a nuclear waste repository involves multidisciplinary codes that must be linked together as a system. The analysts on the project work together as a team, not as individuals with discrete parts of a problem. Although not necessarily required with today's networking capabilities, operation of the system is greatly facilitated by having all the software residing on one computer, since management and maintenance of the system is easier. Furthermore, vast amounts of data needed to be transferred among the team PA analysts. Also, the need

for large amounts of disk storage space and memory was most easily met by a mainframe when the project began.

At the start of the CAMCON development project in January, 1988, there were indications that the C programming language and the UNIX operating system would become quite prevalent in the computer workplace. However, the project chose VAX/VMS (a non-UNIX operating system) and the corresponding DEC Command Language, DCL. The central reason for this selection was that although we were tempted to plan for the future general uses of the CAMCON system, we thought the monumental task of developing the extensive analysis system would tax the available resources, and hence, most tasks should be as simple as possible and use already existing and working computer systems at Sandia (as of January 1988). This approach has been very successful. Nevertheless, a small effort has been made to use FORTRAN or C (now that an ANSI standard for C has been set [Kernighan and Ritchie, 1988; ANSI C, 1989]) in place of DCL for interacting with the operating system to increase portability to different platforms.

3.2 Software Quality Assurance Requirements

Note

The software QA requirements and their implementation are explained in detail in Rechard et al. (1991) and officially issued as PAP02¹ (Performance Assessment Procedure number 2), as part of the Sandia National Laboratories WIPP Project Operating Procedures.² Pertinent sections of the requirements are repeated here and throughout the programmer's manual for completeness but should not be considered as authoritative since changes in the QA procedures are likely to occur over time.

Herein, quality assurance, as related to computer software, means that the software user (PA analyst) has a reasonable degree of assurance that the software will correctly perform its stated capabilities when given the proper input. The WIPP PA software QA procedures (Rechard et al., 1991) accomplish this assurance by supplying a framework for controlling five aspects—traceability, retrievability, verification, peer review, and documentation—so that the analyst can depend upon software quality and consequently deliver quality work. The software QA procedures establish different minimum requirements for these properties for different classes and categories of codes based on the safety and programmatic risk associated with the task. This is a graded approach as endorsed by the WIPP Quality Assurance Program Description, or QAPD (QAPD, most recent).

¹PAP02 (1993) was originally designated QAP 2-2, Quality Assurance Procedure 2-2, prior to October 1992.

²The Quality Assurance Program Description (QAPD) (QAPD, most recent), originally designated Quality Assurance Program Plan (QAPP) (QAPP, 1990), is the primary QA document for the WIPP project at Sandia with the PAP02 elaborating on the basic requirements. Another document, QAP 19-1, Computer Software Requirements, also has some bearing upon PAP02, but its requirements are intended to be equivalent. Figure 1 of the QAPD describes the QA document hierarchy.

3.3 Software Classification

3.3.1 Description of the Four Software Classes

For QA purposes, software is identified by a letter that indicates its stage of development. The four software classes are A, C, D, and X (Table 3-1), which represent the following stages:

- A - Adjudicated (full QA status)
- C - Candidate (partial QA status, possibly undergoing continued refinement)
- D - Dormant (obsolete software formerly in Class A or C)
- X - eXperimental (entry level, software in early stages of development or experimentation, no QA requirements)

Software developers and sponsors should strive to classify software to the highest possible QA level consistent with its importance within the WIPP project. Although new software can be entered at any level, a QA coordinator decides whether software is entered into Class C, D, or X, while a software review committee decides whether to classify software as Class A. The various classes of software offer the user the following assurances:

Table 3-1. Relationship Between Software Class and Quality Assurance Requirements (Rechard et al., 1991, Table 2.1)

Software Class QA Requirement	A	C	D	X
Status	Adjudicated	Candidate	Dormant	Experimental
Source statements	Fixed	Fixed	Fixed	Not Fixed
Direct user accessibility	Yes	Yes	No ^a	No ^b
Traceability	Yes	Yes	c	No
Retrievability	Yes	Yes	c	No
Verification	Yes	Yes	c	No
Documentation				
Internal	Yes	Yes	c	No
Help File and Abstract	Yes	Yes	c	No
Formal Reports	Yes	No	c	No
Discrepancy Records	Yes	No	c	No

^a Source code can be made available upon request.

^b Software available to individuals within WIPP project, but usually only from software developer.

^c QA properties of last A or C classification.

Class A . Class A (Adjudicated) software has been evaluated by a software review committee. The software satisfies the QA requirements for traceability, retrievability, verification, peer review, and documentation. The software is available to any interested user within the WIPP project at Sandia. Any analysis where the consequences from discrepancies in the software (which affect analysis performance) are considered major in relation to meeting other expectations of the customer, such as time and cost, should use Class A software (e.g., final performance assessment of the WIPP as regards federal and state environmental or human safety regulations).

Class C . Class C (Candidate) software is a candidate for Class A, but currently satisfies only the traceability and retrievability requirements (as evaluated by the QA Coordinator). The adequacy of documentation and verification has not been formally evaluated. An up-to-date help file is maintained, a software abstract has been written, and required internal documentation exists. Furthermore, verification tests are available. However, external documentation and formal reports are in progress. Class C software is often undergoing continual refinement to adapt the software's capabilities to changing requirements. The software is available to any interested user within the WIPP project at Sandia.

Class D . Class D (Dormant or historical) software is software that was formerly classified as Class A or C. Class D software is archived because it is no longer being used (usually because a more sophisticated version has superseded its use). Class D software can be retrieved from a cache, if necessary. Results from Class D software may be compared with other software in benchmark comparisons, but it is not appropriate as the sole basis of an analysis.

Class X . Class X (eXperimental) software is in the early stages of development and has not been processed through any formal QA procedures. The primary reason for the Class X classification is to make the existence of the software known to potential users so that they can provide preliminary values for scoping calculations, calculations on short notice, or calculations where the results will not be used to decide the long-term WIPP performance. Usually, a user must obtain Class X software by contacting the software developer.

3.3.2 Proprietary Software

For proprietary software, all requirements of the software QA procedures apply within the constraints of the license agreement for the software. For example, internal documentation requirements will be waived when the source coding is not available. Thus, proprietary software can potentially reach Class A.

TRI-6342-591-0

Figure 3-1a. Steps followed to reach a Class X, C, or A software QA rating (part 1).

TRI-6342-591-0

Figure 3-1b. Steps followed to reach a Class X, C, or A software QA rating (part 2) (after Rechard et al., 1991. Figure 3.1).

3.4 Software Development or Acquisition Procedures

The development or acquisition of software used by the PA Department follows the procedures described below and shown in Figure 3.1. This discussion comes from software QA procedures PAP02 (1993), but is supplemented with specific instruction.

3.4.1 Task Leader Establishes Need

When a modeling activity is identified, the modeling task leader (TL) for PA modeling establishes which software is needed to solve the problem. The software may already exist or may need to be developed. If the software already exists, the TL acquires the software, making sure that it can reach Class A or C, as required. If the software does not already exist, then the TL contracts for the software to be developed, either with a Sandia organization or an external company, and specifies as deliverables adequate external and internal documentation, verification, and traceability.

3.4.2 QA Coordinator Assigns a Software Sponsor

After the need is established and the code is being acquired or developed, the QA coordinator assigns a sponsor for the code; if the software sponsor is unable, for any reason, to act as software consultant, then a software consultant is also assigned. The QA coordinator also defines the user interface and data flow for the software within the CAMCON system.

3.4.3 Developer or Code Consultant Implements Development or Modifications

The developer or code consultant writes or modifies the software (Class X), directly interacting with the TL for the PA modeling task and the QA coordinator. Software planning and programming guidelines are discussed in Chapter 5.

3.4.4 Inspection and Verification

Inspection and verification tests, as specified by the TL or developer, are performed to determine whether the software can run pertinent calculations. If it cannot, then the need for this software is again reviewed by the TL, following the process described above. If the software passes the test, then the software continues to be developed following the procedures below. More specifics on software verification are described in Section 3.7.

3.4.5 Software Sponsor Enters Software into CAMCON as Class X

Software development or modifications can continue without entering Class X software into the CAMCON system. However, inclusion of the software as Class X in the CAMCON system often serves

to notify potential users of its existence, thereby encouraging its preliminary use and a discussion of its features. If the TL, users, or sponsor want the software to be used in this manner, the sponsor may enter the software into the CAMCON system, provided a help file is written that describes the name, purpose, authors, sponsor, and consultant(s) (i.e., the introductory information [Level 1] is completed in the help file). More specifics on entering a code into the CAMCON system are described in the following paragraphs.

3.4.6 Software Sponsor Enters Software into CAMCON as Class C

For a candidate Class C software, the software sponsor and software consultant must (1) assign a version number (see Section 3.3), (2) verify the software's capabilities (see Section 3.7), (3) complete the help file (see Section 4.6), (4) generate a software listing (see Section 4.7.1), and (5) generate the software abstract (see Section 4.7.1). After the QA coordinator has approved the abstract, the software sponsor starts a software notebook (see Section 4.7.1) for the software that includes the (1) software abstract, (2) software listing, (3) example/verification problems, and (4) help file.

After the QA coordinator has approved the software abstract, the sponsor enters the software into CAMCON as Class C with the appropriate fixed version number (see Section 4.1).

The specific instructions for a software sponsor are as follows (see also Section 3.4.8, "Writing CAMCONexec Procedural Files," for similar instructions for the CAMCONexec sponsor):

1. Create a subdirectory with the same name as the new program and the protections (S:RE, O:RWE, G:RE, W:RE) in the CAMCON\$ROOT directory.
2. Copy the optimized executable, help, and source files for the program to this directory. (The object files and debug version of the executable files should not be stored in the [CAMCON] directory.)
3. (New software sponsors only) Create a file in the CAMCON symbols subdirectory, CAMCON\$ROOT:[SYMBOLS], with the name *sponsor_user_name_SYMS.COM*. Notify the CAMCONexec sponsor that this file has been created.
4. Define a symbol to run the code by adding a line to the file *sponsor_user_name_SYMS.COM* located in CAMCON\$ROOT:[SYMBOLS]. This symbol definition should refer to the CAMCON directory by its logical name, i.e., CAMCON\$ROOT:[CODE_NAME]. (Also see Section 2.6, "Logicals and Symbols.") Because this DCL file is executed at login time by all CAMCON users, it is essential that this file be correct; hence, test your additions and changes.
5. Update the CAMCON help file, CHELP, with the command `ADDCHHELP code_name.HLP`. (CHELP follows the standard VMS help format [DEC, 1988a].) (See Section 4.6, "On-Line Documentation.")
6. Mail the CAMCONexec sponsor the following information for use in developing a CAMCONexec interface with the new code:

- A one-line description of the code. (This description will appear on-line with the other CAMCON codes when the CAMCON help option is selected.)
 - A brief description of the code. (This description will appear after the code is selected from CAMCON.)
 - A short description (for prompt) of all program I/O files in the order they appear on the command line, including (Section 4.2.3)
 - Usage (input/output, optional/required)
 - Type (text string, CAMDAT data base file, ...)
 - Default identifier (same as that in the CAMCON user's manual (Rechard, 1992) or help file) (Section 4.2.2)(The parameters in the call to the CAMCON_LIB routine FILDFNAM contain this information.)
 - If the code is typically or appropriately run in a sequence with other codes in the CAMCON system, this sequencing information should be provided.
7. Upon notice from the CAMCONexec sponsor that the interface to the code is complete, test the program from CAMCONexec and notify the CAMCONexec sponsor that the code performs as expected.
 8. Notify users that the code is available by using the CHANGES utility (see Section 12.3).

3.4.7 Software Sponsor Enters Software into CAMCON as Class A

For a candidate for Class A software, the software sponsor and software consultant must perform the following tasks in addition to those required for Class C software: (1) collect referenceable user and theory documentation, (2) collect hardcopies of verification tests and documentation (e.g., benchmark test, in-use test, and analytic comparisons), and (3) run internally developed software through a language analyzer, if available in the CAMCON system, to identify hidden programming errors. This information should be added to the software notebooks (Section 4.7.1).

At this point, the software sponsor determines whether the software is ready to be considered for Class A. If the software is calculational SES software, then it must be reviewed by the software review committee. The software review committee consists of the software sponsor, software consultant (if applicable), peer outside of the PA Department, PA analyst, and modeling task leader. Two-thirds of the committee must approve the software for Class A based on the presentation by the sponsor regarding documentation, verification, traceability, and language analyzer result (if applicable).

The software review committee must prepare and send to the QA coordinator a review form that contains its decision. Any differences of opinion must be recorded on separate review forms (ask for Form PA002, current version, from the SWCF records manager). If the software does not progress to Class A, the software is reviewed again, according to the procedure above. If the software review committee declares that the software is Class A but that limitations to use exist, then those limitations must be cited on the review form.

Non-SES software is also reviewed by a software review committee, though the committee usually is smaller consisting of the software sponsor, software consultant, and one peer, either inside or outside the PA Department. The QA coordinator assigns the peer reviewer to exercise the code. The software review committee then prepares a review form.

If the review form for either the SES or non-SES software states that the software is "Class A," then the QA coordinator passes the form to the SWCF records manager for filing. The code sponsor then changes the code identifier to QA Status A. The software sponsor must also note any cited limitations in the help file (Section 4.6).

3.4.8 Writing CAMCONexec Procedural Files for Software

The procedural files are normally written by the CAMCONexec sponsor, but the previous responsibility for providing the necessary information and testing resides with the software sponsor. (Parts of section 3.4 describe the steps and necessary information for placing software into the CAMCON system.)

After specifying the input and output information for a new code to be installed into CAMCONexec, the CAMCONexec sponsor should proceed as follows in generating procedural files:

1. Develop a procedural file that interfaces CAMCONexec with the new program by prompting the user for input according to CAMCONexec standards (Section 4.2, "Files and Entering File Names") and then invoking the program with these arguments. The easiest way to generate a procedural file is to find a prototype in the subdirectory CAMCON\$ROOT:[DRIVERS] and use it in conjunction with the code input/output information provided by the sponsor to develop a similar driver for the new code in a working directory outside [CAMCON].
 - Name the procedural file *code_DRIVER.COM*.
 - When the new code is part of a typical sequence, the sequence should have been provided to you by the software sponsor. The name of the next code in the sequence, if any, should be assigned to the symbol NEXT_PROGRAM_DEFAULT in the procedural file. If the code is preceded in the sequence, the procedural file for the preceding program must be modified to assign the symbol NEXT_PROGRAM_DEFAULT.
 - If the new CAMCON code is a general purpose utility (such as a graphics package) whose use should not modify the CAMCON user's default code selection, the procedural file should assign an asterisk (*) to the symbol NEXT_PROGRAM_DEFAULT.
2. If a sponsor is new, add a line to the file CAMCON_SYMS.COM in the subdirectory CAMCON\$ROOT:[SYMBOLS] referencing the sponsor's symbol file *sponsor_user_name_SYMS.COM*.
3. Test the new procedural file before installing it by executing CAMCON with the pathname to the directory containing the procedural file as a parameter, for example, **\$CAMCON disk:[directory.subdirectory]**.

4. Install the new procedural file by placing it in the subdirectory CAMCON\$ROOT:[DRIVERS]. Also, add the procedural file name to the file DRIVERS.ALL by running the DCL file LISTDRIVERS.XCOM in the [DRIVERS] subdirectory.
5. Notify the code sponsor so that the interface can be tested further.
6. Upon notification from the sponsor that code testing is complete, the process can be completed by adding the code (and sponsor) to the SPONSORS.DAT file located in CAMCON\$ROOT:[CHANGES] and adding the code name and its one-line description to the DRIVERS.HLP file located in CAMCON\$ROOT:[DRIVERS]. Both of these files should be added to the current CAMCON help with ADDCHHELP.

Specific requirements of the software (including procedural files) for interfacing with the user are described in Chapter 4.

3.5 Modifying Software in the CAMCON System

Since most software used for evaluating the compliance of nuclear waste repositories is complex, the possibility of discovering limitations, inaccuracies, or errors always exists, even for Class A software versions, which have satisfied the verification requirements. The modification and potential downgrading of software follow the procedures described below and shown in Figure 3-2.

3.5.1 Need Established

The PA analyst (or other user) notifies the software sponsor that software needs to be modified (either an enhancement or error correction) through a change request. For corrections to Class A software, the change request must be specified on a formal request form (ask for Form PA003, current version, from the SWCF records manager). The software sponsor then discusses the modification with the QA coordinator, software consultant, PA analyst, and task leader for the modeling task, as necessary, to establish the priority and scope of interest in the modification. If the modification is for a PA calculation for evaluating WIPP repository compliance, or for an error correction, or if it can be easily implemented, then the software sponsor directs the code consultant to implement or direct the modification. If the modification is specific to a particular analysis that does not directly evaluate WIPP repository compliance, then the PA analyst may modify the code and document the modification as described in Section 3.8, "Single-Analysis Software," when reporting the results.

3.5.2 Downgrading Software

If the changes are either minor errors being corrected, minor enhancements being added, or changes that are cosmetic or input/output specific, then a new revision of the software can maintain a Class A rating, provided the decision is noted in the update history of the help file. The QA coordinator must concur with the software sponsor's assessment that the changes are cosmetic or I/O-specific. The software review committee must concur with the assessment that the changes are minor.

TRII-6342 265-0

Figure 3-2. Steps followed for modifying Class A or C software (Rechard et al., 1991, Figure 3-2).

If significant capabilities are added or errors corrected in Class A software, the new software version is normally reclassified as Class C and reevaluated as described in Section 3.4, "Software Development or Acquisition Procedures."

For most modifications to Class C software, the new software version will retain the Class C rating, provided the help file is updated.

When retrieving an obsolete version of a Class A or C code (where obsolete means that a new version of the same class has replaced the cached version), the QA coordinator will downgrade the old version of a Class A or C code to Class D before allowing its use (e.g., benchmarking exercises). However, when a code that is not obsolete (e.g., a seldom-used code or version) is retrieved, the code can maintain its former class if a sponsor is assigned and the sponsor and QA coordinator jointly decide that the code can meet the current requirements for that class; otherwise, the QA coordinator must downgrade the code to Class D. Guidelines for changing the software ID are given in Section 4.1.1.

3.5.3 Inactive Software

Only operational software with a sponsor can be classified as Class A or C. Loss of operational status, loss of a sponsor, limited use, known significant errors, or a superior replacement are sufficient reasons for the QA coordinator to remove software from active use by purging the file from the currently operating version of the CAMCON system. For Class A and C software, purging can occur only after verifying that a cached version of the software is available.

3.6 Replacing Software Already in the CAMCON System

If the new version modifies the code command line in any way, the CAMCONexec sponsor must be notified of these changes so that a new interface can be developed and tested, as described above, before the new version is installed.

Once the interface is completed, the new version is installed as follows:

1. Create a directory named CAMCON\$ROOT:[code name.OLDmmmyy] (or other appropriate Name, e.g., A_, D_, Section 2.8.3)
2. Copy the current version into the "OLD" directory.
3. Copy the new version from your directory into CAMCON\$ROOT:[code_name].
4. Purge the directories.
5. Add to your symbol definition file, OLD_codename==path.
6. Notify the CAMCON system users about the new version by using the CHANGES utility (see Section 12.3).

This procedure is preferred since it keeps a working executable version available to the CAMCON system at all times and provides an easily identifiable copy of the most recently used one. Note that some

sponsors may choose to maintain, for example, the last three versions of the code, but at least one is expected to be available.

3.7 Verification

3.7.1 Definition

Verification of software is the process of illustrating through sufficient testing that the software satisfactorily performs its stated capabilities and providing a point of reference for testing of future modifications and testing the software on a new machine as appropriate. All Class C or A software must be verified.

3.7.2 Examples of Verification Methods

The following is a list of possible verification methods:

- Hand Calculation - the comparison of results obtained by implementing a solution by hand (to the results obtained by the software being verified where "by hand" includes the normal manual arithmetic operations outside a computational code as well as the use of spreadsheets).
- In-Use Test - the citation of widespread use of software (e.g., plotting packages) over a sufficient period of time to exercise most features of the software. In-use tests that previously "broke" a code may be retained as test cases.
- Comparison with Analytic Solution - the comparison of results obtained by analytically solving a mathematical model with those obtained by the software being verified.
- Benchmarking - the comparison of results made with one code with other codes that implement other solution techniques (e.g., numerical techniques) or mathematical formulations, where all codes are designed to solve comparable problems.
- Use in Sensitivity Analysis - the inclusion of a code in a sensitivity analysis. Sensitivity analysis as used here refers to the general measure of influence of a parameter on the variation in a result. The influence of a parameter can be measured based on equal percentage changes from a base case value or equal percentage changes of the total expected range of a parameter. While the latter is more common for WIPP calculations, both techniques require the analyst to gain vast experience with the code and thereby systematically test the capabilities of a code.
- Convergence Tests - the systematic refinement of spatial and/or temporal meshes of a numerically implemented mathematical model to determine whether zero, first, second, or higher order accuracy is observed. The observation can then be compared with the theoretically expected behavior to help evaluate whether the numerical procedure was correctly implemented.
- Other - depending upon the nature and complexity of the code, the software sponsor and/or software review committee may ask for additional specific verification tests. In this case, the nature of the test should be included in the test case documentation.

3.7.3 Appropriate Verification Method Dependent on Complexity, Type, and QA Level

All the verification methods can be used on any piece of software, but the extent to which the software is tested is determined by the complexity of the software, the software type (SES or non-SES), and the software QA level (C and A). To elaborate concerning software complexity, adequate verification of simple code may be achieved (1) directly by comparing results against hand-calculated numbers or (2) indirectly by in-use tests and citing widespread use of the code. Verification of complex codes may require testing in stages (i.e., testing of individual modules) followed by (1) extensive numerical tests and comparison of results with analytic solutions, (2) benchmarking the code against other verified software, or (3) using the code in sensitivity studies. Concerning software type, verification for non-SES codes can consist primarily of in-use test, while verifications for SES codes should include some comparisons with analytic solutions and possibly benchmarking with other codes. Finally, concerning software QA level, the number of individuals checking on the adequacy increases between Class C and Class A as noted below.

3.7.4 Determining Adequacy

Evaluating the adequacy of software verification is the responsibility of the software sponsor for Class C software. For Class A software, it is the responsibility of the software sponsor, the software review committee, and peers technically reviewing formal reports on the software.

3.7.5 Documenting Verification

Refer to Section 4.7, "External Documentation."

3.8 Single-Analysis Software and Analysis-Specific Modifications

Software written and intended solely for use within a single analysis not directly affecting WIPP performance with applicable federal and state regulations is exempt from requirements of PAP02 (1993), the software QA procedures, except that the documentation of the software shall be as described in Section 4.7, External Documentation.

Furthermore, changes to software that has been previously quality assured and changes that are specific to one analysis not directly affecting WIPP compliance issues are also exempt from these procedures except for the documentation requirements described below.

Error corrections, features, or capabilities added for two or more analyses or users, or added for an analysis directly affecting WIPP performance as determined by the task leader, are not considered analysis-specific modifications; these modifications shall be treated as new versions or revisions to existing software and shall follow the QA steps within PAP02 (1993).

The individual using software written or modified for a single analysis shall ensure that the documentation included with the reported results contains the following basic elements:

- The software or modification must contain the minimum internal documentation required by PAP02 (1993).
- The report must list the code source or modified section of code. If the code listing is too lengthy, the individual must submit a hardcopy or microfiche listing (and possibly the listing on computer storage media) to the Sandia WIPP Central File (SWCF) and note the location and identification in the report.
- The report (or internal documentation) must describe the code input and data used.
- The report must describe the method of verification.
- The report must describe code validation as appropriate.

4. User Interface Guidelines

This chapter describes suggested guidelines on how software should interact with the user, including suggestions on standard startup, manner of input and file names, error messages, etc., to provide a common user interface.

4.1 Traceability

For software to be maintained over time, it is important that users can identify the software and version used in a calculation to retrieve the correct copies of that software, if needed. The software QA procedures establish standards for tracing and retrieving software.

4.1.1 Software Name, PA Version ID, Date Stamp

To maintain the capabilities of tracing and retrieving software, the following information must be included on printed output, graphics output, and data bases that store results: the software name, the PA version identification (ID), and the date of the software that was used to generate the results. For software developed external to the PA Department, the original version ID accompanying the software (from which enhancements may have been added) may also be included. If several codes are used in sequence to produce the results, the data base that stores results must record the software name, PA version ID, input files, and date stamp for each code that writes data onto the data base.

The PA software identifier (ID) is of the form

QVV.RRCO

where

- Q** is the QA software classification of A, C, D, or X (see Section 3.3)
- VV** is a one- or two-digit integer designating the major version number (use a dash in the first position when the major version number is less than 10)
- RR** is a two-digit integer designating the release, or minor version number (use a zero in the first position when the revision number is less than 10)
- C** is the computer designator (for example, A for Alliant, C for CRAY, P for PC, V for VAX, and Z for Alpha)
- O** is the computer operating system (for example, V for VMS and U for UNIX)

The PA version ID changes as the software changes. Depending on the type of modification and the software classification, software identifiers are changed as follows:

Q Designator. The Q designator indicates the QA status of the software. As fully described in Section 3.4, "Software Development or Acquisition Procedures," the Q portion of the software ID usually starts

at X to indicate the experimental nature of the software. The designator changes from X to C after required verification is performed (Section 3.7), required documentation is created (Section 4.7), and the software abstract (Form PA001 created by QA_PRINT [Chapter 12]) is approved by the QA coordinator (Section 3.4.6). The designator changes from C to A after favorable review by the software review committee (Section 3.4.7) and the QA coordinator places the review form (PA003, current version) in the software notebook (Section 4.7.1) or gives it to the SWCF records manager.

The QA status can be downgraded because of major modifications, enhancements, or discovery of discrepancies as described in Section 3.5, "Modifying Software in the CAMCON System."

The Q and VV.RR portions of the software ID are not entirely independent of each other. Guidelines are provided under the next topic.

VV and RR Designators. The VV and RR designators respectively indicate major and minor changes to the software. For minor revisions, such as internal or external cosmetic changes, minor bug fixes, array size changes, and minor enhancements, the release designator (RR) is incremented by one. In all cases for C and A software, an update history must be maintained in the on-line documentation (Section 4.6) and internal documentation (Section 5.6).

For major revisions that substantially change the software, such as adding a new capability, input changes that render the formal software documentation incompatible, adding a new and independent numerical algorithm, or correcting a major error, the major version designator (VV) is incremented by one and the release designator (RR) returns to zero (00).

As stated above, the Q and VV.RR portions of the software ID are not entirely independent of each other. The decision as to whether a VV.RR change should accompany a Q designator change (or vice versa) is the responsibility of the software sponsor, QA coordinator, and software review committee. Guidelines are as follows:

- Q and VV.RR Independent
 - Class X or C software changes version or release (VV.RR)—provided the code remains at the X or C level, the Q and VV.RR designators are independent.
 - Class A software changes release number (RR)—provided the software sponsor, QA coordinator, and the software review committee concur that the change is cosmetic, a minor bug fix, or a minor enhancement (see Section 3.5), class and Q designator remains A.
 - Class A or C software is downgraded to D—when the software is downgraded to D (dormant) the VV.RR must not change.
- Q and VV Dependent
 - Software QA status upgraded from X to C—the VV.RR portion normally changes to 1.00. However, an exception can occur. If an X code is used in many or highly visible PA calculations

prior to upgrading, the QA coordinator and sponsor may jointly decide to change only the Q designator to maintain continuity with previous calculations.

- Class A software changes version number (VV)—software QA status and Q designator are downgraded to C level until formal reports are revised, verification tests performed, and a Class A rating approved by the software review committee.
- Class A software downgraded to Class X—although this has never occurred, in this case, the sponsor and QA coordinator will jointly decide whether to (a) rename the software and change the VV.RR portion to 1.00 or (b) retain the name and continue to increment VV.RR.

C and O Designators. These designators respectively identify the computer and operating system on which the software is executed. These designators change only when software is ported to another computer and/or operating system. The remainder of the software ID normally is unchanged unless the porting required substantial changes or other unrelated modifications where done in conjunction with the porting.

4.1.2 Author Names, Software Origin, Government Legal Disclaimer, and Proprietary Information

Printed output from PA software will display the author names, code origin, and either a government legal disclaimer on Sandia codes or proprietary information on external software (similar to requirements specified under internal documentation).

4.1.3 Using CAMCON_LIB Routines to Meet Traceability QA Requirements (Welcome and Exit)

To (1) properly identify the software and version for traceability, and (2) provide a uniform look to software developed specifically for the WIPP, a standard set of routines has been written and collected in CAMCON_LIB (Rechard et al., 1991, Table 4-1). Detailed explanations of the CALL statements are in Chapter 8, "CAMCON_LIB: Quality Assurance Routine Library."

Example of an Opening Section. The opening sections of most programs should be similar. The following code segment provides an example of the opening section. QASETUP places QA information (program name, version ID, revision date, current date and time, code author, and code sponsor) into a common block for use by other subroutines and QABANNER prints code banner and lists credits (authors and origin of code). The routines QASETUP and QABANNER are located in CAMCON_LIB. Use of this library is described in Chapter 8.

```
C... Load the /CAMCON_LIB/ common with the program information
CALL QASETUP ('TESTPROG', '1.00', '01/15/90',
&           'A. P. Gilkey', 'A. P. Gilkey')

C... Write a welcome banner to the terminal
CALL QABANNER (0, 'CAMCON_LIB test program', ' ', ' ')
```

Closing Section. CAMCON_LIB also provides for a consistent and graceful exit from programs. The closing section should use the following guidelines:

- A normal program execution should
 - print QA information onto the output file by calling QAPAGE
 - provide timing information with a call to QACPUS
 - terminate with an END in the main program, and STOP 'Normal *codename* completion'
- A code-trapped error should exit through a call to QAABORT, which returns an error status code to the operating system and prints "STOP" with an abort message.

4.2 Files and Entering File Names

4.2.1 File Types

Data moves in and out of the codes interactively and through files. The files consist of three file categories each consisting of several types

- Data bases
 - computational
 - secondary
- Input
 - ASCII text
 - binary data transfer file
- Output
 - descriptive ASCII text
 - data transfer file (binary or ASCII)
 - debugging ASCII file
 - log file of output normally sent to the terminal

4.2.2 Naming Conventions

Files generated by CAMCONexec procedural files (Section 3.4.8) follow a naming convention. However, all software must permit these default names to be overridden. The naming convention consists of five segments for the file name, two of which are required.

A default file name generated by the CAMCON executive program contains five segments as follows:

name_Sxxxx_t_Rxxx.ext

1. The first segment (required), *name*, consists of the code name (or, in some cases, a problem descriptive name) for which the file is used as output.
2. The second segment (optional), *Sxxxx*, identifies the scenario, where *xxxx* is a numeric ID for the scenario agreed upon by PA analysts prior to the start of major calculations. Typically, the

last two characters are used for the time of intrusion and scenario type while the leading characters vary:

x_1 (e.g., type of transport; 1 = single, 2 = dual)

.

x_{n-2} (e.g., type of retardation; 0 = no, 1 = yes)

x_{n-1} Time of intrusion (1 = 1000 yrs, 2 = 2000 yrs, etc.)

x_n Scenario type (1 = E1, 2 = E2, 3 = E1E2)

3. The third segment (optional), t , identifies whether the file type is regional, local, source, or cuttings scale model (R, L, S, or C, respectively) or general data grid (D).
4. The fourth segment (optional), $Rxxx$, identifies the run number, where xxx is the three-digit ID for the Monte Carlo run (vector).
5. The fifth segment (required), ext , is the file extension

CDB A Computational DataBase file (CAMDAT file).

DBG The ASCII output file containing code execution messages and results useful for DeBuGging.

INP The ASCII INPut control text files.

OUT The file as an ASCII OUTput text file.

SDB The files in the Secondary Data Bases.

TRN $\alpha\alpha\alpha$ The data TRANsfer files used between the translator and main program modules (either binary or ASCII) without explanatory headings, where $\alpha\alpha\alpha$ is a three-character descriptor for data contained in the transfer file (for example, VEL for velocity, ICS for initial conditions, RIN for restart input, or ROT for restart output). Transfer files are typically temporary and are used to transfer data between the translator and the main program.

The CAMCON user's manual (Rechard, 1992) describes the files needed, created, and/or used by the various codes in the CAMCON system modules. As an example, the data base file for the regional scale, scenario type E1 at 1000-year intrusion with retardation and dual transport, run 1 is as follows:

STAFF2D_S2111_R_R001.CDB

(VAX/VMS V5.0 and above permit file names and extensions with up to 39 characters each.)

By default, a code should only use the two required segments, $name$ and ext , of the file name when run outside the CAMCON executive package. Furthermore, unless obvious alternatives exist, for default input data files, the $name.ext$ segment should typically be one of the following:

CAMDAT.CDB

PROPERTY.SDB

Codename.INP

Codename.TRN $\alpha\alpha\alpha$

and for default output data files, the $name.ext$ segment should typically be one of the following:

codename.CDB

codename.OUT

codename.TRN $\alpha\alpha\alpha$
codename.DBG

For some applications, the debug (.DBG) and output (.OUT) files are combined (.DBG or .OUT).

The other three segments (*Sxxxx_t_Rxxx.*) are used and generated by the CAMCONexec program, DRIVERS, when running inside the CAMCON executive package. Even here, the DCL procedures must allow the user to override the default names.

4.2.3 Entering File Names

Reading File Names on Command Line. As a option, read all names of files used by the code at the same time the code is executed ("command line read") (use FILDFNAM and FILRDNAMS in CAMCON_LIB). Dimension file names to at least 132 characters.

File Names not Supplied on Command Line. If running the program from the VMS prompt, read file names interactively if file names are not supplied on the command line. Often this is the only interactive input, although some programs allow the user to interactively enter the commands found in the user input file.

Read file names in the following standard order, if applicable:

- Required computational data base (CDB) files (input or output)
- Required secondary data base files (SDB) files (input or output)
- Required ASCII input files (INP)
- Required output file (OUT,TRN)
- Optional ASCII input files (INP)
- Optional output files (OUT,TRN,DBG)

A file name of CANCEL should specify that the file is not needed, and DEFAULT should force the use of the default file name. All of these capabilities are built into the CAMCON_LIB routines FILDFNAM and FILRDNAMS .

4.2.4 Example of File Reading

The following code segment calls several CAMCON_LIB routines to define and read files and to set up a diagnostic file (.DBG). The example as written will read file names from the command line and, if the program is being run from the VMS prompt, will interactively request files not specified on the command line or not found in the default or specified directory.

```

C      -   Define three files for FILRDNAMS
      CALL FILDFNAM ('CAMDAT data base', 'in', 'req', 'CAMDAT.CDB')
      CALL FILDFNAM ('output CAMDAT data base', 'out', 'req', &
        'CAMDAT.CDB')
      CALL FILDFNAM ('diagnostics file', 'out', 'opt', 'TEST.DBG')

C      -   Read in the names of the three files defined above
      CALL FILRDNAMS (FILESP, IERR)
C      -   If the file names could not be read, write the file assignments
C      -   and abort
      IF (IERR .NE. 0) THEN
        CALL WRFILN (0, FILESP)
        CALL QAABORT ('Incorrect file assignments')
      END IF

C      -   If the optional diagnostics file is requested, open the file
      IF (FILESP(3) .NE. ' ') THEN
        NOUT = 6
        CALL FIOPEN (NOUT, 'OUT', 'FORM', FILESP(3), IERR)
      ELSE
        NOUT = 0
      END IF

C      -   Set the unit number of the diagnostics file (may be the terminal)
      IDUM = IQAERRUNI (NOUT)

      IF (NOUT .GT. 0) THEN
C      -   Write the header to the diagnostics file, including the page header,
C      -   the welcome banner, the DOE disclaimer, and the file assignments
        CALL QAPAGE (NOUT, ' ')
        CALL QABANNER (NOUT, ' ', ' ', ' ')
        CALL QADOEDIS (NOUT, '*')
        CALL FILWRNAMS (NOUT, FILESP)
      ENDIF

```

4.3 Parameter Input

Input for most CAMCON codes should occur by reading data either from the secondary or computational data bases or from ASCII text files. Normally, the mathematical model parameters (e.g., permeability [k]) enter via the data bases while numerical model parameters (e.g., solution time step) enter via the input text files. A few codes naturally require interactive input (e.g., plotting codes) and should also interactively accept input data. Guidelines for these forms of input are discussed below.

4.3.1 Reading from Data Bases

- Access the data bases through the libraries, CAMDAT_LIB and SDBREAD_LIB, mentioned in Chapter 2, and thoroughly described in Chapters 6 and 7, respectively.
- Use the standard naming conventions for parameters as the default name with the code, but permit the user to override the name. (See the CAMCON user's reference manual [Rechard, 1992])

for a published list of default names or the secondary data base on-line documentation [help file] on the WIPP computer for the most current version.)

4.3.2 Reading from ASCII Input Files

- Although CAMCON codes may be written to run interactively, all should also be able to run using a user-friendly batch input file.
- Use keywords to identify blocks of parameter data.
- Signify the keyword by an asterisk (*) for the first level and, in the rare instance required, by two asterisks (**) for the zeroth level; for example

```
**keyword  
*keyword  
parameter1=1, parameter2=2
```

- Use parameter names that identify meanings of input values to make input easy to proofread.
- Program the code such that the keywords and parameters within the keyword data blocks can be entered in any order, making the data input file easy for the analyst to organize and understand.
- Omit the keywords if the screen instructions help organize parameter input when the codes are run interactively.
- Check input for plausibility and validity, checking that the values do not violate physical limits or code algorithm limits.
- Identify bad input and abort gracefully.
- Use the parsing routines FFRDFLDS and FFRDLIN in CAMCON_LIB to read a file record and thus permit a versatile input structure. (In these routines, lowercase always returns as uppercase unless enclosed by quotation marks or apostrophes. Furthermore, variables can be either numeric or alphanumeric; see Section 8.2.3, "Free-Field Input.")
- Assume that any ASCII character (not just ANSI standard FORTRAN) may appear in a character string.

The general instructions given to users for constructing input files are listed below and pointed out in the example on the facing page (Rechard, 1992). The reference numbers in the example correspond with the numbers from the list below (more specific details on the parsing routines are given in Chapter 8):

1. Precede the keyword identifying a data block with an asterisk (*).
2. Place keywords and their parameters anywhere in an 80-column record. (All 80 columns are scanned.) FFRDFLDS allows more than 80 characters; however, 80 is a convenient length for screen display.
3. Use an exclamation point (!) in any column to signal that a comment follows for the remainder of the record.
4. Delimit parameters with commas (,) or spaces.

5. Separate a parameter from its value(s) with an equal sign.
6. Limit numerical data to 30 characters (E30.0).
7. Continue text onto the next record by using an ampersand (&) at the end of the record to be continued.
8. Enclose character variables containing an ampersand (&), exclamation point (!), delimiter characters (commas or equal signs or spaces—leading, embedded, or trailing), or those variables that are not to be converted to upper case, with an apostrophe (') or quotation marks (").
9. Use quotation marks to embed apostrophes and apostrophes to embed quotation marks within character variables.
10. Except for character variables enclosed with apostrophes or quotation marks, case is unimportant for making comparisons within a code.
11. A field cannot be continued. Break records between fields, preferable before a parameter rather than between a parameter and its value(s).

```

=====
!
! TITLE:      Sample Input for PREBOAST
! ANALYST:    R.P. Rechard, SNL
! DATE:       July 10, 1991
!=====
1
!
! *HEADING
!   TITLE2 = BOAST II CALCULATION:  WIPP GAS PRODUCTION
!
2
! *GEOMETRY
!   COORD = CYLINDRICAL
!
! *BOUNDARY
! Pressure Boundary Conditions are Obtained from CAMDAT File
! ELEMENT SIDE SET DATA
!   PRESS, ID_PRESS = 1
!
! *PROPERTIES
!
! Define Fluid (Oil, Water, and Gas) Properties
! All Element Blocks have the Same Fluid Properties
! OIL = BRINE, WATER = BRINE, GAS = GAS (2 Phases)
!   FLUID, MAT=ALL, NOILP=10, NWATP=10, NGASP=8
!   FLUID, MAT=all, DEN_OIL = 1200.00, DEN_WAT = 1200., &
!   FLUID, MAT=ALL, DEN_GAS = 0.08099425 ! @ 303.15 K
!   FLUID, MAT=ALL, BUB_PT  = 0.0, BUB_DEPTH=0.0, BUB_GRAD=0.0
!   FLUID, MAT=ALL, VSLOPE  = 0.0, BSLOPE = 0.0, RSLOPE= 0.0, &
!   PMAS   = 5.0E7, IREPRES = 0
!
! *END
!=====

```

Diagram illustrating the input format for a sample input file, with numbered annotations (1-10) pointing to specific lines or fields:

- 1: Points to the first blank line after the header.
- 2: Points to the *GEOMETRY section.
- 3: Points to the *PROPERTIES section.
- 4: Points to the ID_PRESS = 1 line.
- 5: Points to the *PROPERTIES section.
- 6: Points to the DEN_OIL = 1200.00 line.
- 7: Points to the DEN_GAS = 0.08099425 line.
- 8: Points to the BUB_PT = 0.0 line.
- 9: Points to the VSLOPE = 0.0 line.
- 10: Points to the PMAS = 5.0E7 line.

TRI-6342-1457-1

4.3.3 Reading Interactively

All the guidelines mentioned when reading from an input file are even more important when interactively reading data. For example, check the reasonableness of input and gracefully request the information again if errors are found rather than abruptly aborting with a terse read error message. Also, the FFRDFLDS and FFRDLIN subroutines of CAMCON_LIB work equally well interactively as parsers.

4.4 Code Operation

Make a code reasonably bomb-proof. Thus, things that are likely to cause errors (e.g., user input) should be checked. If a program aborts, it should do so gracefully with an informative error message for the user.

4.5 Error Messages

When writing error messages, distinguish between errors caused by traps deep in the program intended to avoid meaningless calculations and those caused by erroneous user input data. The error message for a program trap should tell the user to call the code sponsor with any relevant information (such as the subroutine name), while the error message for a user input error should tell the user what the problem is as clearly as possible and not include irrelevant information such as the subroutine name.

4.6 On-Line Documentation

4.6.1 QA Requirements for On-line Documentation

A software help file is required on-line documentation that must be developed and maintained for each piece of Class C and A software (e.g., FORTRAN library or code) used for assessing the performance of WIPP. Although a part of the external documentation discussed in Section 4.7, it is discussed separately because of the necessity for detail.

The help file shall contain the following (only the adequacy of the QA information will be formally evaluated by the QA coordinator for Class C software):

- All QA information necessary to complete the software abstract, i.e., a brief description of the purpose and capabilities of the software, the name(s) of the author(s), and the name of the code sponsor
- Update history of the software, including date, PA software ID, and description of modification
- Instructions for executing the software and necessary input and output files

4.6.2 General Help File Contents

The general information available in a help file includes entry-level text (describing the title, purpose, authors, sponsor, company, and phone number), QA information, update history, and instructions for executing the code. Optional but desirable additions for codes include summary of input commands, data input from CAMDAT, and an example of an input file (refer also to ABSGEN and HLPCHK in Chapter 12):

TRI-6334-218-0

*The primary contact for a code is the sponsor and so this later information can be omitted if desired.

Similarly, the help file for libraries includes entry level text, update history, QA information, and information on linking the library. Optional but desirable additions for libraries include a short description of routines available and examples of use:

TRI-6334-218-1

As mentioned earlier, some of the information found in the help file is used to create the software abstract, which is additional documentation required for all Performance Assessment software. The code ABSGEN (described in Chapter 12), which generates the Software Abstract, also expect several specific headings under each level identifier; these headings are listed in the following subsections.

Following is an input structure of the on-line documentation (help file on the VAX). Entries marked optional are not required by the software QA procedures but are still recommended.

4.6.3 Help File Structure

The rules for entering text in help files provide a uniform look and facilitate generating software abstracts. These rules are listed below. The rule numbers correspond with the numbers on the example that follows the list. (Additional information is available in DEC documents [1988a] and in the descriptions of ABSGEN and HLPCHK in Chapter 12.)

1. Start all level numbers in column 1.
2. Start all level identifiers in column 3.
3. Start all headings in column 3.
4. Start all subheadings in column 6 and subsubheadings in column 9.
5. Use as many characters as necessary for identifiers and headings, but follow headings with a colon (:) and at least one white space (space, tab, new line).
6. Text for an identifier can be any number of lines with any number of characters per line, but delimit the text with a blank line.

Example:

4.6.4 Entry-Level Text

The entry-level text in the help file describes the code name, title, purpose, code authors, CAMCON sponsor, and sponsor's and consultant's company and telephone number. The help file is designed so that the user immediately views level 1 information (title, purpose, authors, sponsor, company, and phone number) on the WIPP computer, and then can call up level 2 information (QA information, update history, execution instructions, summary of input commands, and an example input file) followed by other levels if necessary. Most of the level 1 and level 2 text is required by the QA procedures and by the software abstract (see PAP02, 1993).

Required Headings Under CODE_NAME Identifier:

1 CODE NAME

Title:

Purpose:

Authors:

Sponsor Name: (include SNL organization or company and phone number)

Consultant: (may be the same as Sponsor Name, and company and phone number can be omitted)

4.6.5 Update History Subtopic

The update history fields list the current version, date, language, and number of source lines. When modifications are made, the date, version number, and brief description of modifications are stored here (required text).

Required Headings Under UPDATE_HISTORY Identifier:

2 UPDATE_HISTORY

Version:

Language:

Date:

Example:

2 UPDATE_HISTORY

Version: A-6.02VV
Computer: VAX/VMS 8810
Date: 07/02/92

Language: FORTRAN 77
Total Lines: 8488
Active Lines: 4496
Percent Comments: 47%

07/02/92 A-6.02VV Improved routine GSEPEB.
Added a check so that material regions are not
overwritten by IJK-line defined element ranges.
Does not affect version 6.01VV because this is
an I/O specific change.

04/03/92 A-6.01VV Added GENMAP routine which transforms
GENMESH's FD element numbers to CAMDAT element
numbers. No need to drop back to C-level
because the MAP(*) array, which performs the
transformation, was never used. This
modification is transparent to program flow
and logic. This change (rewriting the MAP(*)
array is output-specific and will be
integrated for use with other programs such as
BLOT, ALGEBRA, etc...

01/27/92 A-6.00VV A-level.

01/27/92 C-6.00VV Adapted to CAMDAT_LIB routines. Adapted for
1-D mesh/grids. Cosmetic changes made to HELP

		file wrt program description and capabilities as suggested by Code Review Committee Chairperson; this making the code A-level. Next the review form was completed, and the software abstract was also generated. Both of these documents were then sent to WIPP software librarian. Added DATA OUTPUT section to HELP file. Changed attribute name "DEPTH" to "ELEVAT".
09/26/91	C-5.12VV	Ready for A-level code.
09/17/91	C-5.11VV	Added more diagnostics.
04/01/91	C-5.10VV	Added more input error checking in various routines.

4.6.6 QA Information Subtopic

The QA information fields list data that are used to complete the software abstract. The data include QA level, limitations, keywords, origin, parent program, classification, verification method, and documentation.

Required Headings Under QA_INFO Identifier:

2 QA_INFO

QA_Level: (See UPDATE_HISTORY)

Limitations:

Keywords:

Origin:

Parent Program:

Classification:

Description: (e.g., Government owned, limited distribution)

Type: (e.g., Scientific/engineering software (SES) or non-SES)

Category: (e.g., Sandia internal software or external software)

CAMCON Module: (e.g., Mesh Generation)

Verification: (required)

Hand Calculation

In_Use Test

Comparison with Analytic Solution

Benchmarking

Use in Sensitivity Analysis

Convergence Tests

Other

At least one of these seven entries is required (see Section 3.7, "Verification," for definitions).

Documentation:

(required)

User's Reference

(optional)

Theoretical Reference

(optional)

Verification/Sample Problems Reference

(optional)

Other Reference

(optional)

Primary Reference:

(required)

Example:

2 QA_INFO

QA_Level: See UPDATE_HISTORY

Limitations: GENMESH is a Rectilinear 2D/3D FE/FD mesh/grid generator compatible with the WIPP CAMCON Computational Data base, CAMDAT. In addition to establishing the mesh connectivity, the program generates nodal point coordinates, material region information, Element Side Set and/or Nodal Point Set boundary condition data. In addition, GENMESH automatically inserts the two attribute values, THICK, and DEPTH, into the output CAMDAT file.

Keywords: Finite difference, Finite element, Grid generator, Mesh generator, Rectilinear, Performance Assessment, Waste Isolation Pilot Plant

Origin: Sandia National Laboratories,
Performance Assessment Department 6342,
Albuquerque, NM 87185-5800

Parent Program(s): None
Parent Reference(s): None

Include all name(s) and reference(s), if applicable.

Classification:

Description: Government owned, limited distribution.
Type: non-SES
Category: Sandia internal software
CAMCON Module: Mesh Generation

Verification: Hand Calculation
In_Use Test

Documentation:

User's Reference:

Rechard, R. P., ed. 1992. User's Manual for CAMCON:
Compliance Assessment Methodology Controller, Version 3.0.
SAND90-1983. Albuquerque, NM: Sandia National Laboratories.

Verification/Sample Problems Reference:

Computer: VAX/VMS 8810 Node: Jimmy
Directory: CAMCON\$ROOT:[GENMESH.A_LEVEL.TEST]
Input Files: GENMESH_TEST_ID.INP, GENMESH_TEST_2D.INP,
GENMESH_TEST_3D.INP, GENMESH_TEST_4.INP,
GENMESH_TEST_5.INP, GENMESH_TEST_6.INP

Theoretical Reference: None

Other Reference: None

Primary Reference:

Rechard, R. P., ed. 1992. User's Manual for CAMCON:
Compliance Assessment Methodology Controller, Version 3.0.
SAND90-1983. Albuquerque, NM: Sandia National Laboratories.

4.6.7 Execution Subtopic

The execution fields list the computer symbol for executing the code (e.g., ALGEBRA), and external files needed for execution, listed in order as requested by the code (computational data base files, secondary data base files, input text files, output files, optional input files, optional output files [see Section 4.2.3, "Entering File Names"]).

Example:

2 EXECUTION

Type "GENMesh" at the main menu of CAMCONexec or at a system prompt. Subsequent questions in the procedure file request names for up to three files:

- o Optional input control card data file #1
(Two possibilities for entering data, one of which requires a file):
 - 1a. Interactive (will generate a GENMESH input control card data file)
 - or
 - 1b. Text file created independently or from previous interactive session <GENMESH.INP>
- o Required output PRECAMDAT file
 - 2. Name for binary PRECAMDAT file <PRECAMDAT.CDB>
- o Optional output files
 - 3. Name for diagnostic output file <GENMESH.DBG>

4.6.8 Commands Subtopic

The commands fields summarize the commands and the corresponding parameters used in the input file.

Example:

2 COMMANDS

Contents of GENMESH Input File. The GENMESH text file consists of eight keywords: (1) BOUNDARY_FLAGS, (2) ELEVATION_ELEMENT, (3) END, (4) GRID_SPACING, (5) REGIONS, (6) SETUP_GRID, (7) TITLE, and (8) UNITS

3 BOUNDARY_FLAGS

*BOUNDary_flags

The *BOUNDARY_FLAGS keyword sets boundary flags in the grid. Boundary conditions values are set in the program BCSET or in the pertinent analysis program. Two types of boundary conditions are available.

4 ELEMENT_SIDE_SETS

ELEMENT_side=side_id, IRANGE=imin,imax,JRANGE=jmin,jmax,KRANGE=kmin,kmax

1. side_id - integer identification for element side
2. nmin - minimum grid index in finite-difference grid
3. nmax - maximum grid index in finite-difference grid

The ELEMENT_SIDE boundary flag identifies a group of elements (or grid cells) with a unique ID. This feature is useful for surface boundary conditions for finite elements (e.g. fluid flux). Furthermore, the "nodes" of grid-centered finite-difference codes correspond to finite elements; hence, this type of boundary condition is used with SWIFT II.

4.6.9 Data Subtopic

The data subtopic tabulates the data and its type normally passed from/to the program to/from CAMDAT.

Example:

2 DATA_OUTPUT

GENMESH generates a virgin CAMDAT file, which contains:

3 NODAL_COORDINATES

Nodal coordinate data, stored for a node as:

- (x) - 1-D mesh (NDIM=1),
- (x,y) - 2-D mesh (NDIM=2), and
- (x,y,z) - 3-D mesh (NDIM=3).

For any 1-, 2-, or 3-dimensional rectilinear grid, nodes are numbered first in order of increasing X (I-index), then Y (J-index), and then Z (K-index).

Thus for a 2-D grid that has 5 I-lines and 3 J-lines (the 2-D mesh has 15 nodes and 8 elements), the GENMESH node numbering convention is:

3 SUMMARY

Data GENMESH Transfers to CAMDAT

Data Name	Default Symbol	Data Type
-----	-----	-----
Nodal Coordinates		
X-coordinates	X	Coordinate
Y-coordinates	Y	Coordinate
Z-coordinates	Z	Coordinate
Material Regioning	n./a.	Materials
Element Connectivity	n./a.	Nodes
Element Attributes		
Element thickness	THICK	Attribute
Element centroid elevation	ELEVAT	Attribute
Element X-direction length	DEL_X	Attribute
Element Y-direction length	DEL_X	Attribute
Element Z-direction length	DEL_Z	Attribute
Geometric Boundary Flags		
Nodal point sets	<no default>	Node set
Element side sets	<no default>	Side set

4.6.10 Example Subtopic

The example fields demonstrate the use of all or a subset of the commands summarized in the commands subtopic.

Example:

2 EXAMPLE

The following is an example input file for GENMESH:

```
!=====
!  
! TITLE:      Sample input for GENMESH  
! ANALYST:    R. P. Rechar, SNL  
! DATE:       March 1992  
!  
!=====
!  
*SETUP  
  DIM= 3  
  ORIGIN= 0., 0., 0.  
  IJKMAX= 4, 4, 2  
!  
*GRID  
  FIB, COORD=X, DEL=1., INRANGE=1,4  
  DEL, COORD=Y, DEL=1., INRANGE=1,2  
  DEL, COORD=Y, DEL=2., INRANGE=2,3  
  DEL, COORD=Y, DEL=3., INRANGE=3,4  
  DIV, COORD=Z, INRANGE=1,2, CRANGE=0.,1., FACTOR=1.  
!  
*ELEVATION  
  LOCAT, THICK=2; ELEVAT=2; IRANGE=1,1, JRANGE=1,1, KRANGE=1,1  
  LOCAT, THICK=4; ELEVAT=3; IRANGE=4,4, JRANGE=4,4, KRANGE=2,2  
  
*REG  
  REG=1, IRANGE=1,3, JRANGE=1,3, KRANGE=1,2  
  REG=2, IRANGE=3,4, JRANGE=1,3, KRANGE=1,2  
  REG=3, IRANGE=1,3, JRANGE=3,4, KRANGE=1,2  
!  
*BOUND  
  NODE=1, IRANGE=1,1, KRANGE=1,4  
  NODE=2, IRANGE=4,4, KRANGE=1,4  
  NODE=3, IRANGE=1,4, KRANGE=1,1  
  NODE=4, IRANGE=1,4, KRANGE=4,4  
  
*END  
!=====
```

4.7 External Documentation

Before software can attain Class A or C status, the software must satisfy several requirements for external documentation as described below.

4.7.1 Software Notebooks

The software notebook is a collection of the information available on each piece of software in the CAMCON system that can be used by programmers, analysts, and QA personnel.

TRI-6342-2138-0

¹ The abstract can be printed using ABSGEN (see Chapter 12).

² The help, CAMCONexex, and source sections can be printed using QA_PREP and QA_PRINT (see Chapter 12).

Some pieces of software may be too large to practically reproduce as hardcopy, or there may be proprietary restrictions on reproducing source code, etc. In these cases, a note in the appropriate section of the notebook should simply state why the information has been omitted and, if possible, where to find the information.

Responsibilities. The software sponsor of each piece of software (e.g., code, library, or DCL package) is responsible for providing all the information for the notebooks. The sponsor should use QA_PRINT (see Chapter 12) to help in producing uniform, consistent printouts for the abstract, help file, CAMCONexec procedural file, and source headings of the software notebook.

The QA coordinator or designated appointee helps the sponsor assemble and produce the notebooks to maintain some semblance of uniformity. The QA coordinator is also responsible for filing the notebooks with the Sandia WIPP Central Files (SWCF) records manager.

Updates. Each software notebook is usually updated sometime prior to periodic announced audits and whenever the sponsor or QA coordinator thinks the information has become so outdated as to be misleading or useless; it does not always provide the most current information. Rather, the on-line documentation is the most current document detailing the purpose, update history, QA information, execution, example problem, and data input to and output from data bases.

4.7.2 Software Abstract and Listings

Software Abstract. All Class C and A software will have a software abstract in the software notebook. Current abstracts must be produced (1) when major version numbers change and (2) when QA information in the on-line documentation (help file) changes, especially when the QA status changes. (See Chapter 12 for a discussion of ABSGEN, a program to generate this abstract from on-line documentation, or see QA_PREP and QA_PRINT below.) All software abstracts must be signed by the QA coordinator and be submitted to the SWCF.

Utilities. Two utilities exist to assist the FORTRAN code developer in satisfying QA requirements: QA_PREP and QA_PRINT. Both codes are defined as CAMCON system symbols and are available to all users of the WIPP computer. Their use is summarized below and fully described in Chapter 12, "Software Development Utilities."

QA_PREP searches a specified directory and produces a file named ROUTINES.TXT. This file contains a listing of all *.FOR and *.INC files and identifies the main FORTRAN module.

QA_PRINT uses the file ROUTINES.TXT produced by QA_PREP to run FLINT (the CAMCON implementation of the VMS-FORTRAN code analyzer), print the FLINT output, print the source code, print the CAMCONexec procedural file, and print the on-line documentation.

4.7.3 Records

Two sets of records are maintained for software: *verification records* and *change records*.

Verification Records. For Class C software, at least one test case (e.g., example problem) demonstrating that important capabilities of the software are correctly implemented must be in the help file. Other test cases including necessary input files (*.INP or *.TRN), secondary data base files (*.SDB), computational data base files (*.CD3), and result files (*.OUT, *.DBG, *.TRN, or *.CDB) should be stored in the [code_name.TEST] subdirectory as thought appropriate by the software sponsor. A printout of the help file and [code_name.TEST] subdirectory contents, signed by the sponsor, should be included in the software notebook (see also "Verification," Section 3.7).

In addition to the documentation for Class C verification, Class A software verification must include a summary statement of the (1) purpose, (2) types of the tests performed, and (3) results of the tests including any applicable performance criteria and all signed and dated by the sponsor. All this additional documentation must also be stored in the software notebook.

Change Records. An important aspect of improving the quality of software is the identification and correction of errors, inaccuracies, limitations, and enhancements of software capabilities. A software user should report all desired software enhancements and corrections to the software sponsor for approval (see also Section 3.5, "Modifying Software in the CAMCON System"). Corrections for Class A software shall be submitted by means of a formal report form, the Change Request and Response Form (ask the SWCF records manager for form PA003, current version). In this case, the software sponsor must submit a formal reply about intended action in response to the reported software problem. The form must be filed in the software notebook.

4.8 Formal Reports

All Class A software will have formal reports. The reports describe what the software does (i.e., its purpose) and how to use the software (user's manual). All Class A software categorized as science and engineering software (SES) will also provide a theory manual that describes how the software achieves its purpose, e.g., the theory and assumptions used in the software such as algorithms and numerical solution techniques.

Additional documentation, such as tutorials, sample problems, or programmer's manuals, is encouraged but not required.

The formal reports must be reviewed by the formal peer review and management review process described in Procedure PAP05, "Report Review Quality Assurance Procedures" (1993). If desired, the user's manual, verification records, and theory manual (if necessary) can be combined in one document. Verification and change records can also be included in this document. (Verification documentation is discussed in Section 4.7 and change records are discussed in Section 4.7.3.)

User's Manual. The user's manual shall be sufficient to (1) enable a user with an adequate modeling and proper technical background to set up and run the program and (2) help the user resolve possible difficulties. The user's manual may be combined and published with other CAMCON system codes (e.g., Rechard, 1992). As a minimum, the user's manual will describe

- Input (e.g., variables, units, format, default values)
- Output (e.g., meaning of headers and appropriate units)
- One sample problem

Theory Manual. For Class A SES software, the theory manual will describe, as a minimum, the

- Class of equations solved and the corresponding assumptions and limitations
- Numerical solution techniques and related stability and accuracy with references
- Relationship between numerical and mathematical strategies (e.g., how boundary conditions are introduced)

5. General Programming Guidelines

The primary goals of this chapter and the remaining chapters of this manual are to (1) ensure that the software developed for the CAMCON system does what is intended (reliability), (2) increase software readability and make future software modifications (i.e., enhancement and error correction) easier (reusability), and (3) streamline code development. These goals are primarily accomplished by providing code developers with style and development guidelines, discussed here, and development tools, which are discussed in the following chapters.

The high cost of software development and the higher cost of software maintenance and enhancement make these important goals. We attempted to meet these goals by providing practical pointers to increase the chances that the software will be useful, i.e., do what it was intended to do and decrease the chances that the programmer will waste time. The essence of what is trying to be conveyed is summed up by the elusive word “style”—not a list of rules so much as an approach and an attitude. The guidelines presented herein are essentially good programming practices and are not intended to restrict individual programmers.¹ When these programming practices are broken, some compensating merit should be found in the coding. However, at no point will someone check that a style guideline is followed (unlike the software QA requirements). (Even the examples provided do not follow all the guidelines presented.)

5.1 Software Planning

A critical phase in software development is the initial planning phase. Errors committed during this phase are often ruinous to the timely completion of the code, and have a much greater impact on the project than errors committed during code generation.

Although plans can go astray, plans certainly increase the chances of “success,” i.e., the software doing what it is supposed to do by solving the correct problem and solving this problem correctly. With the maturing of the programming occupation, great focus has been placed on software development as a project within the usual life cycle of a project and the need for planning, in particular. Rather than paraphrase the insightful suggestions made in numerous texts and articles, the following discussion briefly mentions a few pointers pertinent to software development for the CAMCON system.

The planning for the CAMCON system as a whole can involve a group effort in defining goals. However, (1) because the CAMCON system is modularized and (2) because of the flexibility in interfacing codes in CAMCON, most software development projects can normally be planned and carried out by one

1. At the inception of the CAMCON project, these guidelines were informally presented in individual sessions with each programmer.

person. What follows are suggestions not for the CAMCON system as a whole but for the individual codes. The scope of planning on this scale is generally similar to writing a report (Weiss, 1982, p. 16).

For the individual codes, good planning usually consists of the following:

1. Verify the need to program. Can the objective be reached by acquiring or purchasing already existing software? Is the objective too specialized or so ill-defined that it should be done by hand until the procedure is better defined or the needs are more general?
2. Define the subject and QA participants. Name the project and decide whether the code type is SES or non-SES. Who are the software sponsor and consultants?
3. Define the purpose. What are your primary specifications? What must be met before the customer considers the code a success? If possible, define the appropriate test cases to be run after completing the programming.
4. Identify strategic problems. What are the barriers to complete success (time, money, specifications)? What can be done to avert these obstacles?
5. Select the approach and scale. Is the code for one-time use, or is it considered a prototype, or must it serve as a solid foundation for future enhancements? Must the code interface with the CAMCON system or can it stand alone? How many developers are required?
6. Prepare a simple plan and estimate the production schedule.
 - Define solution techniques. (The development of engineering software and the research into numerical algorithms which accompanies such development often precludes a detailed description of the techniques to be implemented in a code.)
 - Plan program input, and presentation of results.
 - Identify capabilities that may be included in a future version of the code.
 - Plan the data storage, allocation, and management of computer memory.
 - Divide code into proposed modules.
 - Define interfaces between modules clearly. This includes unambiguous definition of all shared or possibly conflicting parameters, their units, and physical meaning.
7. Approve the plan. Present the plan to the customer (users) for approval.

These planning steps need not be formal. Even something quickly jotted down and informally discussed with the users may be sufficient for many software development tasks. However, this latter statement should not be taken as diminishing the importance of planning, only that the planning effort should be appropriate given the intended scope of the software development task and effort in generating the coding.

5.2 Readability

This and the following sections deal primarily with increasing readability of software by improving programming style such that future modifications (i.e., enhancements and error corrections) are easier. The section generally consists of rules followed by specific coding examples in FORTRAN. As mentioned before, several books describe style issues in detail (e.g., Kernighan and Plauger, 1974). Here, we emphasize only style rules thought particularly important, parts of which were initially reported in Rottler et al. (1986).

QA standards have not been established in the areas of software maintainability (i.e., internal documentation, code structure, and code readability), portability (i.e., choice of language and extensions), and coding style because of the diverse needs of software used in performance assessment. The WIPP software is not aimed at general situations but instead is developed to solve specific problems requested or needed by DOE customers.

Nonetheless, in general, about 70% of software life cycle costs can be attributed to code maintenance, including code enhancements (40%), bug fixes (15%), and installation with new hardware/software (15%) (Osborne, 1988). Consequently, these coding *guidelines* and the software libraries described in the subsequent chapters attempt to address the software properties and features mentioned above. The following guidelines are demonstrated in the complete subroutine example in Section 5.2.5.

5.2.1 General

The subroutine fragment on the next page points out some of the general guidelines for readability that are listed below:

- To increase general readability within the PA department, use the FORTRAN 77 language. An acceptable alternative is the ANSI C language when the improved capability of this language to interface with the operating system warrants.
- Make a routine read from top to bottom. Branch upward within a routine only to implement a loop.
- Avoid tricky or overly complex code in favor of simple, maintainable code. Do not sacrifice readability for efficiency unless efficiency is a real concern for the code segment in question.
- Do not use the old FORTRAN 66 constructs such as arithmetic IFs, computed GOTOs, and Hollerith data. Remove these constructs from old code when convenient.
- Do not patch or comment bad code; rewrite instead.
- Avoid using standard intrinsic function names in naming user-defined external functions. For example, do not use the function names SQRT, EXP, and LOG when naming an external function.
- Use ANSI upper- and lowercase letters consistently within a subroutine and preferably within a code. The ANSI FORTRAN standard specifies the use of uppercase letters in executable statements. However, complex numerical algorithms may be easier to read when array indices

are lowercase while the matrices are uppercase and may justify an exception. Furthermore, the use of mixed-case letters for COMMENT statements and code output is encouraged to increase readability.

- Use a unique continuation character, such as \$ or &, not one with another syntactic meaning. (The \$ is the only ANSI standard FORTRAN symbol without another syntactic meaning, but an acceptable non-ANSI standard FORTRAN symbol is the &.)
- Number statements always in ascending order within a routine. Make intervals between statement numbers large enough to allow one to insert new labeled statements. The programmer might consider using large numbers (e.g., 10000) for FORMAT and non-executable statements and small numbers for executable statements so that the statement labels convey some meaning. (A FORTRAN format and statement renumbering code, FORMRENUM, is available on the WIPP computer and is described in Chapter 12. Although FORMRENUM functions best on a compilable routine, it can help locate mismatched IF and DO block endings.)

- Place **FORMAT** statements referenced only once in a routine at the point of reference. However, in working with frequently used **FORMAT** statements, the programmer may place them all in one location.
- Indent **DO**-loops and block **IF** constructs.
- End all **DO**-loops with the **CONTINUE** statement, and end nested **DO**-loops on separate labels.
- Avoid the use of the ASCII character code, **CHAR()**, when possible; the character in quotes is much more readable (e.g., ' ' versus **CHAR(32)** for specifying a blank).
- Use spaces between expressions and operation symbols in assignment statements to prevent crowding.

5.2.2 Variable Naming

- Although the **FORTRAN 77** standard for the maximum length of variable names is six characters, it is still necessary to use descriptive names for constants and variables. Consequently, make them longer than six characters and use non-standard characters, such as the underline, if necessary. For portability, consider making the first six characters uniquely identify the variable name.
- Use standard **FORTRAN** naming conventions for real data (A-H, O-Z) and integer data (I-N), but declare all variables.
- Avoid names that are unique by only one character.
- Purely mathematical functions should be defined using familiar notation.
- Names and array sizes should be the same in all occurrences of a named common.
- Only use double precision constants and variables when known to be necessary for numerical accuracy.
- Use variables for input/output unit specifiers, not literals (e.g., **PARAMETER (NOUTPUT=77); CALL IQAERRUNI (NOUTPUT)**).

5.2.3 Declarations

- Declare all variables.
- Declare numerical constants in statements using the **DATA** statement or the **PARAMETER** statement. For example, the expression $0.5 * \text{PI}$ is more suggestive than 1.570796. Other examples include the use of integer variables as array limits and **DO**-loop limits rather than the use of explicit integer constants, when appropriate.
- Be careful about machine precision when using numerical constants. Sometimes it is better to compute numbers to get the proper precision (e.g., $\text{PI} = 4.0\text{D}+00 * \text{ATAN}(1.0\text{D}+00)$).

5.2.4 Modularity

- Keep routine size to one to three pages of output to improve readability. (Ideally, it would be one page, but the comments in the header and the code often make this impractical.)
- Avoid excessive fragmentation (i.e., replacing short segments of code with calls to a routine that performs trivial tasks) unless done to isolate machine-specific coding.
- Link to the CAMCON_LIB, CAMSUPES_LIB, CAMDAT_LIB, and SDBREAD_LIB libraries. Whenever appropriate, use the routines from these libraries.
- Use dynamic memory when appropriate (see CAMSUPES_LIB). Fixed-length arrays may waste memory and put unnecessary constraints on the code.
- Place named COMMON blocks in include files, rather than placing in each subroutine, to facilitate making one change rather than many.
- Carefully organize COMMON block include files so that as few as possible are necessary in any one subroutine to avoid obscuring key information and reducing the readability.

5.2.5 Example

```

SUBROUTINE GAUSSJ( A,          NRANK, NRWDIM, B,          MRHSV,
                  $          MCLDIM, INDXC,  INDXR,  IPIV )
C*****
C
C PURPOSE:          Linear equation solution by Gauss-Jordan elimination.
C                   A is an input matrix of NRANK by NRANK elements, stored
C                   in an array of physical dimensions NRWDIM by NRWDIM.
C                   B is an input matrix of NRANK by MRHSV containing the
C                   MRHSV right-hand side vectors, stored in an array of
C                   physical dimensions NRWDIM by MCLDIM. On output, A is
C                   replaced by its matrix inverse, and B is replaced by the
C                   corresponding set of solution vectors.
C
C SOURCE:           Press, W.H., Flannery, B.P., Teukolsky, S.A.,
C                   Vetterling W.T., "Numerical Recipes: The Art of
C                   Scientific Computing", Cambridge University Press,
C                   1987.
C
C PROGRAMMER:       Jonathan S. Rath
C
C UPDATED:          24-MAY-1993  -JSR: Renamed variables for clarity.
C                   24-AUG-1992  -JSR: Added INDXC,INDXR,IPIV as arguments
C                   25-JUN-1992  -JSR: Made everything DOUBLE PRECISION
C                   31-OCT-1991  -JSR: First Ed.
C
C CALLED BY:        MRQMIN
C
C CALLS:            QAABORT

```

```
C ARGUMENTS:
C ENTRY/
C -common block
C /FILEUN/ (from FORTRAN statement: INCLUDE 'FILEUN.INC')
C NOUTFL = Device number of diagnostics/debug file
C
C /TOOLS/ (from FORTRAN statement: INCLUDE 'TOOLS.INC')
C DEBUG = LOGICAL variable used for print statements written
C         to debug/diagnostic file (very useful for debugging)
C
C -through subroutine call
C A      = Input linear coefficient matrix (REAL)
C NRANK  = Rank of matrix A (INTEGER)
C NRWDIM = Physical number of rows that array A and vector B
C         are dimensioned (INTEGER)
C B      = Input right-hand-side vector
C MRHSV  = Number of right hand side vectors to be used (INTEGER)
C MCLDIM = Physical number of columns that B is dimensioned (INTEGER)
C IPIV   = Bookkeeping array for pivoting (INTEGER)
C INDXC  = Bookkeeping array for columns (INTEGER)
C INDXR  = Bookkeeping array for rows (INTEGER)
C
C LOCAL/
C
C EXIT/
C -through subroutine call
C A      = Output inverse coefficient matrix (REAL)
C B      = Output solution vector (REAL)
C
C*****
C234567
C    IMPLICIT NONE
C    INCLUDE 'FILEUN.INC'
C    INCLUDE 'TOOLS.INC'
C    INTEGER I, II, ICOL, IROW, J, JJ, K, L,
C $     LL, MCLDIM, MRHSV, NRANK, NRWDIM
C    INTEGER INDXC(NRWDIM), INDXR(NRWDIM), IPIV(NRWDIM)
C    REAL*8 DUM, BIG, PIVINV
C    REAL*8 A(NRWDIM,NRWDIM), B(NRWDIM,MCLDIM)
C
C<><><><><><><><><><>
C...Begin Procedures...
C<><><><><><><><><><>
C
C    ...Zero pivot array
C    DO 10 J=1,NRANK
C        IPIV(J)=0.D0
C10 CONTINUE
C    ...Main loop over the columns to be reduced
C    DO 210 I=1,NRANK
C        BIG=0.D0
```

```

DO 120 J=1,NRANK
  IF (IPIV(J).NE.1) THEN
    DO 110 K=1,NRANK
      IF (IPIV(K).EQ.0) THEN
        IF (DABS(A(J,K)).GE.BIG) THEN
          BIG=DABS(A(J,K))
          IROW=J
          ICOL=K
        ENDIF
      ELSEIF (IPIV(K).GT.1) THEN
        WRITE(NOUTFL,*)' **** Routine (GAUSSJ)
$      'Computed a Singular Matrix ****'
        WRITE(NOUTFL,*)' A matrix:'
        DO 100 II=1,NRANK
          WRITE(NOUTFL,900) (A(II,JJ),JJ=1,NRANK)
100      CONTINUE
        CALL QAABORT(' (GAUSSJ-1) - Singular matrix ****')
      ENDIF
110      CONTINUE
    ENDIF
120    CONTINUE
    IPIV(ICOL)=IPIV(ICOL)+1
C
C    ...We now have the pivot element, so we interchange rows,
C    if needed, to put the pivot element on the diagonal.
C    The columns are not physically interchanged, only
C    relabeled: INDX(I), the column of the I_th pivot
C    element, is the I_th column that is reduced, while
C    INDXR(I) is the row in which that pivot element was
C    originally located. If INDXR(I) .NE. INDXC(I) there
C    is an implied column interchange. With this form of
C    bookkeeping, the solution B's will end up in the correct
C    order, and the inverse matrix will be scrambled by
C    columns.
C
    IF (IROW.NE.ICOL) THEN
      DO 130 L=1,NRANK
        TEMP=A(IROW,L)
        A(IROW,L)=A(ICOL,L)
        A(ICOL,L)=TEMP
130      CONTINUE
      DO 140 L=1,MRHSV
        TEMP=B(IROW,L)
        B(IROW,L)=B(ICOL,L)
        B(ICOL,L)=TEMP
140      CONTINUE
    ENDIF
C
C    ...We are now ready to divide the pivot row by the
C    pivot element, located at IROW and ICOL
C

```



```

INDXR(I)=IROW
  INDXC(I)=ICOL
  IF (A(ICOL,ICOL).EQ.0.) THEN
    WRITE(NOUTFL,*)
    $   ' **** Routine (GAUSSJ) Computed a Singular Matrix **** '
    WRITE(NOUTFL,*) ' A matrix: '
    DO 150 II=1,NRANK
      WRITE(NOUTFL,900) (A(II,JJ),JJ=1,NRANK)
150    CONTINUE
    CALL QAABORT('(GAUSSJ-2) - Singular matrix ****')
  ENDIF
  PIVINV=1./(A(ICOL,ICOL))
  A(ICOL,ICOL)=1.D0
  DO 160 L=1,NRANK
    A(ICOL,L)=A(ICOL,L)*PIVINV
160  CONTINUE
  DO 170 L=1,MRHSV
    B(ICOL,L)=B(ICOL,L)*PIVINV
170  CONTINUE
C
C    ...Next we reduce the rows...
C    except for the pivot one, of course
C
    DO 200 LL=1,NRANK
      IF (LL.NE.ICOL) THEN
        TEMP=A(LL,ICOL)
        A(LL,ICOL)=0.D0
        DO 180 L=1,NRANK
          A(LL,L)=A(LL,L)-A(ICOL,L)*TEMP
180        CONTINUE
        DO 190 L=1,MRHSV
          B(LL,L)=B(LL,L)-B(ICOL,L)*TEMP
190        CONTINUE
      ENDIF
    CONTINUE
200  CONTINUE
210 CONTINUE
C
C    ...This is the end of the main loop over columns of the
C    reduction. It only remains to unscramble the solution
C    in view of the column interchanges. We do this by
C    interchanging pairs of columns in the reverse order
C    that the permutation was built up.
C
    DO 230 L=NRANK,1,-1
      IF (INDXR(L).NE.INDXC(L)) THEN
        DO 220 K=1,NRANK
          DUM=A(K,INDXR(L))
          A(K,INDXR(L))=A(K,INDXC(L))
          A(K,INDXC(L))=DUM
220        CONTINUE
      ENDIF
    CONTINUE
230 CONTINUE

```

```

C
C      ...Write out inverse matrix
      IF (DEBUG) THEN
        WRITE(NOUTFL,*)' '
        WRITE(NOUTFL,*)' in GAUSSJ routine:'
        WRITE(NOUTFL,'(A)')' [A**-1]'
        DO 240 I=1,NRANK
          WRITE(NOUTFL,'(1X,<NRANK>(E11.4,1X))')(A(I,J),J=1,NRANK)
240    CONTINUE
      ENDIF
      RETURN
C
C----- F O R M A T   S T A T E M E N T S -----
C
900  FORMAT(1X,6(1PE11.3,1X))
C
C-----
C**** END OF SUBROUTINE GAUSSJ ****
C-----
      END

```

5.3 Portability of Codes

- All FORTRAN code should be ANSI standard FORTRAN 77 unless nonstandard code is clearly desirable for readability.
- Use intrinsic library functions but reference by their generic names rather than their specific names. For example, use the generic name LOG in place of the specific name ALOG, DLOG, or CLOG, and the generic name SQRT in place of the specific name DSQRT or CSQRT. A table of generic function names and the corresponding specific names can be found in most FORTRAN manuals.
- Avoid character strings longer than 132 characters. Some compilers cannot process longer strings.

5.3.1 Machine-Dependent Coding

- All non-ANSI or processor-dependent coding should be clearly identified, either in the main program if generally applicable or in the header for a specific routine, and isolated in low-level routines if possible.
- Use the subroutines in the CAMCON_LIB and CAMSUPES_LIB libraries to perform common machine-specific functions (such as OPEN options, CPU time, time and date).
- Some computers (e.g. VAX) abort a program if an array in FORTRAN is dimensioned to zero elements. To prevent this problem, dimension an ARRAY(N) as ARRAY(MAX(N,1)).
- On the VAX, the CAMCON system version of the code should be compiled with the /NODEBUG /OPTIMIZE options and linked with the /NODEBUG/TRACE options.

5.4 Robustness

- Software robustness: Coding that is less sensitive to misuse or error is an important consideration. Furthermore, the specific use of complex coding should be well documented. However, for calculation of complex, physical phenomena, nonlinear behavior must often be included and is a characteristic that can raise havoc when a programmer is trying to build a robust code. Consequently, a code that is not robust may fail to produce a solution for some parameters, but this lack of robustness is not a WIPP QA issue, provided the analyst is aware that he or she has not solved the problem for these conditions.
- Compare real variables using a tolerance test, not an equals (.EQ.) test unless testing for true zero or comparing integer values.
- Use vectorizable algorithms when possible.
- Initialize all variables with executable statements before use. Some machines do not zero memory prior to execution.
- Code numerical algorithms independently of physical units when possible.
- To prevent the program from aborting or printing meaningless error messages when printing a number that is too large for the FORMAT statement, include the "IOSTAT=IDUM" field in the WRITE statement.

5.5 Efficiency

- Keep coding simple to make it faster.
- Ensure that coding is correct and clear before trying to improve efficiency.
- Measure where code spends time before making decisions on efficiency.
- Search for a faster algorithm (or whole code), rather than tweaking code. The latter usually only makes it marginally faster while the former can make it orders-of-magnitude faster.

5.6 Internal Documentation

As has been stated, (e.g., Kernighan and Plauger, 1974, p. 117), the best internal documentation of a code is clear programming structure which follows the rules of the proceeding sections since the most reliable documentation of a program is the code itself. (Internal comments and external descriptions may differ from the code or be wrong, and thus be useless.) The following sections discuss first the minimum QA requirements, then examples and formats of enlightening comments embedded into the code and finally, the usual extensive descriptions added to the main program and subroutines to help future programmers more readily become familiar with the structure of a complex code. Internal comments can easily get out-of-date if a code undergoes continual revisions and require a personal commitment to keep the information accurate and up-to-date.

5.6.1 Minimum Internal Documentation

As a minimum, all software developed at Sandia and classified as Class A or C will have internal documentation in the main program as listed below. (This information will be added to external software for Classes C and A if the source code is available.)

- Software name and version identifier
- Brief description of software (similar to description on software abstract) indicating purpose, capabilities, and solution method(s)
- Documentation sources
- Name of author(s) and original source of software
- History of modifications, including name of modifier(s), version identifier, date and description of modification
- Government legal disclaimer if Sandia software, or proprietary information, if applicable
- Language and language extensions used
- Machine, operating system, and necessary supporting software, where operative

Much more internal documentation is desirable, and suggestions and guidelines are discussed more thoroughly in the following sections.

5.6.2 Enlightening Comments

- Write using structure, format, and meaningful labels and variable names rather than comment bad coding.
- Make sure comments agree with the code.
- Use extra spaces and good layout of coding on a page to convey meaning rather than relying solely on text comments.
- Only provide enlightening comments. Do not over-comment by highlighting the obvious to decrease the chance for discrepancies with actual coding. Although commenting a program before generating the code is a commendable practice (facilitates composition at the keyboard), make a check afterwards for comments highlighting the obvious.
- Avoid splitting short DO-loops and the block IF construct with comments.

5.6.3 Main Program Headers

Internal documentation at the beginning of the main program must contain the items required in the QA procedures:

- Document software name, version identifier, name of authors, legal disclaimer, etc. (as described in Section 5.6.1, above).

Much more internal descriptive documentation at the beginning of the main program is also desirable.

- Document the meanings and types of variables.
- Document data storage in arrays, if practical.
- Document revisions made and date.
- Consider documenting the hierarchy of the subroutines (the tree structure output from FLINT [Chapter 12] can easily be copied into the code).

This last item is helpful for a programmer trying to modify an existing code, but the information is optional since it can usually be generated by the compiler or a FORTRAN code analyzer.

The following is an example of a header from the code MATSET:

```
C*****
C                                     MATSET
C                                     -----
C
C      MATerial attribute/property names and values SETting program
C
C                                     APRIL 1992
C
C                                     Author
C                                     -----
C
C                                     Jonathan S. Rath
C                                     Applied Mechanics Division
C                                     NEW MEXICO ENGINEERING RESEARCH INSTITUTE
C                                     P.O. Box 25, University Station, University of New Mexico
C                                     Albuquerque, NM 87131, (505) 272-7226
C
C                                     Abstract
C                                     -----
C
C      MATSET sets material names, material property names and values, and
C      attribute names and values in the WIPP Performance Assessment Computational
C      Data Base (CAMDAT file). Material names, material property names, and
C      attribute names are obtained from a user-supplied input text file. In
C      addition, this text file provides the header information displayed on the
C      first record of the CAMDAT file. Both material property values and
C      attribute values are obtained from a Secondary Data Base (SDB). In
C      addition, the input text file can also be used to supply the material
C      property and attribute values, thus overwriting the SDB values.
C
C
```

Primary Reference

1. Rechard, R. P., ed. 1992. "User's Reference Manual for CAMCON: Compliance Assessment Methodology Controller, Version 3.0," SAND90-1983, Albuquerque, NM: Sandia National Laboratories.

Update History

Version	Date	Modifier	Changes
C-8.01VV	16-APR-1992	J.S. Rath	--Modified to suppress GENMESH/GENNET mesh/network attribute names warning statements.
C-8.00VV	14-APR-1992	J.S. Rath	--Adapted for CAMDAT_LIB
C-7.34VV	29-JAN-1992	J.S. Rath	--Corrected mixed-mode CAMDAT file errors wrt new CAMCAT_LIB routines. Handles case where a "GENESIS" CAMDAT is being read (probably created with CAMDAT_LIB)> Eventually CAMDAT_LIB will be implemented in MATSET also.
C-7.33VV	10-OCT-1991	J.S. Rath	--Added more errors wrt .SDBDSCR file.
C-7.32VV	01-OCT-1991	J.S. Rath	--Deleted prompt for PROPERTY.SDBDSCR file.
C-7.31VV	15-AUG-1991	J.S. Rath	--Improved, more efficient, faster version.
C-7.30VV	07-AUG-1991	J.S. Rath	--Adapted for SDBREAD_LIB routines; GENNET network grid.

C-1.00VV 20-OCT-1998 J.S. Rath --First Edition

Disclaimer

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```
C
C                                     Program Modules
C                                     -----
C
C AATTNA:   Assigns ATtribute array NAmes.
C ABCTAB:   Assembles the B.C. interpolation TABle arrays.
C ABLONA:   Assigns BLOck NAmes.
C QAABORT : Stops program execution.
C ACORNA:   Assigns COoRdinate NAmes.
C ADDMEM:   Initializes dynamic arrays, computes memory required.
```

```
C FILWRNAMS:Writes the file names used.
C WRTCAM:   Writes BINARY (and ASCII) format output CAMDAT file(s).
```

```
C                                     Program Flowchart
C                                     -----
C
C      INCLUDE 'FLWCHR.INC'      ! Include file containing flow chart
```

```
C                                     Assumptions and Limitations
C                                     -----
C
C      Language used is ANSI X3.9-1978 FORTRAN 77, except that comments
C      and Hollerith strings use lowercase characters. OPEN statements have
C      been changed to VAX FORTRAN option: READONLY. INTEGER, REAL
C      variable names are explicitly typed. Machine dependent coding exists
C      subroutines: DATE, MEM_MGR, SECOND, TIME, and V_EXT_LIB.
```

```
C                                     Statistics
C                                     -----
C
C      Sandia National Laboratories VAX/VMS 8810 Computer:
C      13001 lines of source code
C      5679 active lines
C      56 percent comments
```

```
C                                     Types of Data Sets
C                                     -----
C
C INPUT/
C   ASCII:      in unit 'INASCI', 'ISDSCR', 'ISECDB'
C   BINARY:     in unit 'IDB'
C   CRT:        in unit 'IDSCRN'
C
C OUTPUT/
C   ASCII:      in unit 'NOUTFL'
C   BINARY:     in unit 'ODB'
C   CRT:        in unit 'ISCREN'
```

C			
C		Files Used	
C		-----	
C			
C	Filename	Units	Description
C	(MATSET.INP)	2	MATSET input control card data file
C			
C	SYS\$COMMAND	6	OPTIONAL diagnostics/debug file
C	(MATSET_SXX_T.DBG)	7	OPTIONAL diagnostics/debug file
C	(PROPERTY.SDB)	50	Secondary data base
C	(PROPERTY.SBDSR)	51	Secondary data base descriptor file
C	(PRECAMDAT.CDB)	30	Binary CAMDAT file (input)
C	(CAMDAT_SXX_T.DCB)	31,32,33	Binary CAMDAT file (output)
C			
C	*****		

5.6.4 Subroutine Headers

Subroutine headers are similar to the descriptive header in the main program:

- Describe the function or purpose of the routine. This documentation should give a knowledgeable programmer enough information to use the routine without having to resort to deciphering the coding.
- Describe meaning and type of global variables used or modified (i.e., calling and common variables).
- Document author if different from the main program.
- Describe meaning and type of local variables.
- Document (by reference or otherwise) data storage in arrays.
- Document revisions made and date.

5.6.5 Include File Headers

Include files within the CAMCON environment are used as mechanisms for sharing information between FORTRAN files. Include files provide modularity by isolating key information and as such are a powerful tool for structural programming. The files should be named using "INC" as the extension (*.INC).

Headers of include files should provide descriptions of common blocks, variables, and arrays. These descriptions should be as detailed as explanations of these items found in the headers of FORTRAN files.

An example of an include file follows:


```

C*****
C  TITLE:    REAL and CHARACTER*1 base array pointers include file
C  AUTHOR:    Jonathan S. Rath
C  UPDATED:   24-MAY-1993  -JSR: Added more descriptive comments, etc.
C*****
C
C    /LOCATC/    (from FORTRAN statement: INCLUDE 'LOCAT.INC')
C    LCPTR  =    Integer array used for pointing to each dynamic array
C                start location in the base CHARACTER*1 array, C.
C    L[name]=    Individual integer pointer to the base CHARACTER*1
C                array, C.  ( L[dynamic-array-name] )
C
C                NOTE: A FORTRAN equivalence statement is used for
C                convenience to permit accessing the base
C                CHARACTER*1 array, C, by BOTH a numeric index
C                of dynamic arrays (LCPTR(index)) and by a single
C                integer variable (L[name]).  It is convenient to
C                key off an index, or range of indices when
C                assigning memory to the base CHARACTER*1 array.
C                However, in a subroutine argument list, clarity
C                is maintained by using distinct integer variables
C                as pointers of the base CHARACTER*1 array because
C                they precede the actual dynamic array name by the
C                letter "L".
C
C*****
C
C    /LOCATR/    (from FORTRAN statement: INCLUDE 'LOCAT.INC')
C    LRPTR  =    Integer array used for pointing to each dynamic array
C                start location in the base REAL array, Q.
C    L[name]=    Individual integer pointer to base REAL array, Q.
C                ( L[dynamic-array-name] )
C
C                NOTE: A FORTRAN equivalence statement is used for
C                convenience to permit accessing the base
C                REAL array, Q, by BOTH a numeric index of
C                dynamic arrays (LRPTR(index)) and by a single
C                integer variable (L[name]).
C
C*****
C234567
      INTEGER
      $LCOORD,   LMAP,      LNUMELB,  LNELNOD,  LICONN,   LIASPRP,
      $LNUMPRP,  LXMATPR,   LISEVOK,  LIEBLOC,  LTIME,    LHIFLAG,
      $LVALHIV,  LVALGLV,   LVALNDV,  LVALELV,  LICNUM,   LICPNT,
      $LICLST,   LNUMICT,   LIXYZIT,  LXCRICT,  LYCRICT,  LZCRICT,
      $LVALICT,  LISEVOK2,  LVALHIV2,  LVALGLV2, LVALNDV2, LVALELV2,
      $LRPTR(30)
      EQUIVALENCE (LRPTR,LCOORD)
      INTEGER
      $LNAMELB,  LNMATPR,   LQAINFO,  LNAMECO,  LNAMHIV,  LNAMGLV,
      $LNAMELV,  LNAMELV,   LNAMEICT,  LNAMEHIV2, LNAMEGLV2, LNAMENDV2,
      $LNAMELV2, LCPTR(13)

```

```

EQUIVALENCE (LCPTR, LNAMELB)
COMMON /LOCATR/
$LCOORD,   LMAP,      LNUMELB,  LNELNOD,  LICONN,   LIASPRP,
$LNUMPRP,  LXMATPR,   LISEVOK,  LIEBLOC,  LTIME,    LHIFLAG,
$LVALHIV,  IVALGLV,   LVALNDV,  LVALELV,  LICNUM,   LICPNT,
$LICLST,   LNUMICT,   LIXYZIT,  LXCRICT,  LYCRICT,  LZCRICT,
$LVALICT,  LISEVOK2,  LVALHIV2,  LVALGLV2,  LVALNDV2,  LVALELV2
COMMON /LOCATC/
$LNAMELB,  LNMATPR,   LQAINFO,  LNAMECO,  LNAMHIV,  LNAMGLV,
$LNAMNDV,  LNAMELV,   LNAMICT,  LNAMHIV2,  LNAMGLV2,  LNAMNDV2,
$LNAMELV2
C*****

```

5.6.6 DCL Procedure Headers

DCL procedure files should be named using the "COM" extension (*.COM). DCL headers are similar to subroutine headers and should include the following information:

- Describe the purpose of the procedure.
- Describe the usage of the procedure, including any parameters.
- Document the author of the procedure.
- Describe the meaning and type of global symbols used or modified.
- Comments should be delimited by using the standard VAX-DCL notation of \$!.

The following is an example of a DCL procedure header:

```

$! *****
$! *** INQ YES NO.COM *** (CAMCON Drivers)          *** Revised 11/03/92 ***
$! *****
$!
$! PURPOSE:      This procedure interactively requests a "YES" or "NO".
$!               The global symbol IS_YES is set TRUE for YES or FALSE for NO.
$!               The procedure will reprompt until a valid response is given
$!               or the user QUITs.
$!
$! USAGE:        @INQ_YES_NO P1 [P2]
$!               where P1 = Text for the INQUIRE. "(Y/N)" and default are appended.
$!               P2 = "YES" or "NO" or "" for the default.
$!
$! AUTHOR:       A. P. Gilkey 09/26/89
$!
$! GLOBAL SYMBOLS:
$!               QUIT_HERE is set to TRUE if the user QUITs (no directory is
$!               returned), or FALSE for a normal return
$!               DISABLE_QUIT must be FALSE or QUIT is not allowed
$!               IS_YES is set to TRUE (for YES) or FALSE (for NO)
$! *****

```

5.7 Interfacing C Codes to the CAMCON System

Occasionally, it is desirable to create utility modules using the ANSI C programming language when the increased capability to interface with the operating system warrants. The guidelines below are applicable to compiling and executing C codes on the WIPP VAX running VMS Version 5.4-3.

5.7.1 Compilation

Compile C code by typing at the system prompt **CC** *cfile*. A list of compiler options can be obtained by typing at the system prompt **HELP CC**.

5.7.2 Linking

Define the location of the C run-time library, which can be found in SYS\$LIBRARY as **\$DEFINE LNK\$LIBRARY SYS\$LIBRARY:VAXCTRL**. This is currently done in CAMCON_SYMS.

Link the C code by typing at the system prompt **LINK** *cfile*.

Additional information can be found by typing at the system prompt **HELP CC LINK**.

5.7.3 Mixing FORTRAN and C

VMS Version 5.4-3 supports mixed-language programming. VMS C is able to call or be called by routines written in other languages.

The details of passing variables are language dependent. When mixing FORTRAN and C,

- Use the VAX/VMS-specific function, %REF, in the FORTRAN calling routine to pass variables by reference.
- Append a null character (i.e., CHAR(0)) on a string variable in the FORTRAN routine when this string variable will be passed to a C routine.
- Remove null characters from a string variable passed from a C routine to a FORTRAN routine.

As an example, the following shows how the CAMCON.LIB FORTRAN routine, EXFILDAT (which passes the date/time stamp of a file) calls a C routine, CXFILDAT:

```

SUBROUTINE EXFILDAT (FILNAM, FDATE, FTIME)
C*****
C***
C***  FILE MODIFICATION DATE MODULE
C***  ---
C*****
C
C  PURPOSE:  Obtains the date and time at which a file has been
C            last modified by the system.
C

```

```

C      AUTHOR:      A. P. Gilkey
C
C      DATE:        January 1992 -- First Ed.
C
C      CALLED VIA:  CAMCON_LIB
C
C      CALLS:       CXFILDAT          (VMS C Routine)
C                  %REF              (VMS System RTL Routine)
C
C      ARGUMENTS:
C
C      --through subroutine call
C      FILNAM = Name of file to be checked (CHARACTER input)
C      FDATE  = File modification date    (CHARACTER output)
C      FTIME  = File modification time    (CHARACTER output)
C
C      LOCAL/
C      CNAM   = Copy of FILNAM with a null character appended to it.
C              Used as input to the routine CXFILDAT.
C      CDAT   = Copy of string containing the date the file was modified.
C              It is output from CXFILDAT and is terminated by a null
C              character which must be removed so it may be displayed
C              properly.
C      CTIM   = Copy of string containing the time the file was modified.
C              It is output from CXFILDAT and is terminated by a null
C              character which must be removed so it can be displayed
C              properly.
C
C*****
C      CHARACTER*(*) FILNAM
C      CHARACTER*(*) FDATE
C      CHARACTER*(*) FTIME
C
C      CHARACTER*129 CNAM
C      CHARACTER*10 CDAT, CTIM
C
C      CNAM = FILNAM
C      I = INDEX (FILNAM, ' ')
C
C... Append a null character to the string. This is important because C
C      uses the null character to mark the end of the string.
C      CNAM(I:I) = CHAR (0)
C
C
C              *** WARNING***
C              Machine dependent function %REF*
C
C      Call the C routine using 'by reference' parameter passing in order to
C      correctly pass the string.
C      CALL CXFILDAT (%REF(CNAM), %REF(CDAT), %REF(CTIM))

```

* See SDBREAD_LIB for a generic subroutine that places this machine-dependent function in a low-level routine.

```
C      ... If an error occurred, then pass back empty strings
      IF (ICHAR (CDAT(1:1)) .EQ. 0) CDAT = ' '
      IF (ICHAR (CTIM(1:1)) .EQ. 0) CTIM = ' '

C      Remove null characters terminating the strings CDAT/CTIM
      FDATE = CDAT(1:8)
      FTIME = CTIM(1:8)
      RETURN
      END

C*****
```


6. CAMDAT_LIB:

Computational Data Base Interface Library

This chapter describes the calls to the routines that read and write data to a computational data base (CAMDAT) neutral file, briefly discusses the history behind the selection of the CAMDAT file format, and describes suggested ways to use the CAMDAT neutral file subroutines to help the developer understand what can and cannot be done.

6.1 Background on the Selected Format

Storage of input and output requires a versatile file format that has been extensively tested. Although some projects (e.g., evaluation of transport contaminants or water rights disputes) have had some success with using a GIS package as the data base for storing and displaying results, WIPP PA rejected this approach because at the time

- Fast access (though not necessarily through a direct access file) directly to the data as stored (rather than through ASCII files) was essential since each file was projected to be as large as 5 MB (10,000 blocks) (and one complete simulation might involve thousands of these files).
- Plotting capabilities, though extensive in GIS packages, did not have all the necessary capabilities, and because source code was unavailable, it limited the opportunity for modification.
- Adding arrays with a potentially large dimension to store time step information was awkward and could hamper the usefulness.

The original file format chosen for CAMDAT was based on GENESIS (Taylor et al., 1987) and EXODUS (Mills-Curran et al., 1988), developed by Sandia National Laboratories, Engineering Analysis Department, for finite-element computer codes. This file format was originally chosen for the following reasons:

- It had demonstrated versatility in handling fluid and solid mechanics codes, multiple element types, and various boundary conditions.
- It could be easily modified to store both finite-element and finite-difference meshes and results.
- The file could be easily modified to store material properties.
- It stored data as unformatted binary for space efficiency.
- It had a file structure that defined the length of all records before the record was read, implying that the reading program could dynamically allocate memory for all arrays.
- It had powerful data manipulation and plotting codes already available (e.g., Gilkey, 1988).

A potential drawback was that it had a sequential file format, which, while simple and easy to use for programmers, made reading and writing a large data base file potentially cumbersome.

Initial changes necessary to this file format were numerous and included storage of material properties, changing the storage of boundary condition information, expansion of QA information stored, and naming all entities stored.

Although the initial file format served the project well, ever-increasing types of information have needed to be stored. Hence, the data base is now accessed through a set of subroutines. The standard interface permits the sponsor of the data base file to change the structure to meet these changing needs and yet not significantly affect the operation of individual codes.

6.2 Correspondence Between Generic Computational Data Base and Data Entities in CAMDAT File

As mentioned previously and repeated here, basically three types of information are stored in a CAMDAT neutral file (Figure 6-1):

- Quality assurance information
- Model description data, such as finite-element or finite-difference geometry data; geologic, hydrologic, and chemical parameters; and model boundary conditions
- Analysis results data, such as fluid flow results, concentrations from source term or transport modules, and particle pathways

The correspondence of this general-to-specific information is discussed below and shown in Figure 6-1. The correspondence between the material property section and CAMDAT deserves special mention. When discussing parameters (or properties) in CAMDAT, we make a subtle distinction between two types of parameters: "material" and "attribute."

Material parameters Parameters or characteristics that vary only with material regions or not at all are termed *material* parameters or properties. These material parameters are defined for each material region of the mesh. Typical examples include material partition coefficient (K_d) and solid density (ρ_s).

Attribute parameters Parameters that have a rough characteristic range for each material but vary spatially and are thus different at each element in the computational mesh are termed *attribute* parameters. (The properties are attributes of each element of the mesh.) Typical examples include hydraulic transmissivity, matrix porosity, and bulk density (ρ_b).

Although not all the computational codes recognize the same division of parameters, storage within the CAMDAT files is consistent and a translation from one type of description to the other is made in the preprocessor for the computational model (computer code).

TRI-6334-44-1

Figure 6-1. Correspondence between generic computational data base file and CAMDAT neutral file entities.

The following description of CAMDAT reiterates information pertinent to the WIPP project reported by Taylor et al. (1986) and Mills-Curran et al. (1988) concerning the GENESIS and EXODUS data base after which the computational data base is designed. The description uses the terminology of finite elements. For example, although the definition of the term “nodal point” changes between FE or node-centered FD and body-centered FD analyses, a node is always described in FE analysis to be consistent.

6.2.1 Heading

The heading is an 80-character string placed on all printouts and plots from the computational data base. For the compliance evaluation, the following four groups of information are usually recorded on this line:

1. TITLE - descriptive, but brief title for stored data (CHARACTER*53)
2. IDSCNR - succinct scenario ID (CHARACTER*8)
3. SCLMTH - scale of the computer model (CHARACTER*8); choices are REGIONAL, SOURCE, LOCAL, or CUTTINGS
4. SIMRUN - the simulation run number (CHARACTER*8)

6.2.2 Quality Assurance Information

The first information necessary for this block of data is the number of quality assurance records (NQAREC)—a value which changes each time a code writes to the file. Following this information are the NQAREC arrays storing the eight-character name, version, date and time of all codes that write to the file (e.g., ALGEBRA C-3.11VV, 10/1/91, 09:30:00). This information is important for assuring that the calculations can be repeated—an important function of quality assurance procedures. Along with the HEADER information, the name, version, and date of each code that writes to the file are printed on all plots or printouts of data from the data base file.

6.2.3 Optional Text

CAMDAT can also store any number of records of optional text. The first item of information is the number of optional records (NXINFO). Following this item are the NXINFO records of optional text as CHARACTER*80.

For the WIPP compliance evaluation, the random seed, SEED, (but stored as a character variable) used for the Monte Carlo sampling is stored as optional text.

In addition, for the WIPP, the translators for finite difference codes frequently require the number of elements (computational cells or grid blocks) in the x, y, and z directions. Although the information

could be computed each time, the information (NX, NY, and NZ) is also stored here as character variables and then converted to numerical data.

Finally, an optional text record states the units used throughout the computations.

6.2.4 Data Base Version and Model Size

The data base version number defines the structure of the data base. Programs accessing the data file should abort if the data base version number is not compatible with the assumed version number in the code.

The following parameters define the size of the model:

NUMNOD	- number of nodes (either FE or FD)
NDIM	- number of coordinates (spatial dimensions) per node
NUMEL	- total number of elements, including all element types
NELBLK	- number of element blocks (for WIPP, NELBLK is the number of different material regions)

6.2.5 Nodal Point Coordinates

The mesh information is stored as nodal point coordinates x,y,z. The labels for the x,y,z-component must be specified.

6.2.6 Element Map

The element map contains the finite-difference element number for each CAMDAT element number. CAMDAT element numbering is explained in Section 6.2.7, and finite-difference element numbering is depicted in Figure 6-2.

6.2.7 Material Block Information

Element (or grid block) data are stored in blocks or groups. The block data refer to groups of elements representing different types of material or layers of strata surrounding the repository. Each block has the same material and element type. Grouping elements with similar material and element type is more space-efficient and permits vector processing of each element block. The local and global numbers of an element are implicitly defined by the order in which they appear in the file. Elements are globally numbered consecutively across all element blocks in the order the element blocks appear in the file.

Element Block IDs and Names. Each block contains an integer block ID and a block name. By assigning a unique ID to the blocks, an analysis code can decipher the order in which materials or layers are stored in the computational data base.

Element Connectivity for a Material Block. For FE analysis, the nodes connected together to form each element are stored in the file. All elements in a material block must be of the same element type (i.e., contain the same number of nodes). No convention is specified in the data base, which implies that the codes must agree on conventions. For the codes used at Sandia, a counterclockwise ordering of nodes is used to define the connectivity of elements. In addition, for three-dimensional analysis, nodes are numbered first with increasing x, then increasing y, then z.

For FD analysis, the connectivity is unnecessary; however, to allow a general FE plotting package to display results for both FE and FD analysis (so that an analyst has to learn and use only one plotting package), a connectivity array is necessary for FD results as well, but the array is easy to generate.

Although not limited by CAMDAT, the node and element numbering used for WIPP FD grids is shown in Figure 6-2.

TRI-6334-45-0

Figure 6-2. Storage of WIPP finite-difference mesh in a CAMDAT file.

Attribute Parameters for each Element. Although some material properties are stored as block information, many are stored as element attributes to accommodate subtle changes of parameters within the same stratigraphic layer, if necessary. The attribute array stores information that varies with each element (e.g., transmissivity, porosity, brine density). Each attribute parameter has a name for identification. A particular attribute need not be defined in all material blocks.

Material Parameters for Material (Element) Blocks. The material parameter array stores information pertaining to properties that vary only with each material (element) block (e.g., rock density, nuclide partition coefficients). Each material parameter has a name for identification. A particular material parameter need not be defined in all material blocks.

6.2.8 Boundary Condition Data

The file format can store boundary condition information (e.g., load or fluid pressure conditions) in two ways:

- Node sets
- Element side sets

The following parameters define the size of all boundary condition information:

NUMNPS	- number of node sets
LNPSNL	- length of the node sets node list
NUMESS	- number of element side sets
LGELEL	- length of the element side sets element list
LGNODL	- length of the element side sets node list

Node Sets. A node set refers to a set of nodes (one or many) that has been identified with a unique ID (flag). Although a particular node may appear in any number of node sets, a node should appear only once in each node set. Each node in a set is assigned an individual factor (e.g., pressure or flux). All node sets are concatenated into one list; similarly, distribution factors for all nodes are concatenated. Consequently, besides the IDs, the node set lists and distribution factors; a pointer list and a counter list are required. Their descriptions follow:

- **IDS AND NAMES FOR EACH NODE SET.** Each node set has an ID (flag) and an eight-character identifier. Similarly to the material block ID, the node set ID is a unique integer label assigned by the user. The IDs are in an integer array of length NUMNPS. The names are in a CHARACTER*8 array of length NUMNPS.
- **NUMBER OF NODES IN EACH NODE SET.** The number of nodes in each node set is contained in an integer array of length NUMNPS.

- **POINTERS FOR LOCATING EACH NODE SET.** An index for each node set which locates the beginning of the node set within the concatenated node list described below is contained in an integer array of length NUMNPS.
- **CONCATENATED LIST OF NODES.** The lists of nodes for all sets is concatenated into a single list. The count and pointer lists mentioned above are used to identify the nodes in any one particular node set. The concatenated list is contained in an integer array of length LNPSNL.
- **FACTORS CORRESPONDING TO EACH NODE.** Each node in the concatenated node list has a corresponding nodal factor stored in a similar concatenated list. Depending on how the analysis program interprets the data, these factors prescribe either the actual constraint conditions (e.g., pressure or flux) or the spatial distributions of the constraints (interpreted as multiplication factors in the latter case). The concatenated factor list is contained in a real array of length LNPSNL.

Element Side Sets. An element side set refers to a set of elements identified with a unique ID. This feature is useful for surface boundary conditions (e.g., heat or fluid flux).

Similarly to node sets, an element side should appear only once in each element side set. However, the element number may appear more than once within a side set if more than one side of an element is part of the set. Further, the nodes associated with a side set will generally appear several times within that side set's node list. Likewise, each side in a set is assigned an individual factor (e.g., flux). As before, all side sets are concatenated into one list; in the same way, the factors for all side sets are concatenated.

Consequently, the required information for storing element side sets is similar to that for storing node data (IDs, counts, pointers, nodal list, factor list) except that both the element side and the element side's associated nodes must be stored. Eight data components exist: one ID list, two count lists, two pointer lists, one element side list, one nodal list, and one factor list. Their descriptions follow.

For the WIPP, the finite element codes use arrays as described. The finite-difference codes need only a few of the arrays because nodes associated with an element are easily deciphered, since the mesh connectivity is regular. The requirements for element side sets follow:

- **IDS AND NAMES FOR EACH ELEMENT SIDE SET.** Each element side set has an ID (flag) and an eight-character identifier. The IDs are in an integer array of length NUMESS. The names are in a CHARACTER*8 array of length NUMESS.
- **NUMBER OF ELEMENT SIDES IN EACH ELEMENT SIDE SET.** The number of element sides in each side set is contained in an integer array of length NUMESS. Similarly to node point sets, an element side should appear only once in each element side set.
- **NUMBER OF NODES ASSOCIATED WITH EACH ELEMENT SIDE SET.** The total number of element side nodes in each side set is contained in an integer array of length NUMESS. The number of nodes per element side is implied by the type of element (e.g., quadrilateral).

- **POINTERS FOR LOCATING ELEMENTS ASSOCIATED WITH SIDE SET.** An index for locating each set of elements comprising the element side set within the concatenated list of elements for the side sets is contained in an integer array of length NUMESS.
- **POINTERS FOR LOCATING NODES ASSOCIATED WITH SIDE SET.** An index to locate the set of nodes associated with each side set within the concatenated list of all nodes is contained in an integer array of length NUMESS.
- **CONCATENATED LIST OF ELEMENTS ENCOMPASSING ALL SIDE SETS.** A concatenated list of elements encompassing all side sets is contained in an integer array of length LGELEL.
- **CONCATENATED LIST OF NODES ENCOMPASSING ALL SIDE SETS.** A concatenated list of nodes encompassing all side sets is contained in an integer array of length LGNODL.
- **CONCATENATED LIST OF FACTORS FOR ELEMENTS COMPRISING SIDE SETS.** Each element in the side sets has a corresponding factor. The factor list corresponds one-for-one to the concatenated list of elements (two bullets above); consequently the length of the real array is LGELEL. To maintain compatibility with the EXODUS data base (Mills-Curran et al., 1988), the array is padded with zeros to length of LGNODL.

6.2.9 Results

The final segment of the file are the results. This section of the file can vary greatly; hence, dynamic memory allocation is especially useful for reading element data. The variables are separated into two general classes: variables output at every time step ("history" variables) and variables output at designated time steps. This grouping allows an analyst to reduce the size of the output file. Variables output at designated time steps are further subdivided into three classes: global, element, and nodal. Specifically,

- History – output at every time step
- Global
- Element } output at designated time steps
- Nodal }

History and global variables refer to values of physical properties that apply to the large regions or the entire analysis, such as total energy or mass of the system. These properties can sometimes help indicate the accuracy of the analysis by checking whether energy or mass is conserved during the calculations.

Element variables refer to values of physical properties that apply to the finite element or the finite difference computational cell (grid block). An element variable may not be defined for every element block. The "element variable truth table" has an entry for each element variable, which consists of a logical value for each element block. The value is true if and only if the variable is defined in that element block. Most codes used in the WIPP performance assessment define each element variable for all element blocks.

Nodal variables refer to values of physical properties that apply to the computational FE or FD node.

6.3 General Guidelines on the Use of CAMDAT_LIB Routines

6.3.1 Sponsorship and Version

Author/Sponsor: A. P. Gilkey
Version/Date: C-1.10VV/August 1992
Language: FORTRAN 77

6.3.2 Overview of CAMDAT_LIB

The CAMDAT_LIB routines handle all computational data base (CDB) neutral file input and output. A data base neutral file can be accessed only through these routines; the CDB neutral file should not be accessed directly. The routine DBSETUP must be called to initialize the library before any other CAMDAT_LIB routines are called.

When creating or reading a CAMDAT file, the file must first be opened. The data base can be opened as an input data base or an output data base, but not both. The open routine requires a unit number, which is used in all subsequent routine calls to identify the data base file.

After the open routine is invoked, the routines that read or write (1) the QA information and (2) model description can be called in any order. However, these routines must be called before any routines that process the analysis results. Furthermore, for efficiency, all analysis results needed for a particular time step should be processed before proceeding to the next time step.

The CAMDAT_LIB routines manipulate the neutral file entities logically with little regard to how the data base file is organized physically. For example, the attribute names and values are handled as a logical item, even though currently the attribute values are stored with the property values and the attribute names are stored later with other names.

Output Data Base. An output data base file can be one of two kinds: a *new* data base being generated or a *connected* data base. All data base entities on a new data base must be specified fully with calls to data base output (DBO) routines (routines whose names begin with DBO). If a particular data base entity does not exist, no action is necessary. For example, if there are no node sets, routine DBONDSET need not be called.

To modify an existing data base, an input data base can be *connected* to an output data base when the output data base is opened. The user must call data base output (DBO) routines only to specify items that are to be changed. By default, all QA and model description information is copied. No analysis results are copied unless requested. For example, to copy the QA and model description data with an added QA record, the user would call routines to perform the following tasks: open the input data base, open the output data base (connecting it to the input data base), add the QA record, then close the output data base.

There are some restrictions on the order in which DBO routines can be called. The QA and model description routines can be called in any order, but the DBOHEAD routine must be called after these routines and before any analysis results routines are called. The first step in processing the analysis results is to define the types and names of all variables to be output. All the variables must be specified fully for the current time step before advancing to the next time step.

Input Data Base. When processing an input data base, the user need only retrieve information that will be used by the program. This does not include information that needs to be copied to a *connected* output data base; this occurs automatically. When the data base is opened, it is scanned for all the sizing information that might be needed to read the data base. This information is available with a single call to DBISIZES.

The data base input (DBI) routines (routines whose names begin with DBI) can be called in any order with some restrictions. Any QA and model description information needed should be read (and stored in memory if necessary) before proceeding to the analysis results. If an output data base is connected, DBOHEAD must be called before the input data base processes any analysis results. The user must also ensure that the current time step corresponds to the appropriate connected output data base time step if variables are to be copied.

The analysis results routines are most efficient if the user reads approximately the same variables for each time step and processes the time steps sequentially.

General Use Comments. Routines whose names begin with DBP display useful summary information about an input or output data base. As a rule, do not write out the entire CAMDAT data base file in ASCII for debugging or other purposes. Instead, use the GROPE utility (Rechard, ed., 1992) to display any CAMDAT data base file entry.

The CAMDAT_LIB routines require the use of dynamic memory. The following lines must be included in any calling program:

```
DIMENSION RMEM(1)
CHARACTER*1 CMEM(1)

CALL MDINIT (RMEM)
CALL MCINIT (CMEM)

CALL DBSETUP (RMEM, CMEM, IERR)
```

If the calling code also needs dynamic memory, it must use the same RMEM and CMEM arrays (see Section 9.2.2, "Memory Management Routines").

Some of the CAMDAT variable types (attributes, properties, elements) require what is called an existence (truth) table to describe where in the computational grid a particular variable is defined. A computational grid is broken down into blocks that are typically associated with specific materials. The existence table defines in which blocks a particular variable is defined. The existence table is either a singly or doubly dimensioned logical array where one of the dimensions is always a block number. For example, (1) ISATOK(b) is true if and only if the associated attribute exists in block b (see DBIATTR and DBOATTR), or (2) ISEVOK(b,i) is true if and only if element variable i exists in block b (see DBIEVROK and DBOEVROK).

6.3.3 Error Messages

Almost all CAMDAT_LIB routines return an error flag. Zero indicates no error. A positive value is the FORTRAN I/O error status from an input or output operation (indicated by "I/O" in the error flag descriptions for specific routines). A value of -1 indicates an end of file was encountered. All other errors result in a negative value. Most other errors involve an invalid parameter, such as an invalid unit number or undefined variable name. Some routines check for dynamic memory errors. These errors may have occurred in the calling program before the routine was called. In general, a message is displayed when an error is flagged. Possible errors are discussed with each routine description.

6.3.4 Linking

The CAMDAT_LIB routines are an object library in the [LIBRARIES] subdirectory (see Section 2.10, "Software Libraries"). CAMDAT_LIB must be linked with libraries CAMCON_LIB and CAMSUPES_LIB. Link the three libraries with a code using the following command (logical names of libraries are assigned by each library sponsor):

LINK *code_name* ..., CAMDAT_LIB/LIB, CAMCON_LIB/LIB, CAMSUPES_LIB/LIB

A FLINT library for CAMDAT_LIB available for checking interfaces is in CAMCON\$ROOT:[LIBRARIES.CAMDAT_LIB]CAMDAT_LIB.LBT.

6.3.5 Summary of Routine Calls

CAMDAT_LIB includes the following routines:

General Routines

- DBERRUNI - define the unit number for the error messages
- DBFIXMEM - reset dynamic memory after M α COMP

File Initialization

- DBSETUP - initialize the library
- DBIOPEN - open data base file for reading; must be called before any other DBI routine for the data base
- DBOOPEN - open data base file for writing; may be connected to an open input data base and has an associated scratch file; must be called before any other DBO routine for the data base

- DBICLOSE - close the input data base file
- DBOCLOSE - close the output data base file

- DBPDBNAM - print the data base file name

- DBISIZES - return the sizes of all QA and input data items on the data base file (e.g., the number of unique attributes, etc.); set with various DBO routines
- DBPSIZES - print the data base size information

- DBITITLE - return the data base file title
- DBOTITLE - set the data base file title
- DBPTITLE - print the title

- DBIVERS - return the data base file version; set by default to the current CAMDAT version
- DBPVERS - print the data base version

QA Information

- DBIINFO - return the information records
- DBOINFO - set the information records
- DBPINFO - print the information records

- DBIQAREC - return the QA records
- DBOQAREC - set the QA records
- DBPQAREC - print the QA records

Model Description

- DBIATTR - return the values for the given attribute for all elements
- DBOATTR - set the values for the given attribute for all elements
- DBIATNAM - return the unique attribute names
- DBPAPNAM - print the attribute and property names

- DBIELBLK - return the element block names and IDs
- DBOELBLK - set the element block names and IDs
- DBPELBLK - print the element blocks summary

- DBOHEAD - write the QA information and model description as copied from the connected data base being read or set with DBO routines

- DBILINK - return the connectivity for all element blocks
- DBOLINK - set the connectivity for all element blocks

- DBIMAP - return the element order map
- DBOMAP - set the element order map

- DBINDSET - return the node sets
- DBONDSET - set the node sets
- DBPNDSET - print the node set summary

- DBINELB - return the number of elements per block; also returned by DBILINK

- DBIPROP - return the values for the given property for all element blocks
- DBOPROP - set the values for the given property for all element blocks
- DBIPRNAME - return the unique property names

- DBISDSET - return the side sets
- DBOSDSET - set the side sets
- DBPSDSET - print the side set summary

- DBIXYZ - return the coordinate names and the coordinates
- DBOXYZ - set the coordinate names and the coordinates

Analysis Results

- DBIEVROK - return the element variable truth table
- DBOEVROK - set the element variable truth table

- DBINVAR - return the number of variables; set with DBOVRNAM
- DBPNVAR - print the number of variables

- DBISTEP - advance to the specified time step and return the time
- DBOSTEP - set the current time step and advance to next time step
- DBINSTP - return the number of time steps

- DBITIME - advance to the next time step and return the time
- DBOIME - set the time for this time step

- DBIVAR - return the given variable for this time step
- DBOVAR - set the given variable for this time step

- DBIVRNAM - return the variable names of the given type
- DBOVRNAM - define the output variables
- DBPVRNAM - print the variable names

- DBINDVAR - define input variables as needed

6.3.6 Example

The example below shows a series of FORTRAN code fragments containing CAMDAT_LIB calls that create a CAMDAT data base file:

```

C=====
C...  Set base arrays for dynamic memory
      COMMON/CMEM/CQ(1)
      CHARACTER*1 CQ
      COMMON/RMEM/ Q(1)
      REAL      Q
      INTEGER IQ(1)
      LOGICAL LQ(1)
      EQUIVALENCE A(IQ,Q), (LQ,Q)

      CALL MDINIT(Q)
      CALL MCINIT(CQ)

C===== INITIALIZATION =====
C...  Initialize the library
      CALL DBSETUP (RMEM, CMEM, IERR)

C...  Define unit number for error messages
      CALL DBERRUNI (NOUT)

C...  Open the output data base and associated scratch file
      CALL DBOOPEN(ODB,-1,SCODB,FILENAME,IERR)

C...  Define title (heading)
      HEAD = TITLE//IDSCNR//SCLMTH//SIMRUN
      CALL DBOTITLE(ODB,HEAD,IERR)

C===== QA =====
C...  Add QA record
      CALL DBOQAREC(ODB,'ADD',QAREC,IERR)

C...  Add information record(s)
      CALL DBOINFO(ODB,NINFO,INFO,IERR)

C===== MODEL DESCRIPTION =====
C...  Define grid coordinates
      CALL DBOXYZ (ODB,NDIM,NUMNP,NAMXYZ,XN,YN,ZN,IERR)

C...  Define element material blocks
      CALL DBOELBLK (ODB,NELBLK,NAMELB,IDELB,IERR)

```

```

C... Define connectivity
      CALL DBOLINK (ODB,NELBLK,NELX,NELY,NELZ,NUMELB,MAXLNK,
+      NUMLINK, LINK, IERR)

C... Define attributes and block truth table
C... ISATOK (B) = .TRUE. if attribute is defined for block B
      DO 10 I = 1, NUMATR
        CALL DBOATTR (ODB,'ADD',NAMATR(I),ISATOK(1,I),ATTRIB(1,I),IERR)
      10 CONTINUE

C... Define properties
      DO 20 I = 1, NUMPRP
        CALL DBOPROP (ODB,'ADD',NAMPRP(I),ISPROK(1,I),PROP(1,I),IERR)
      20 CONTINUE

C... No boundary conditions defined (node or side sets)
C... CDB definition section is complete
C... Write it out to the CDB
      CALL DBOHEAD (ODB,Q,CQ,IERR)

C===== ANALYSIS RESULTS =====
C... Define element variable names
      CALL DBOVRNAM (ODB,'ELE','ADD',NVAREL,NAMELV,IDUM,Q,CQ,IERR)

C... Define nodal variable names
      CALL DBOVRNAM (ODB,'NOD','ADD',NVARND,NAMNDV,IDUM,Q,CQ,IERR)

C... Loop over time
      DO 60 N = 1, NSTEP

C...   Define time for this step
      CALL DBOTIME (ODB,TIME(N),WHOLE,IERR)

C...   Define values of all element variables
      DO 40 I = 1,NVAREL
        CALL DBOVAR (ODB,'ELE',NAMELV(I),I,VALELV(1,I),Q,CQ,IERR)
      40 CONTINUE

C...   Define values of all nodal variables
      DO 50 I = 1,NVARND
        CALL DBOVAR (ODB,'NOD',NAMNDV(I),I,VALNDV(1,I),Q,CQ,IERR)
      50 CONTINUE

C...   Step finished, output it to the data base
      CALL DBOSTEP (ODB,Q,CQ,IERR)

      60 CONTINUE
C=====

```

6.4 Description of Routine Calls

6.4.1 General Routines

Detailed descriptions of general CAMDAT_LIB routines are given on the following pages. The routines described in this section set up parameters for all CAMDAT_LIB system routines. They do not refer to a specific data base file.

DBERRUNI
Subroutine

Name	DBERRUNI - Define unit number for error messages			
Description	DBERRUNI sets the unit number for any error messages. The messages can be directed to the screen or suppressed.			
Syntax	CALL DBERRUNI (IUNIT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The unit number for any error messages. <div> <div><0 - Output to screen</div> <div>=0 - Suppress display</div> </div>

DBFIXMEM
Subroutine

Name	• DBFIXMEM - Correct memory references after calling MαCOMP
Description	DBFIXMEM corrects all internal memory references after dynamic memory has been compressed. It is called immediately after each call to MDCOMP or MCCOMP (see Section 9.2.3, "Advanced Memory Management Routines"). Most users do not call these routines and thus do not need to call DBFIXMEM.
Syntax	CALL DBFIXMEM
Error Flag Values	-10 - CAMDAT_LIB bug - <i>message</i> (call sponsor for software)
See Also	MαCOMP in CAMSUPES_LIB

6.4.2 Detailed Descriptions of File Initialization Routines

Detailed descriptions of CAMDAT_LIB file initialization routines are given on the following pages. The routines described in this section are used to open, close, and initialize CAMDAT files.

DBSETUP

Subroutine

Name	DBSETUP - Initialize library			
Description	DBSETUP initializes CAMDAT_LIB. This routine must be called after MDINIT and MCINIT and before any other DB routine.			
Syntax	CALL DBSETUP (RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	RMEM	I/O	real array	The dynamic memory real array.
	CMEM	I/O	char*1 array	The dynamic memory character array.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB)		
	-11	- Too much dynamic memory requested		

DBIOPEN

Subroutine

Name	DBIOPEN - Oper. data base for reading			
Description	DBIOPEN opens an input data base and scans for sizing information. This routine must be called before any other DBI routine.			
Syntax	CALL DBIOPEN (IUNIT, FILE, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The input data base file unit number.
	FILE	Input	char*(*)	The input data base file name.
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10 - CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB) -11 - Too much dynamic memory requested -12 - Too many *.CDB files defined -13 - DBSETUP must be called first -20 - Unit already opened i/o - Cannot open file <i>file</i> i/o - Invalid CAMDAT data base file			

DBOOPEN

Subroutine

Name	DBOOPEN - Open data base for writing			
Description	DBOOPEN opens an output data base and its scratch file. The output data base may have a connected input data base.			
Syntax	CALL DBOOPEN (IUNIT, IUNITC, IUNITS, FILE, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	IUNITC	Input	integer	The connected input data base file unit number (<0 if none).
	IUNITS	Input	integer	Scratch file unit number.
	FILE	Input	char*(*)	Output data base file name.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10 - CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB) -11 - Too much dynamic memory requested -12 - Too many *.CDB files defined -13 - DBSETUP must be called first -20 - Undefined connected input data base file -20 - Unit already opened i/o - Cannot open file <i>file</i> i/o - Cannot open scratch file			

DBICLOSE
Subroutine

Name	DBICLOSE - Close input data base			
Description	DBICLOSE closes an input data base.			
Syntax	CALL DBICLOSE (IUNIT, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		

DBOCLOSE

Subroutine

Name	DBOCLOSE - Close output data base			
Description	DBOCLOSE closes an output data base.			
Syntax	CALL DBOCLOSE (IUNIT, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	-30	- Output data base header has not been written		

DBPDBNAM

Subroutine

Name	DBPDBNAM - Print data base file name			
Description	DBPDBNAM prints the data base file name.			
Syntax	CALL DBPDBNAM (IUNIT, IUNPRT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The unit number for the data base.
	IUNPRT	Input	integer	The display file unit number (≤ 0 for standard output).

DBISIZES

Subroutine

Name	DBISIZES - Return sizes of data base descriptive data			
Description	DBISIZES returns the sizing information for the QA and model description information from an input data base.			
Syntax	CALL DBISIZES (IUNIT, NQAREC, NINFO, NDIM, NUMNP, NELBLK, NUMEL, NELX, NELY, NELZ, MAXLNK, NUMATR, NUMPRP, NUMNPS, LNPSNL, NUMESS, LGELEL, LGNODL, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NQAREC	Output	integer	The number of QA records.
	NINFO	Output	integer	The number of information records.
	NDIM	Output	integer	The number of coordinates per node.
	NUMNP	Output	integer	The number of nodes.
	NELBLK	Output	integer	The number of element blocks.
	NUMEL	Output	integer	The number of elements.
	NELn	Output	integer	The number of elements in the n th (X, Y, or Z) dimension.
	MAXLNK	Output	integer	The maximum number of nodes per element.
	NUMATR	Output	integer	The maximum number of unique attributes.
	NUMPRP	Output	integer	The number of unique properties.
	NUMNPS	Output	integer	The number of node sets.
	LNPSNL	Output	integer	The length of the node sets list.
	NUMESS	Output	integer	The number of side sets.
	LGELEL	Output	integer	The length of the side sets element list.
	LGNODL	Output	integer	The length of the side sets node list.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10 - CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB) -20 - Undefined input data base unit number			
See Also	DBISDSET, DBOSDSET			

DBPSIZES
Subroutine

Name	DBPSIZES - Print data base sizing information			
Description	DBPSIZES displays the data base sizing information.			
Syntax	CALL DBPSIZES (IUNIT, IUNPRT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	The display file unit number (≤ 0 for standard output).

DBITITLE

Subroutine

Name	DBITITLE - Return data base title			
Description	DBITITLE returns the title of an input data base.			
Syntax	CALL DBITITLE (IUNIT, TITLE, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	TITLE	Output	char*(*)	Data base title.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading title		

DBOTITLE

Subroutine

Name DBOTITLE - Set data base title

Description DBOTITLE sets the title of an output data base.

Syntax CALL DBOTITLE (IUNIT, TITLE, IERRDB)

**Variables in
Call**

<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
IUNIT	Input	integer	Output data base file unit number.
TITLE	Input	char(*)	Data base title.
IERRDB	Output	integer	Error flag.

**Error Flag
Values**

- 10 - CAMDAT_LIB bug - *message* (call sponsor of CAMDAT_LIB)
- 20 - Undefined output data base unit number
- i/o - Writing scratch file

DBPTITLE
Subroutine

Name	DBPTITLE - Print data base title			
Description	DBPVERS displays the data base title.			
Syntax	CALL DBPTITLE (IUNIT, IUNPRT, TITLE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	The display file unit number (≤ 0 for standard output).
	TITLE	Input	char*(*)	Data base title.

DBIVERS
Subroutine

Name	DBIVERS - Return data base version			
Description	DBIVERS returns the version number (NVERS) from an input data base.			
Syntax	CALL DBIVERS (IUNIT, NVERS, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NVERS	Output	integer	CAMDAT version number (EXODUS = 0).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		

DBPVERS
Subroutine

Name DBPVERS - Print data base version

Description DBPVERS displays the data base version.

Syntax CALL DBPVERS (IUNIT, IUNPRT)

**Variables in
Call**

<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
IUNIT	Input	integer	Data base file unit number
IUNPRT	Input	integer	The display file unit number (≤ 0 for standard output).

6.4.3 Detailed Descriptions of QA Information Routines

Detailed descriptions of CAMDAT_LIB QA information routines are given on the following pages. The routines described in this section read and write quality assurance (QA) and optional information to the CAMDAT files.

DBIINFO
Subroutine

Name	DBIINFO - Return information records			
Description	DBIINFO returns the information records from an input data base.			
Syntax	CALL DBIINFO (IUNIT, NINFO, INFO, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NINFO	Output	integer	The number of information records.
	INFO	Output	char*80 array	The information records: INFO (NINFO).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading information record <i>info</i>		

DBOINFO
Subroutine

Name	DBOINFO - Set information records			
Description	DBOINFO sets the information records of an output data base.			
Syntax	CALL DBOINFO (IUNITO, NINFO, INFO, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNITO	Input	integer	Output data base file unit number.
	NINFO	Input	integer	The number of information records.
	INFO	Input	char*80 array	The information records: INFO (NINFO).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor for software)		
	-20	- Undefined output data base unit number		
	i/o	- Writing scratch file		

DBPINFO
Subroutine

Name	DBPINFO - Print information records			
Description	DBPINFO prints the information records.			
Syntax	CALL DBPINFO (IUNIT, IUNPRT, NINFO, INFO)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	Display file unit number (≤ 0 for standard output).
	NINFO	Input	integer	The number of information records.
	INFO	Input	char*80 array	The information records: INFO (NINFO).

DBIQAREC

Subroutine

Name	DBIQAREC - Return QA records			
Description	DBIQAREC returns the QA records from an input data base.			
Syntax	CALL DBIQAREC (IUNIT, NQAREC,QAREC, IERRDB)			
Variables in Call	Name	I/O	Type	Description
	IUNIT	Input	integer	Input data base file unit number.
	NQAREC	Output	integer	The number of QA records.
	QAREC	Output	char*8 array	QAREC (<i>n</i> ,NQAREC) The QA records (first array subscript <i>n</i>) are as follows: 1. Analysis code name 2. Analysis QA code descriptor 3. Analysis date 4. Analysis time
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10 - CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB) -20 - Undefined input data base unit number i/o - Scanning forward/backward on input data base i/o - Reading QA record <i>iqa rec</i>			
See Also	QAMAKREC in CAMCON_LIB			

DBOQAREC**Subroutine**

Name	DBOQAREC - Set QA records			
Description	DBOQAREC sets a single QA record of an output data base. This record is added to the end of the existing or copied QA records. DBOQAREC also controls whether the QA records will be copied from the connected input data base. By default, the QA records are copied.			
Syntax	CALL DBOQAREC (IUNIT, OPTION, QAREC, IERRDB)			
Variables in Call	Name	I/O	Type	Description
	IUNIT	Input	integer	Output data base file unit number.
	OPTION	Input	char*(*)	The action to be taken (case in unimportant, only the first character is used): RESET - Do not copy any QA records from the connected input data base; by default all QA records are copied. COPY - Copy all QA records from the connected input data base. ADD - Add QA record (default option)
	QAREC	Input	char*8 array	QAREC (4) The QA records: 1. Analysis code name 2. Analysis QA code descriptor 3. Analysis date 4. Analysis time
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	-20	- Undefined connected input data base		
	-21	- Unknown <i>action</i>		
	i/o	- Writing scratch file		
See Also	QAMAKREC in CAMCON_LIB			

DBPQAREC
Subroutine

Name	DBPQAREC - Print QA records			
Description	DBPQAREC prints the QA records.			
Syntax	CALL DBPQAREC (IUNIT, IUNPRT, NQAREC,QAREC)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	Display unit file number (≤ 0 for standard output).
	NQAREC	Input	integer	The number of QA records.
	QAREC	Input	char*8 array	QAREC (n ,NQAREC) The QA records (first array subscript n) are as follows: <ol style="list-style-type: none"> 1. Analysis code name 2. Analysis QA code descriptor 3. Analysis date 4. Analysis time
See Also	QAMAKREC in CAMCON_LIB			

6.4.4 Detailed Descriptions of Model Description Routines

Detailed descriptions of CAMDAT_LIB model description routines are given on the following pages. The routines described in this section read or write information that describes the computational model. This includes nodal coordinates, element connectivity, element property attributes, element block properties, and boundary conditions as either parameter node sets or side sets.

DBIATTR
Subroutine

Name	DBIATTR - Return attribute values for all elements			
Description	DBIATTR returns the requested attribute for all elements from an input data base.			
Syntax	CALL DBIATTR (IUNIT, NAME, INDEX, ISATOK, ATRIB, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NAME	I/O	char*(*)	The attribute name. If INDEX > 0, INDEX is used and NAME is set (if LEN(NAME) > 1).
	INDEX	I/O	integer	The attribute index. If INDEX ≤ 0, NAME is used and INDEX is set (if INDEX < 0).
	ISATOK	Output	logical	Attribute of block b exists if and only if ISATOK(b).
	ATLIB	Output	real	The attribute for all elements: ATRIB (NUMEL.).
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	-22	- Cannot find attribute name <i>name</i>		

DBOATTR
Subroutine

Name	DBOATTR - Set attribute values for all elements			
Description	DBOATTR sets the values for a single attribute for all elements of an output data base. It also controls which attributes, if any, will be copied from the connected input data base. By default, all attributes are copied.			
Syntax	CALL DBOATTR (IUNIT, OPTION, NAME, ISATOK, ATRIB, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	OPTION	Input	char(*)	Action to be taken (case is unimportant, only the first character is checked): RESET - Do not copy any attributes from the connected input data base. COPY - Copy named attribute from the connected input data base. DELETE - Delete named attribute (only for copied attributes). ADD - Add named attribute or replace values if copied (default option).
	NAME	Input	char(*)	The attribute name. If OPTION = COPY and NAME = *, all attributes are copied.
	ISATOK	Input	logical array	Attribute of block b exists if and only if ISATOK(b). ISATOK is not used if OPTION = COPY.
	ATRIB	Input	real array	The attribute for all elements: ATRIB (NUMEL).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	-20	- Undefined connected input data base		
	-21	- Attribute is undefined for all blocks		
	-21	- Unknown action <i>action</i>		
	i/o	- Writing scratch file		

DBIATNAM
Subroutine

Name	DBIATNAM - Return unique attribute names			
Description	DBIATNAM returns the unique attribute names from an input data base.			
Syntax	CALL DBIATNAM (IUNIT, NUMATR, NAMATR, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NUMATR	Output	integer	The number of unique attributes.
	NAMATR	Output	char*8 array	The unique attribute names: NAMATR (NUMATR)
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		

DBPAPNAM

Subroutine

Name	DBPAPNAM - Print attribute and property names			
Description	DBPAPNAM displays the attribute and property names.			
Syntax	CALL DBPAPNAM (IUNIT, IUNPRT, NUMATR, NAMATR, NUMPRP, NAMPRP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	Display file unit number (≤ 0 for standard output).
	NUMATR	Input	integer	The number of attributes.
	NAMATR	Input	char*8 array	The attribute names: NAMATR (NUMATR)
	NUMPRP	Input	integer	The number of properties.
	NAMPRP	Input	char*8 array	The property names: NAMPRP (NUMPRP)

DBIELBLK
Subroutine

Name	DBIELBLK - Return element block names and IDs			
Description	DBIELBLK returns the element block names and IDs for all element blocks from an input data base.			
Syntax	CALL DBIELBLK (IUNIT, NELBLK, NAMELB, IDELB, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NELBLK	Output	integer	The number of element blocks.
	NAMELB	Output	char*8 array	The element block names for each block: NAMELB (NELBLK).
	IDELB	Output	integer array	The element block IDs for each block: IDELB (NELBLK)
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading element block sizing parameters for block <i>ielb</i>		
	i/o	- Reading element block names		

DBOELBLK

Subroutine

Name	DBOELBLK - Set element block names and IDs			
Description	DBOELBLK sets the element block names and IDs for all element blocks of an output data base.			
Syntax	CALL DBOELBLK (IUNIT, NELBLK, NAMELB, IDELB, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	NELBLK	Input	integer	The number of element blocks.
	NAMELB	Input	char*8 array	The element block names for each block: NAMELB (NELBLK).
	IDELB	Input	integer array	The element block IDs for each block: IDELB (NELBLK).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	i/o	- Writing scratch file		

DBPELBLK
Subroutine

Name	DBPELBLK - Print element block summary			
Description	DBPELBLK prints the element block summary.			
Syntax	CALL DBPELBLK (IUNIT, IUNPRT, NELBLK, NAMELB, IDELB, NUMELB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	Display unit file number (≤ 0 for standard output).
	NELBLK	Input	integer	The number of element blocks.
	NAMELB	Input	char*8 array	The element block names for each block: NAMELB (NELBLK).
	IDELB	Input	integer array	The element block IDs for each block: IDELB (NELBLK).
	NUMELB	Input	integer array	The number of elements for each block: NUMELB (NELBLK).

DBOHEAD**Subroutine**

Name	DBOHEAD - Write QA information and model description			
Description	DBOHEAD writes the QA information and the model description to the output data base. The information is read from the corrected input data base, if any, or it has been set previously with DBO routines.			
Syntax	CALL DBOHEAD (IUNIT, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	none	- Output data base version is different from connected input data base (warning only)		
	-11	- Too much dynamic memory requested		
	-20	- Undefined output data base unit number		
	-20	- Undefined connected input data base		
	-22	- Cannot find attributed name <i>name</i>		
	-22	- Cannot find property name <i>name</i>		
	-31	- Title is not set		
	-31	- Coordinates are not set		
	-31	- Element block names and IDs are not set		
	-31	- Connectivity is not set		
	-31	- Node sets are not set		
	-31	- Side sets are not set		
	-31	- QA records are not set		
	-31	- Information records are not set		
	i/o	- Scanning forward/backward on scratch file		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading title		
Error Flag Values	i/o	- Reading nodal coordinates		
	i/o	- Reading coordinate names		

Error Flag	i/o	- Reading element order map
Values (cont.)	i/o	- Reading element block sizing parameters for block <i>ielb</i>
	i/o	- Reading element block names
	i/o	- Reading element block sizing parameters for block <i>ielb</i>
	i/o	- Reading connectivity for element block <i>ielb</i>
	i/o	- Reading node set IDs and names
	i/o	- Reading node set number of nodes
	i/o	- Reading node set indices
	i/o	- Reading node set nodes
	i/o	- Reading node set distribution factors
	i/o	- Reading side set IDs and names
	i/o	- Reading side set number of elements
	i/o	- Reading side set number of nodes
	i/o	- Reading side set element indices
	i/o	- Reading side set node indices
	i/o	- Reading side set elements
	i/o	- Reading side set nodes
	i/o	- Reading side set distribution factors
	i/o	- Reading QA record <i>iqua</i>
	i/o	- Reading information record <i>info</i>
	i/o	- Reading scratch file
	i/o	- Reading connected input data base
	i/o	- Writing output data base

DBILINK
Subroutine

Name	DBILINK - Return connectivity for all element blocks			
Description	DBILINK returns the connectivity for all elements from an input data base.			
Syntax	CALL DBILINK (IUNIT, NELBLK, NELX, NELY, NELZ, NUMELB, MAXLNK, NUMLNK, LINK, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NELBLK	Output	integer	The number of element blocks.
	NELn	Output	integer	The number of elements in the n (X, Y, or Z) dimension.
	NUMELB	Output	integer array	The number of elements in each block: NUMELB (NELBLK).
	MAXLNK	Output	integer	The first LINK dimension (equal to the maximum number of nodes per element).
	NUMLNK	Output	integer array	The number of nodes per element in each block: NUMLNK (NELBLK)
	LINK	Output	integer array	The connectivity for all elements: LINK (MAXLNK, NUMEL).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading element block sizing parameters for block <i>ielb</i>		
	i/o	- Reading connectivity for element block <i>ielb</i>		

DBOLINK
Subroutine

Name	DBOLINK - Set connectivity for all element blocks			
Description	DBOLINK sets the connectivity for all elements of an output data base. Note that the number of elements in the X, Y, and Z dimensions are ignored at this time.			
Syntax	CALL DBOLINK (IUNIT, NELBLK, NELX, NELY, NELZ, NUMELB, MAXLNK, NUMLNK, LINK, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	NELBK	Input	integer	The number of element blocks.
	NELn	Input	integer	The number of elements in the n (X, Y, or Z) dimension.
	NUMELB	Input	integer array	The number of elements in each block: NUMELB (NELBLK).
	MAXLNK	Input	integer	The first LINK dimension (at least the maximum number of nodes per element).
	NUMLNK	Input	integer array	The number of nodes per element in each block: NUMLNK(NELBLK). If NUMLNK(1) is <0, MAXLNK is used for all blocks.
	LINK	Input	integer array	The connectivity for all elements: LINK (MAXLNK, NUMEL).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	i/o	- Writing scratch file		

DBIMAP
Subroutine

Name	DBIMAP - Return element map			
Description	DBIMAP returns the element map from an input data base.			
Syntax	CALL DBIMAP (IUNIT, NUMEL, MAPEL, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NUMEL	Output	integer	The number of elements.
	MAPEL	Output	integer array	The element map: MAPEL (NUMEL).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading element map		

DBOMAP
Subroutine

Name	DBOMAP - Set element map			
Description	DBOMAP sets the element map of an output data base. If DBOMAP is not called for a new data base, the element map is set to 1...NUMEL.			
Syntax	CALL DBOMAP (IUNIT, NUMEL, MAPEL, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	NUMEL	Input	integer	The number of elements.
	MAPEL	Input	integer array	The element map: MAPEL (NUMEL).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	i/o	- Writing scratch file		

DBINDSET
Subroutine

Name	DBINDSET - Return node sets			
Description	DBINDSET returns the node set information from an input data base.			
Syntax	CALL DBINDSET (IUNIT, NUMNPS, NAMNPS, IDNPS, NNNPS, IXNNPS, LTNNPS, FACNPS, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NUMNPS	Output	integer	The number of node sets.
	NAMNPS	Output	char*8 array	The name for each node set: NAMNPS (NUMNPS).
	IDNPS	Output	integer array	The node set ID for each node set: IDNPS (NUMNPS).
	NNNPS	Output	integer array	The number of nodes for each set: NNNPS (NUMNPS)
	IXNNPS	Output	integer array	The index of the first node for each set: IXNNPS (NUMNPS).
	LTNNPS	Output	integer array	The nodes for all sets: LTNNPS (LNPSNL).
	FACNPS	Output	real array	The distribution factors for all sets: FACNPS (LNPSNL).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading node set IDs and names		
	i/o	- Reading node set number of nodes		
	i/o	- Reading node set indices		
	i/o	- Reading node set nodes		
	i/o	- Reading node set distribution factors		

DBONDSET
Subroutine

Name	DBONDSET - Set node sets			
Description	DBONDSET sets the node set information of an output data base.			
Syntax	CALL DBONDSET (IUNIT, NUMNPS, NAMNPS, IDNPS, NNNPS, IXNNPS, LTNNPS, FACNPS, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	NUMNPS	Input	integer	The number of node sets.
	NAMNPS	Input	char*8 array	The name for each node set: NAMNPS (NUMNPS).
	IDNPS	Input	integer array	The node set ID for each node set: IDNPS (NUMNPS).
	NNNPS	Input	integer array	The number of nodes for each set: NNNPS (NUMNPS).
	IXNNPS	Input	integer array	The index of the first node for each set: IXNNPS (NUMNPS).
	LTNNPS	Input	integer array	The nodes for all sets: LTNNPS (LNPSNL).
	FACNPS	Input	real array	The distribution factors for all sets: FACNPS (LNPSNL).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	i/o	- Writing scratch file		

DBPNDSET
Subroutine

Name	DBPNDSET - Print node sets summary			
Description	DBPNDSET displays the node set summary.			
Syntax	CALL DBPNDSET (IUNIT, IUNPRT, NUMNPS, NAMNPS, IDNPS, NNNPS)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	Display file unit number (≤ 0 for standard output).
	NUMNPS	Input	integer	The number of node sets.
	NAMNPS	Input	char*8 array	The name for each node set: NAMNPS (NUMNPS).
	IDNPS	Input	integer array	The node set ID for each node set: IDNPS (NUMNPS).
	NNNPS	Input	integer array	The number of nodes for each set: NNNPS (NUMNPS).

DBINELB
Subroutine

Name	DBINELB - Return number of elements per block			
Description	DBINELB returns the number of elements per block for all element blocks from an input data base.			
Syntax	CALL DBINELB (IUNIT, NELBLK, NUMELB, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NELBLK	Output	integer	The number of element blocks.
	NUMELB	Output	integer array	The number of elements for each block: NUMELB (NELBLK).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading element block sizing parameters for block <i>ielb</i>		

DBIPROP
Subroutine

Name	DBIPROP - Return property values for all element blocks			
Description	DBIPROP returns the requested property for all element blocks from an input data base.			
Syntax	CALL DBIPROP (IUNIT, NAME, INDEX, ISPROK, PROP, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NAME	I/O	char*(*)	The property name. If INDEX > 0, INDEX is used and NAME is set (if LEN(NAME) > 1).
	INDEX	I/O	integer	The property index. If INDEX ≤ 0, NAME is used and INDEX is set (if INDEX < 0)
	ISPROK	Output	logical array	Property of block b exists if and only if ISPROK(b).
	PROP	Output	real array	The property for all elements blocks: PROP (NELBLK).
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	-22	- Cannot find property name <i>name</i>		

DBOPROP
Subroutine

Name	DBOPROP - Set property values for all elements blocks			
Description	DBOPROP sets the values for a single property for all element blocks of an output data base. It also controls which properties, if any, will be copied from the connected input data base. By default, all properties are copied.			
Syntax	CALL DBOPROP (IUNIT, OPTION, NAME, ISPROK, PROP, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	OPTION	Input	char*(*)	Action to be taken (case is unimportant; only the first character is checked): RESET - Do not copy any properties from the connected input data base. COPY - Copy named property from the connected input data base. DELETE - Delete named property (only for copied properties). ADD - Add named property or replace values if copied (default option).
	NAME	Input	char*(*)	The property name. If OPTION = COPY and NAME = *, all properties are copied.
	ISPROK	Input	logical array	Property of block b exists if and only if ISPROK(b). ISPROK is not used if OPTION = COPY.
	PROP	Input	real array	The property for each element block: PROP (NELBLK).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	-20	- Undefined connected input data base		
	-21	- Property is undefined for all blocks		
	-21	- Unknown action <i>action</i>		
	-23	- Cannot output properties on CAMDAT data base		
	i/o	- Writing scratch file		

DBIPRNAM
Subroutine

Name	DBIPRNAM - Return unique property names			
Description	DBIPRNAM returns the unique property names from an input data base.			
Syntax	CALL DBIPRNAM (IUNIT, NUMPRP, NAMPRP, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NUMPRP	Output	integer	The number of unique properties.
	NAMPRP	Output	char*8 array	The unique property names: NAMPRP (NUMPRP).
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		

DBISDSET
Subroutine

Name	DBISDSET - Return side sets			
Description	DBISDSET returns the side set information from an input data base.			
Syntax	CALL DBISDSET (IUNIT, NUMESS, NAMES, IDS, NELEM, NNODES, IXELEM, IXNODE, LTELEM, LTNODE, FACTOR, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NUMESS	Output	integer	The number of element side sets.
	NAMES	Output	char*8 array	The name for each side set: NAMES (NUMESS).
	IDS	Output	integer array	The side set ID for each side set: IDS (NUMESS).
	NELEM	Output	integer array	The number of elements for each set: NELEM (NUMESS).
	NNODES	Output	integer array	The number of nodes for each set: NNODES (NUMESS).
	IXELEM	Output	integer array	The index of the first element for each set: IXELEM (NUMESS).
	IXNODE	Output	integer array	The index of the first node for each set: IXNODE (NUMESS).
	LTELEM	Output	integer array	The elements for all sets: LTELEM (LGELEL).
	LTNODE	Output	integer array	The nodes for all sets: LTNODE(LGNODL).
	FACTOR	Output	real array	The distribution factors for all sets: FACTOR (LGELEL).
	IERRDB	Output	integer	Error flag.

DBISDSET
Subroutine

**Error Flag
Values**

-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)
-20	- Undefined input data base unit number
i/o	- Scanning forward/backward on input data base
i/o	- Reading side set IDs and names
i/o	- Reading side set number of elements
i/o	- Reading side set number of nodes
i/o	- Reading side set element indices
i/o	- Reading side set node indices
i/o	- Reading side set elements
i/o	- Reading side set nodes
i/o	- Reading side set distribution factors

DBOSDSET
Subroutine

Name	DBOSDSET - Set side sets			
Description	DBOSDSET sets the side set information of an output data base.			
Syntax	CALL DBOSDSET (IUNIT, NUMESS, NAMES, IDS, NELEM, NNODES, IXELEM, IXNODE, LTELEM, LTNODE, FACTOR, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	NUMESS	Input	integer	The number of side sets.
	NAMES	Input	char*8 array	The name for each side set: NAMES (NUMESS).
	IDS	Input	integer array	The side set ID for each side set: IDS (NUMESS).
	NELEM	Input	integer array	The number of elements for each set: NELEM (NUMESS).
	NNODES	Input	integer array	The number of nodes for each set: NNODES (NUMESS).
	IXELEM	Input	integer array	The index of the first element for each set: IXELEM (NUMESS).
	IXNODE	Input	integer array	The index of the first node for each set: IXNODE (NUMESS).
	LTELEM	Input	integer array	The elements for all sets: LTELEM (LGELEL).
	LTNODE	Input	integer array	The nodes for all sets: LTNODE (LGNODL).
	FACTOR	Input	real array	The distribution factors for all sets: FACTOR (LGELEL).
	IERRDB	Output	integer	Error flag.

DBOSDSET
Subroutine

Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)
	-20	- Undefined output data base unit number
	i/o	- Writing scratch file

See Also	DBISIZES
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DBPSDSET
Subroutine

Name	DBPSDSET - Print side set summary			
Description	DBPSDSET prints the side set summary.			
Syntax	CALL DBPSDSET (IUNIT, IUNPRT, NUMESS, NAMES, IDS, NELEM, NNODES)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	Display file unit number (≤ 0 for standard output).
	NUMESS	Input	integer	The number of side sets.
	NAMES	Input	char*8 array	The name for each side set: NAMES (NUMESS).
	IDS	Input	integer array	The side set ID for each side set: IDS (NUMESS).
	NELEM	Input	integer array	The number of elements for each set: NELEM (NUMESS).
	NNODES	Input	integer array	The number of nodes for each set: NNODES (NUMESS).

DBIXYZ
Subroutine

Name	DBIXYZ - Return coordinate names and coordinates			
Description	DBIXYZ returns the coordinate names and the coordinates from an input data base.			
Syntax	CALL DBIXYZ (IUNIT, NDIM, NUMNP, NAMXYZ, XN, YN, ZN, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NDIM	Output	integer	The number of coordinates per node.
	NUMNP	Output	integer	The number of nodes.
	NAMXYZ	Output	char*8 array	The coordinate names: NAMXYZ (NDIM).
	nN	Output	real array	The (X, Y, or Z) coordinates for all nodes in the n th direction: XN(NUMNP), YN(NUMNP), ZN(NUMNP)
	IERRDB	Output	integer	Error flag.
Error Flag Values	<ul style="list-style-type: none">-10 - CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)-20 - Undefined input data base unit numberi/o - Scanning forward/backward on input data basei/o - Reading nodal coordinatesi/o - Reading coordinate names			

DBOXYZ
Subroutine

Name	DBOXYZ - Set coordinate names and coordinates			
Description	DBOXYZ sets the coordinate names and the coordinates of an output data base scratch file.			
Syntax	CALL DBOXYZ (IUNIT, NDIM, NUMNP, NAMXYZ, XN, YN, ZN, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	NDIM	Input	integer	The number of coordinates per node.
	NUMNP	Input	integer	The number of nodes.
	NAMXYZ	Input	char*8 array	The coordinate names: NAMXYZ (NDIM).
	nN	Input	real array	The (X, Y, or Z) coordinates for all nodes in the n th direction: XN(NUMNP), YN(NUMNP), ZN(NUMNP)
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	i/o	- Writing scratch file		

6.4.5 Detailed Descriptions of Analysis Results Routines

Detailed descriptions of CAMDAT_LIB analysis results routines are given on the following pages. This section describes functions that read and write analysis results data and related entities. These include simulation times and results variables (history, global, nodal, and elemental).

DBIEVROK
Subroutine

Name	DBIEVROK - Return element variable existence (truth) table			
Description	DBIEVROK returns from an input data base the table specifying existence of element variables in a block as a logical array.			
Syntax	CALL DBIEVROK (IUNIT, NELBLK, NVAREL, ISEVOK, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NELBLK	Output	integer	The number of element blocks.
	NVAREL	Output	integer	The number of element variables.
	ISEVOK	Output	logical array	The element variable existence table. Variable <i>i</i> of block <i>b</i> exists if and only if ISEVOK(<i>b,i</i>).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading element variable truth table		

DBOEVROK

Subroutine

Name	DBOEVROK - Set element variable truth table			
Description	DBOEVROK sets the element variable truth table for a single element variable of an output data base. If DBOEVROK is not called, the variable is defined for all element blocks.			
Syntax	CALL DBOEVROK (IUNIT, NAME, INDEX, ISEVOK, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	NAME	I/O	char*(*)	The variable name. If INDEX > 0, INDEX is used and value is set (if LEN (NAME) > 1)
	INDEX	I/O	integer	The variable index. If INDEX ≤ 0, NAME is used and INDEX is set (if INDEX < 0).
	ISEVOK	Input	logical	The element variable truth table. Variable of block b exists if and only if ISEVOK(b).
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	-21	- Element variable is undefined for all blocks		
	-22	- Cannot find variable name <i>name</i>		
	-32	- Variables cannot be defined if within time step		

DBINVAR
Subroutine

Name	DBINVAR - Return number of variables			
Description	DBINVAR returns the number of variables from an input data base.			
Syntax	CALL DBINVAR (IUNIT, NVARHI, NVARGL, NVARNP, NVAREL, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NVARHI	Output	integer	The number of history variables.
	NVARGL	Output	integer	The number of global variables.
	NVARNP	Output	integer	The number of nodal variables.
	NVAREL	Output	integer	The number of element variables.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		

DBPNVAR
Subroutine

Name	DBPNVAR - Print number of variables			
Description	DBPNVAR displays the number of variables.			
Syntax	CALL DBPNVAR (IUNIT, IUNPRT, NVARHI, NVARGL, NVARNP, NVAREL)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	Display file unit number (≤ 0 for standard output).
	NVARHI	Input	integer	The number of history variables.
	NVARGL	Input	integer	The number of global variables.
	NVARNP	Input	integer	The number of nodal variables.
	NVAREL	Input	integer	The number of element variables.

DBISTEP
Subroutine

Name	DBISTEP - Advance to specified time step			
Description	DBISTEP advances the current time step of an input data base to the specified time step and returns the time step information for that step. If the data base is within the current time step, the data base is not moved. DBISTEP may also be called to rewind the data base.			
Syntax	CALL DBISTEP (IUNIT, ISTEP, TIME, WHOLE, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	ISTEP	Input	integer	The desired time step number; if ≤ 0 , rewind to start of data base.
	TIME	Output	real	The time step time.
	WHOLE	Output	logical	.TRUE. if and only if time step has all variables, versus only history variables.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading time of time step <i>istep</i>		

DBOSTEP
Subroutine

Name	DBOSTEP - Write the current time step; advance to the next step			
Description	<p>DBOSTEP writes the completed time step and advances the current time step to the next time step of an output data base. If an input data base is connected, the variables to be copied are read from the current time step of the input data base before the time step is written.</p> <p>DBOSTEP writes the variable names and the element variable truth table before the first step. If DBOSTEP is called after the variable names have been defined but before the time step time or variables have been set, the variable names and truth table are written.</p>			
Syntax	CALL DBOSTEP (IUNIT, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	<ul style="list-style-type: none">-10 - CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)-20 - Undefined output data base unit number-20 - Undefined connected input data base-30 - Output data base header has not been written-32 - Connected input data base is not within time step-32 - Time has not been set for this time stepi/o - Scanning forward/backward on input data basei/o - Reading time of time step <i>istep</i>i/o - Reading history variables of time step <i>istep</i>i/o - Reading global variables of time step <i>istep</i>i/o - Reading nodal variables of time step <i>istep</i>i/o - Reading element variables of time step <i>istep</i>i/o - Writing output data base			

DBINSTEP
Subroutine

Name	DBINSTEP - Return the number of time steps			
Description	DBINSTEP returns the number of time steps in an input data base.			
Syntax	CALL DBINSTEP (IUNIT, NSTEPS, NSTEPW, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	NSTEPS	Output	integer	The number of data base time steps.
	NSTEPW	Output	integer	The number of time steps with all variables, versus only history variables.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading time of time step <i>istep</i>		

DBITIME
Subroutine

Name	DBITIME - Advance time for this time step			
Description	DBITIME advances the current step of an input data base to the next time step and returns the time step information for that step.			
Syntax	CALL DBITIME (IUNIT, TIME, WHOLE, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	TIME	Output	real	The time step time.
	WHOLE	Output	logical	.TRUE. if and only if time step has all variables, versus only history variables.
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading time of time step <i>istep</i>		

DBOTIME
Subroutine

Name	DBOTIME - Set time for this time step			
Description	DBOTIME sets the time step time for the current time step of an output data base.			
Syntax	CALL DBOTIME (IUNIT, TIME, WHOLE, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	TIME	Input	real	The time step time.
	WHOLE	Input	logical	.TRUE. if and only if time step has all variables, versus only history variables.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)		
	-20	- Undefined output data base unit number		
	-30	- Output data base header has not been written		
	-32	- Time has already been set for this time step		

DBIVAR
Subroutine

Name	DBIVAR - Return given variable for this time step			
Description	DBIVAR returns the values of the requested variable for the current time step from an input data base.			
Syntax	CALL DBIVAR (IUNIT, VTYPE, NAME, INDEX, VAR, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	VTYPE	Input	char(*)	The type of variable requested (case is unimportant; only the first character is checked): HISTORY - History variables GLOBAL - Global variables NODAL - Nodal variables ELEMENT - Element variables
	NAME	I/O	char(*)	The variable name. If INDEX > 0, INDEX is used and NAME is set (if LEN (NAME) > 1).
	INDEX	I/O	integer	The variable index. If INDEX ≤ 0, NAME is used and INDEX is set (if INDEX < 0).
	VAR	Output	real array	The returned variable values: VAR(*).
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.

Error Flag	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)
Values	-11	- Too much dynamic memory requested
	-20	- Undefined input data base unit number
	-21	- Unknown variable type <i>vtype</i>
	-21	- Variable type <i>vtype</i> invalid on history-only time step
	-22	- Cannot find variable name <i>name</i>
	-32	- DBITIME/STEP must be called before DBIVAR
	i/o	- Scanning forward/backward on input data base
	i/o	- Reading time of time step <i>istep</i>
	i/o	- Reading history variables of time step <i>istep</i>
	i/o	- Reading global variables of time step <i>istep</i>
	i/o	- Reading nodal variables of time step <i>istep</i>
	i/o	- Reading element variables of time step <i>istep</i>

DBOVAR
Subroutine

Name	DBOVAR - Set given variable for this time step			
Description	DBOVAR sets the value of the requested variable for the current time step of an output data base.			
Syntax	CALL DBOVAR (IUNIT, VTYPE, NAME, INDEX, VAR, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	VTYPE	Input	char*(*)	The type of variable requested (case is unimportant; only the first character is checked): HISTORY - History variables GLOBAL - Global variables NODAL - Nodal variables ELEMENT - Element variables
	NAME	I/O	char*(*)	The variable name. If INDEX > 0, INDEX is used and NAME is set (if LEN (NAME) > 1).
	INDEX	I/O	integer	The variable index. If INDEX ≤ 0, NAME is used and INDEX is set (if INDEX < 0).
	VAR	Input	real array	The variable values: VAR(*).
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10 - CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB) -20 - Undefined output data base unit number -21 - Unknown variable type <i>vtype</i> -21 - Variable type <i>vtype</i> invalid on history-only time step -22 - Cannot find variable name <i>name</i> -30 - Output data base header has not been written -32 - Time has not been set for this time step			

DBIVRNAM
Subroutine

Name	DBIVRNAM - Return variable names of the given type			
Description	DBIVRNAM returns the names of the given variable type from an input data base.			
Syntax	CALL DBIVRNAM (IUNIT, VTYPE, NVAR, NAMES, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Input data base file unit number.
	VTYPE	Input	char*(*)	The type of variable requested (case is unimportant, only the first character is checked): HISTORY - History variables GLOBAL - Global variables NODAL - Nodal variables ELEMENT - Element variables
	NVAR	Output	integer	The number of variables of the given type.
	NAMES	Output	char*8 array	The names of the variables of the given type: NAMES (NVAR).
	IERRDB	Output	integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - message (call sponsor of CAMDAT_LIB)		
	-20	- Undefined input data base unit number		
	-21	- Unknown variable type <i>vtype</i>		
	i/o	- Scanning forward/backward on input data base		
	i/o	- Reading VARIABLE NAMES		

DBOVRNAM**Subroutine**

Name	DBOVRNAM - Define output variables			
Description	DBOVRNAM defines the names of the variables of a given type to be written to an output data base. It also controls whether any variables are to be copied from the connected input data base. By default, no variables are copied. DBOVRNAM may be called more than once for a given variable type, but all variables must be defined by this routine before DBOTIME or DBOVAR is called.			
Syntax	CALL DBOVRNAM (IUNIT, VTYPE, OPTION, NVAR, NAMES, LDUMMY, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Output data base file unit number.
	VTYPE	Input	char*(*)	The type of variable requested (case is unimportant; only the first character is checked): HISTORY - History variables GLOBAL - Global variables NODAL - Nodal variables ELEMENT - Element variables
	OPTION	Input	char*(*)	Action to be taken (case is unimportant; only the first character is checked): RESET - Do not copy any variables from the connected input data base. COPY - Copy named variable from the connected input data base. DELETE - Delete named variable (only for copied variables). ADD - Add named variable or replace values if copied (default option).
	NVAR	Input	integer	The number of variables of the given type.
	NAMES	Input	char*(*) array	The variable name: NAMES (NVAR). If OPTION = COPY and NAMES(1) = *, all attributes are copied.
	LDUMMY	None	None	
	RMEM			Dummy.
	CMEM			Dummy.
	IERRDB	Output	integer	Error flag.

**Error Flag
Values**

- 10 - CAMDAT_LIB bug - *message* (call sponsor of CAMDAT_LIB)
- 11 - Too much dynamic memory requested
- 20 - Undefined output data base unit number
- 20 - Undefined connected input data base
- 21 - Unknown variable type *vtype*
- 21 - Unknown action *action*
- 32 - Variables cannot be defined if within time step

DBPVRNAM**Subroutine**

Name	DBPVRNAM - Print variable names			
Description	DBPVRNAM displays the variable names.			
Syntax	CALL DBPVRNAM (IUNIT, IUNPRT, NVARHI, NAMEHV, NVARGL, NAMEGV, NVARNP, NAMENV, NVAREL, NAMEEV)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	IUNPRT	Input	integer	Display file unit number (≤ 0 for standard output).
	NVARHI	Input	integer	The number of history variables.
	NAMEHV	Input	char*8 array	The history variable names: NAMEHV (NVARHI)
	NVARGL	Input	integer	The number of global variables.
	NAMEGV	Input	char*8 array	The global variable names: NAMEGV (NVARGL).
	NVARNP	Input	integer	The number of nodal variables.
	NAMENV	Input	char*8 array	The nodal variable names: NAMENV (NVARNP).
	NVAREL	Input	integer	The number of element variables.
	NAMEEV	Input	char*8 array	The element variable names: NAMEEV (NVAREL).

DBINDVAR
Subroutine

Name	DBINDVAR - Define input variables as needed			
Description	DBINDVAR defines which input variables are needed from an input data base. Either the name or the variable index is used to specify a variable. This routine is optional and is included to improve efficiency.			
Syntax	CALL DBINDVAR (IUNIT, VTYPE, ACTION, NAME, INDEX, RMEM, CMEM, IERRDB)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Data base file unit number.
	VTYPE	Input	char*(*)	Type of variable requested (case is unimportant; only the first character is used): HISTORY - history variable(s) GLOBAL - global variable(s) NODAL - nodal variable(s) ELEMENT - element variable(s) * - all variables
	ACTION	Input	char*(*)	Action to be taken: RESET - delete the named variable from the list of needed variables DELETE - delete the named variable ADD - add the named variable to the list of needed variables
	NAME	Input/ Output	char*(*)	The variable name. If INDEX > 0, INDEX rather than NAME is used to specify the variable. If INDEX > 0 and the length of NAME > 1, then NAME is set. If NAME is '*' and INDEX ≤ 0, then all variables of the type specified in VTYPE are added or deleted.
	INDEX	Input/ Output	integer	The variable index. If INDEX ≤ 0, NAME rather than INDEX is used to specify the variable. INDEX is set if INDEX < 0.

DBINDVAR
Subroutine

Variables in Call (Cont.)	RMEM	Dummy.
	CMEM	Dummy.
	IERRDB Output integer	Error flag.
Error Flag Values	-10	- CAMDAT_LIB bug - <i>message</i> (call sponsor of CAMDAT_LIB)
	-11	- Too much dynamic memory requested
	-20	- Undefined input data base unit number
	-21	- Unknown variable type <i>vtype</i>
	-22	- Cannot find variable name <i>name</i>
See Also	DBIVAR and DBOVRNAM. Variables are also added to the list of needed input variables through these routines.	
Warning	A request to delete variables is dangerous if the input data base is connected to an output data base that is copying input variables.	

7. *SDBREAD_LIB:*

Secondary Data Base Interface Library

This chapter describes the calls to the routines that read and write data from the neutral files, created from the secondary data base tables, storing parameters for chemical, mechanical, probabilistic, and hydrologic models. However, this chapter first provides a general description of the contents of the relational tables in the secondary data base.

7.1 General Description of the Secondary Data Base

The secondary data base stores the information that defines the conceptual model of the disposal system. Although text and general scientific information on the assumed important physical processes for the scenario are not stored, all other data necessary to model the disposal system for a potential release scenario are stored in the data base; for instance, data gaps existing in the primary data base will have been filled in using objective interpolation or expert judgement (see also Section 2.9, "Data Bases").

The purpose of the secondary data base is to

- Provide consistent distributions among all the computational models used in the PA simulation.
- Place responsibility for maintaining the most current parameter values with only a few individuals.
- Provide a uniform interface for software used by PA analysts.
- Provide a uniform interface for investigators communicating with the PA Department.

7.1.1 Secondary Data Base Structure and Similar Data Entities

Because of the diverse types of information stored, the secondary data base consists of several separate tables (see Figure 2-5). The general scheme of the secondary data base tables is to place numeric variables needed for identifying and searching records at the beginning of a record, then value(s) of interest, then elaborating text. At present, the elaborating text in each of the tables consists primarily of QA information as follows:

- QA Information
 - QA classification of the information
 - Primary source of underlying data for parameter (INFOSR)
 - Name of person making the change (CATALG)
 - Date of last change (CHDATE)

7.1.2 Storage of Conceptual Model Stratigraphy

For WIPP, stratigraphic layer data from DOE, potash, and oil and gas wells were combined to form a secondary data base table. From this data base table, a conceptual (and mathematical) model of the

stratigraphy is developed using the codes in the property assignment and mesh generation modules of the CAMCON system (see Rechard, 1992). The stratigraphic information is stored in two separate tables: well locations and layer elevations.

Well Locations. Information in the well-location table contains the following information (the usual identifier in the SDB neutral file, which is described in the next section, is shown in parenthesis):

- Identifier for information in each record
 - Standard well ID for WIPP (IDWELL)
 - Alternate well ID for WIPP (IDALT)
- Stored information
 - Location in universal transverse mercator (UTM) coordinates (m) (XUTM, YUTM)
 - Location in state planar coordinates (ft) (XSTPLAN, YSTPLAN)
 - Location as section, township, and range (SECTION, TOWNSHP, RANGE)

Layer Elevations. The layer-elevation table contains the following information:

- Identifier for information in each record
 - Material ID (IDMTRL) (e.g., stratigraphic layer)
 - Well ID for WIPP (IDWELL)
 - Indication of top or bottom of layer (IDLEVEL)
- Stored information
 - Elevation above mean sea level of appropriate surface of material (m) (ELEVAT)
 - Reference datum for elevation (DATUM)
 - Measurement units (UNITS)

7.1.3 Storage of Parameter Data

The values and distributions of model parameters are stored in a separate table within the secondary data base. This information is used by the property assignment module of the CAMCON system (Rechard, 1992). The table contains the following information.

- Identifier for information in each record
 - ID for material (IDMTRL)
 - WIPP ID for well (IDWELL)
 - ID for material parameter (IDPRAM)
- Stored information
 - Type of distribution (DISTYP)

- Mean parameter value of distribution (MEAN)
- Median parameter of distribution (MEDIAN)
- Lower limit of range (LOWRNG)
- Upper limit of range (HIRNGE)
- Measurement units in SI system (UNITS)

and depending on distribution type, one or all of the following information

- Data values for tabulated data and corresponding name of independent variable (PARAM)
 - Probability, and corresponding parameter value of distribution (TABVALU)
- Other elaborating or pertinent information can include (but is not required)
 - Value of additional information to the project
 - Importance of parameter in individual applied models or within the total PA composite consequence or probability model
 - Measurement error of data
 - Measurement technique

7.2 General Description of SDB Neutral Files

For the tables of the secondary data base to be accessible to the routines in SDBREAD_LIB (and eventually, the codes in the Property Assignment Module of the CAMCON system [Rechard, 1992]), the relational tables are exported from the data base system. The exported files are written sequentially in an ASCII neutral file format.

7.2.1 SDB Descriptor Records (Keywords)

For the SDBREAD_LIB routines to perform properly, a description of the data entries must either be appended to the front of this ASCII neutral file or reside in a separate file. The SDBREAD_LIB routines use this description to decipher the contents of the neutral file. This approach is intended to eliminate the need to modify a code that accesses the SDB neutral files through the SDBREAD_LIB routines when the structure of the SDB neutral files changes (Figure 7-1).

When a separate file is used for the descriptor records, the default location is the same directory as the SDB neutral file [SDB α], although the location can be changed. The default file name is the SDB neutral file name with the extension .SDBDSCR. For example, the descriptor file name for the SDB neutral file, PROPERTY.SDB, would be PROPERTY.SDBDSCR.

7.2.2 Format of SDB Descriptor Records

*TITLE=*title* <no default>

descriptive but brief title for stored data (CHARACTER*72).

TRI-6334-284-0

Figure 7.1. SDBREAD_LIB typically accesses three SDB neutral files exported from the secondary data base tables. These SDB files require descriptor records to be appended to the file or reside in a separate file.

***SDBVERSION=QVV.RRT**

The version of both the secondary data base and SDB neutral field is identified by the *SDBVERSION keyword.

The purpose of the version number is to maintain the capability of tracing the parameters when the PA secondary data base is the primary means of controlling parameter input. Each version of the SDB neutral file is marked with the secondary data base PA version identification (ID) and a QA level prefix. The PA version ID is of the form (Rechard et al., 1992, p. 22):

QVV.RRT

where

- Q** is the SDB neutral file classification (A-Adjudicated, C-Candidate, X-experimental, T-temporary); equivalent to the lowest classification level of a parameter contained in the SDB neutral file; the fourth classification, D for dormant or historical, is used only when 100% of the parameters are historical.
- VV** is a one- or two-digit integer designating the major version number of the secondary data base.
- RR** is a two-digit integer designating the revision number of the secondary data base.
- T** is a two letter identifier designating the type of secondary data base (PR - property file, EL - elevation file, LC - well location file).

The PA version ID changes depending on the type of modification as follows:

- For minor revisions to entries in the secondary data base such as data entry corrections, the revision number (**RR**) is incremented by one.
- For major revisions that substantially change several parameter distributions in the secondary data base, the major version number (**VV**) is incremented by one and the revision number (**RR**) returns to zero.

Parameter Identification Records

The SDBREAD_LIB routines assume that any descriptor record that does not start with an asterisk keyword (e.g., *ENTRY=*name₁, name₂, ...*) is a record identifying the fields required to describe a parameter. The parameter identification records give the name, column boundaries, formats, and expanded name for each field on the SDB neutral file. The column numbers that indicate the begin and end columns for the field are separated by a colon. All remaining information in the descriptor record is separated by one or more blanks. (If the expanded name contains any blanks, enclose the name in single quotes.) (See Section 7.2.4, "Example".)

*** HEADERLINES=*n***

When the SDB neutral file contains additional miscellaneous header records (such as additional comments after the *ENDDSCR record but before the data records), then the number of such "header" records, *n*, must be specified in the descriptor file by HEADERLINES=*n*. Any number of these additional records may precede the data.

*** ENTRY=*name₁, name₂, ...***

Although not required in the secondary data base, the SDB neutral file uses multiple records for model parameters that need more than three points to describe the probability density

function (pdf) or cumulative distribution function (cdf). The *ENTRY keyword flags the names (*name*, *name*, ...) that uniquely identify the distribution. If any of the names in the *ENTRY list change from one record to the next, the SDBREAD_LIB routines assume a new distribution is being described.

*** ENDDSCR**

The descriptor information is terminated by an *ENDDSCR record.

7.2.3 Example of Descriptor Records

```
*TITLE='SDB neutral file of model parameters'
*SDBVERSION = C-3.12PR
*ENTRY=IDMTRL, IDWELL, IDPRAM
  IDMTRL      2:9      A8      'Material ID'
  IDWELL      11:18     A8      'Well ID'
  IDPRAM      20:27     A8      'Parameter ID'
  IDTAB       29:40     A12     'ID of independent variable'
  MEAN        41.52     1PE12.4 'Mean of distribution'
  MEDIAN      53.64     1PE12.4 'Median of distribution'
  LOWRNG      65:76     1PE12.4 'Minimum of distribution'
  HIRNGE      77.88     1PE12.4 'Maximum of distribution'
  PARAM       89:100    1PE12.4 'Parameter value at ind. variable'
  TABVAL      101:112   1PE12.4 'Independent variable value'
  DISTYP      114:125   A12     'Distribution type'
  UNITS       127:138   A12     Units
  INFOSR      140:155   A16     'Parameter source'
  CATALG      157:172   A16     Cataloger
  CHDATE      174:181   A8      'Last change'
*HEADERLINES=3
*ENDSDCR
```

7.2.4 Identification of SDB Neutral Files

As explained in Section 7.2.2, the SDB neutral files are identified by the PA version identification (ID) number plus a QA-level prefix. The QA-level prefix identifies the lowest level of classification of the parameters in the file (excluding class D). The QA classification levels are A (Adjudicated), C (Candidate), X (eXperimental), and D (Dormant or historical). For example, if a file includes both A- and C-level parameters, then the QA-level prefix would be C. The D classification is never used as a QA-level ID for an SDB neutral file unless 100% of the parameters are historical.

In general, parameters in an official SDB neutral file may not be changed. However, two types of parameter files are permitted as subsets of the SDB neutral file: a subset based on QA level (e.g., to generate an A-level only parameter file) and a subset that contains parameters changed by a PA analyst for the purpose of a comparison analysis. The latter subset is used by the PA analyst when he or she needs to compare different parameter values to better understand specific results; for this subset, the subset of modified parameters is designated "T" for temporary.

The values and distributions of the parameters in the SDB neutral file with a T designation are the full responsibility of the PA analyst. If a QA designation standard (A, C, X) is under consideration for this temporary SDB neutral file, then the parameter values and distributions must be adjudicated by the Analysis Review Workshop and/or described in documents that report on the analysis (Rechard et al., 1991, p. 37) (Figure 7.2).

7.3 General Guidelines on the Use of SDBREAD_LIB Routines

7.3.1 Sponsorship and Version

Author/Sponsor: H. J. Iuzzolino
Version:/Date: C-1.20VV/November 1992
Language: FORTRAN 77

7.3.2 Overview of Capabilities and Method

SDBREAD_LIB enables a FORTRAN program to selectively read data from and write data to formatted SDB neutral files without being affected by changes in the number and column position of fields in the file. That is, the number and position of fields in the data base may be changed without having to modify the program reading the SDB neutral files as long as the lengths of the character-type data fields remain unchanged. One file is required by SDBREAD_LIB: a data base neutral file with several descriptor header records appended to the front. Alternatively, the descriptor header records may be in a separate file. The data base neutral file must have a fixed format with the data arranged in columns. The data may be integer, floating, and/or text.

Upon initialization of a data base neutral file, a format for reading or writing a line of data is constructed from the data in a descriptor file (described in Section 7.2.1). When reading, each record of the data base neutral file is read using this format. The data fields are compared to a retrieval condition, and if the condition is true, specified data are returned to the calling program. When writing, data sent by the calling program are converted to a text line using the format and are written to the data base.

7.3.3 Linking

The SDBREAD_LIB routines are in an object library in the [LIBRARIES] subdirectory (see Section 2.10, "Software Libraries"), CAMCON\$ROOT:[LIBRARIES.SDBREAD_LIB]SDBREAD_LIB.OLB. The SDBREAD_LIB sponsor defines the logical symbol SDBREAD_LIB to point to this file. The link command has the following form:

\$LINK *code_name* ..., SDBREAD_LIB/LIB

7.3.4 Error Messages

In all cases, ERROR = TRUE if an error was encountered or FALSE if no error was encountered.

TRI-6342-2157-0

Figure 7.2. Example of data moving from the secondary data base to a CDB neutral file and the various possible identifiers for CAMCON SDB neutral files.

7.3.5 Summary

The following routines are available for general use:

- SDBARES - Compare two text strings
- SDBCASES - Specify case sensitivity
- SDBCLOC - Get the location of a character variable
- SDBFRES - Compare two floating point numbers
- SDBGETF - Retrieve floating point data from a data base
- SDBGETL - Retrieve data of any type from a data base
- SDBIATR - Get the attributes of an identifier
- SDBILOC - Get the location of an integer variable
- SDBINFO - Get data base summary information
- SDBINIT - Prepare a data base for reading or writing
- SDBIRES - Compare two integers
- SDBNINFO - Get identifier names
- SDBNUMDB - Get data base FORTRAN unit number
- SDBPUTL - Write data to a data base
- SDBRLOC - Get the location of a real variable
- SDBSCMP - Compare the values in two text strings
- SDBSKHDR - Skip past the data base header
- SDBRWIND - Rewind the data base file

The following advanced routines are available but use requires an understanding of the internal algorithms of SDBREAD_LIB:

- SDBCONCR - Concatenate pieces of the retrieval condition
- SDBMOV RV - Move the retrieved values into common block SDBRTRVE
- SDBSETRC - Set pointers in the arrays needed to process the retrieval condition
- SDBSETRV - Set up the tables needed to process data retrieval
- SDBTSTRC - Test the retrieval condition on a record of data

7.3.6 Examples

The SDBREAD_LIB routines are called by a user-written program to read or write a data base. Up to ten data bases can be used in one program.

In simplest form, the user:

- Calls SDBINIT to initialize the reading or writing of each data base
- Puts the retrieval restrictions on the data into a character string
- Puts the names of the fields to be fetched into an array
- Puts the location(s) of storage for the retrieved variable(s) into an array
- Calls SDBGETL to get data that satisfies the retrieval condition from the data base

Subroutine SDBPUTL is used to write a new data base file. When writing a new database, any header lines must be in the new data base file before SDBPUTL is called.

In the preceding description, the retrieval condition may be a text string containing one or more expressions of the form ID OP VALUE separated by .AND. or .OR., where ID is the name of a data base identifier, OP is a relational operator, and VALUE is a numeric or text value. ID must be specified in the same case (upper or lower) as it appears in the data base descriptor file. OP must be in the set (.EQ., .NE., .GT., .GE., .LT., .LE., .INCL., .EXCL.). The include and exclude operators (.INCL. and .EXCL.) are used only with text data. ID and VALUE must be of the same type (integer, floating point, or text). Parentheses may be used to group parts of the condition.

For example, the condition “IDMTRL.EQ. DrftSeal.AND. IDPRAM.EQ. DnsBlk” would cause the bulk density (DnsBlk) of the drift seal (DRftSeal) to be retrieved while the condition “IDMTRL.EQ. DrftSeal.OR. IDPRAM.EQ. DnsBlk” would cause all drift seal entries and all bulk density entries to be retrieved. The condition “IDPRAM.EQ. DnsBlk.AND. (MEDIAN.GT. 2000. .OR. MEDIAN.LT. 1000)” would retrieve all entries with median values of bulk density either larger than 2000 or less than 1000.

An example of using several of the SDBREAD_LIB routines follows.

```

PROGRAM SDBLOOK
=====
C
FUNCTION: List secondary data base entries that satisfy a specified
retrieval condition.
=====
C
IMPLICIT NONE
INTEGER MAXNID, MAXRET, NID, NUMDB
PARAMETER (MAXRET=500, MAXNID=20)
INTEGER LOCPUT(MAXNID), LOCRET(MAXNID)
REAL HIRNGE(MAXRET), LOWRNG(MAXRET), MEDIAN(MAXRET), MEAN(MAXRET)
$ SCALE(MAXRET), VRYFRC(MAXRET)
LOGICAL ERROR, GOTALL, RONLY
CHARACTER*8 CHDATE(MAXRET), IDMTRL(MAXRET), IDPRAM(MAXRET),
$ IDWELL(MAXRET), PUTIDN(MAXNID), RETRID(MAXNID)
CHARACTER*12 DBNAME, DISTYP(MAXRET), DTYPE, IDSCAL(MAXRET),
$ UNITS(MAXRET)
CHARACTER*16 CATALG(MAXRET), INFOSR(MAXRET)
CHARACTER*80 CONDIT, DBASE, DBDSCR, FILESP(2)
DATA NUMDB/1/
C
C<><><><><><><><><><>
C...Begin Procedures...
C<><><><><><><><><><>
C
C... Load the start up common with program information
CALL QASETUP('SDBLOOK','X-1.00','09/09/92','H.J. Iuzzolino',
$ 'H.J. Iuzzolino')

```



```

C... Write a welcome banner to the terminal
CALL QABANNER(0,'SDBLOOK',' ',' ')

C... Define the files for FILRDNAMS
CALL FILDFNAM(' Secondary data base:','inp','req'
$           'CAMCON$ROOT:[database]PROPERTY.SDB')
CALL FILDFNAM(' Secondary data base descriptor file:','inp','req',
$           'CAMCON$ROOT:[database]PROPERTY.SDBDSCR')

C... Read names of files defined above
ERROR = .FALSE.
CALL FILRDNAMS(FILESP,ERROR)
IF (ERROR) THEN
    CALL FILWRNAMS(0,FILESP)
    CALL QAABORT('(SDBLOOK) - incorrect file assignments ***)
ENDIF

C... Open the secondary data base:
DBASE      = FILESP(1)
DBSDSCR    = FILESP(2)
DBNAME     = 'OLD'
RDONLY     = .TRUE.
ERROR      = .FALSE.
CALL SDBINIT(DBASE, DBDSCR, DBNAME, NUMDB, RDONLY, ERROR)
IF (ERROR) THEN
    CALL QAABORT ('(SDBINIT) - Failed on secondary data base : '//
$              DBASE//' ***)
endif

C... Save the names of the data base parameters to be retrieved.
NID        = 15
RETRID(1)  = 'IDMTRL'
RETRID(2)  = 'IDWELL'

RETRID(15) = 'CHDATE'

C... Save the locations of the arrays of the data base parameters
C to be retrieved.
LOCRET(1)  = SDBCLOC(IDMTRL)
LOCRET(2)  = SDBCLOC(IDWELL)

LOCRET(15) = SDBCLOC(CHDATE)

C... Request the retrieval condition
100 CALL FFRDLIN(0, 0, ' Enter the retrieval condition (return to '//
$              'quit): ',CONDIT, ERROR)

```

SDBREAD_LIB

General Guidelines on the Use of SDBREAD_LIB Routines

```
        IF (ERROR) THEN
            CALL QAMESSAG(0, 'WARNING', ' Error encountered reading '//
+               'condition (CONDIT)' ****')
        ENDIF
        IF(CONDIT .EQ. ' ') GOTO 200

C... Retrieve NID parameters for each secondary data base entry
110 CALL SDBGETL(DBNAME, CONDIT, MAXRET, NID, RETRID, NFOUND, LOCRET,
$           GOTALL, ERROR)
        IF (NFOUND .EQ. 0) THEN
            CALL QAMESSAG(0, 'WARNING', CONDIT//' -- No entry in the '//
$           'secondary data base ****')          GOTO 100
        ENDIF
        IF (ERROR) THEN
            CALL QAABORT('(SDBGETL) - Errors ****')
        ENDIF

C... Write the data in a form dependent on the distribution type

        IF (.NOT. GOTALL) GOTO 110
        GOTO 100

200 CLOSE(NUMDB)
        STOP 'SDBLOOK Normal Completion'
C=====
C**** END OF PROGRAM SDBLOOK ****
C=====
        END
```

7.4 Description of Routine Calls

7.4.1 General Routines

Descriptions of general routines are given on the following pages. Lengths of character variables are arbitrary unless a length is specified in the “Variables in Call” paragraph of the routine descriptions.

SDBARES
Function

Name	SDBARES - Compare two text strings			
Description	SDBARES returns the logical result (.TRUE. or .FALSE.) of a comparison of two text strings, where the relational operator is a variable and the text strings come from a data base or user input.			
Syntax	logical = SDBARES (AVAR, OP, AVAL, LENAVAL, ERROR) or IF (SDBARES (AVAR, OP, AVAL, LENAVAL, ERROR)) ...			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	AVAR	Input	character	Text string
	OP	Input	character (length≤2)	Symbolic relational operator: =, !=, >, >=, <, <=, @, or !@, where ! means NOT, @ means INCLUDES, and !@ means EXCLUDES
	AVAL	Input	character	Text string
	LENAVAL	Input	integer	Number of characters in AVAL
	ERROR	Output	logical	.FALSE. if OP is in the above list, .TRUE. otherwise.
Return Value	The value of logical expression AVAL OP AVAR.			

SDBCASES

Subroutine

Name	SDBCASES - Specify case sensitivity			
Description	SDBCASES allows the user to specify case sensitivity for the data base DBNAME. The default is case-insensitive comparisons on text fields.			
Syntax	CALL SDBCASES (DBNAME, STATUS, ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	Data base name.
	STATUS	Input	logical	.TRUE. to make comparisons case sensitive. .FALSE. to make comparisons case insensitive.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.

SDBCLOC
Function

Name	SDBCLOC - Return the location of a character variable			
Description	SDBCLOC returns the location in memory of a character variable. SDBCLOC takes the place of the VAX-dependent function %LOC and is available to reduce the amount of machine-dependent coding.			
Syntax	location = SDBCLOC (CVAR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	CVAR	Input	character	Character variable.
Return Value	Memory location of CVAR.			

SDBFRES

Function

Name	SDBFRES - Compare two floating point numbers			
Description	SDBFRES returns the logical result (.TRUE. or .FALSE.) of a comparison of two floating point numbers, where the relational operator is a variable and the floating point numbers come from a data base or user input.			
Syntax	logical = SDBFRES (FVAR, OP, FVAL, ERROR) or IF (SDBFRES (FVAR, OP, FVAL, ERROR)) ...			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FVAR	Input	real	Floating point variable or value
	OP	Input	character (length≤2)	Symbolic relational operator: =, !=, >, >=, <, <=, where ! means NOT
	FVAL	Input	real	Floating point variable or value
	LENAVAL	Input	integer	Number of characters in AVAL
	ERROR	Output	logical	.FALSE. if OP is in the above list, .TRUE. otherwise.
Return Value	The value of logical expression FVAL OP FVAR.			

SDBGETF
Subroutine

Name	SDBGETF - Retrieve floating point (real) data			
Description	SDBGETF returns up to MAXRET real values for each of the NID identifier names in array RETRID provided retrieval condition COND is satisfied.			
Syntax	CALL SDBGETF (DBNAME, COND, MAXRET, NID, RETRID, NFOUND, VAL, GOTALL, ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.
	COND	Input	character	The retrieval condition.
	MAXRET	Input	integer	Count of the maximum lines to be returned. If there may be more data to be returned, GOTALL is set to .FALSE.
	NID	Input	integer	Count of identifiers to be retrieved.
	RETRID	Input	character array (length≤16)	Names of identifiers to be retrieved.
	NFOUND	Output	integer	Count of lines of data that satisfied the retrieval conditions.
	VAL	Output	real array	Values of identifiers that were retrieved. NID times NFOUND values are stored in VAL (NID values for each line).
	GOTALL	Output	logical	.TRUE. if all lines on the data base were checked. .FALSE. if more lines on the data base need to be checked.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.
Comment	SDBGETF will skip over any data base header lines.			

SDBGETL
Subroutine

Name	SDBGETL - Retrieve data of any type			
Description	SDBGETL returns up to MAXRET values for each of the NID identifier names in array RETRID provided retrieval condition COND is satisfied.			
Syntax	CALLSDBGETL(DBNAME,COND,MAXRET,NID,RETRID,NFOUND,LOCVAL,GOTALL,ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.
	COND	Input	character	The retrieval condition.
	MAXRET	Input	integer	Count of the maximum lines to be returned. If there may be more data to be returned, GOTALL is set to .FALSE.
	NID	Input	integer	Count of identifiers to be retrieved.
	RETRID	Input	character array (length≤16)	Names of identifiers to be retrieved.
	NFOUND	Output	integer	Count of lines of data that satisfied the retrieval conditions.
	LOCVAL	Output	integer array	Locations of arrays where retrieved values are stored. NFOUND values are stored in each array whose location is in LOCVAL. There should be NID array locations in LOCVAL.
	GOTALL	Output	logical	.TRUE. if all lines on the data base were checked. .FALSE. if more lines on the data base need to be checked.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.
Comment	SDBGETL will skip over any data base header lines.			

SDBIATR
Subroutine

Name SDBIATR - Return attributes

Description SDBIATR returns the attributes of a data base identifier.

Syntax CALL SDBIATR (DBNAME, IDENT, TYPE, NBYTES, FMT, KOLI, KOLF,
ERROR)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.
	IDENT	Input	character (length≤16)	The name of a data base identifier.
	TYPE	Output	char*4	Type of identifier: CHAR, INT, or REAL.
	NBYTES	Output	integer	Length of the variable corresponding to IDENT, in bytes (integer and real variables always require 4 bytes).
	FMT	Output	char*16	Format for the variable corresponding to IDENT, enclosed in parentheses. The format is taken from the descriptor file.
	KOLI	Output	integer	Starting column on the data base for the IDENT field.
	KOLF	Output	integer	Ending column on the data base for the IDENT field.
	ERROR	Output	logical	.FALSE. if there is no error; .TRUE. if the data base does not exist or if IDENT is not on the data base.

SDBILOC
Function

Name	SDBILOC - Return location of an integer variable			
Description	SDBILOC returns the location in memory of an integer variable. SDBILOC takes the place of the VAX-dependent function %LOC and is available to reduce the amount of machine-dependent coding.			
Syntax	location = SDBILOC (IVAR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IVAR	Input	integer	Integer variable.
Return Value	Memory location of IVAR.			

SDBINFO
Subroutine

Name	SDBINFO - Get data base summary information			
Description	SDBINFO returns general information about a data base.			
Syntax	CALL SDBINFO (DBNAME, NUDB, NLINES, NENTRY, ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.
	NUDB	Output	integer	FORTTRAN unit number assigned to the data base.
	NLINES	Output	integer	Number of lines of data in an existing data base.
	NENTRY	Output	integer	Number of entries in an existing data base.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.

SDBINIT
Subroutine

Name	SDBINIT - Data base read/write initialization			
Description	SDBINIT performs data base initialization for reading or writing. When writing a new data base, the file must exist and contain header information before SDBINIT is called.			
Syntax	CALL SDBINIT (DBASE, DBDSCR, DBNAME, UNITNUM, RDONLY, ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBASE	Input	character (length≤16)	The path and file name of the data base.
	DBDSCR	Input	character	The path and name of the file describing the data base neutral file (data base descriptor file). Normally, DBDSCR is blank, indicating the descriptor information is at the beginning of the data base neutral file.
	DBNAME	Input	character (length≤16)	The name of the data base.
	UNITNUM	Input	integer	User's choice of FORTRAN unit number for the data base. If zero, the number is assigned by SDBINIT as 50 + the data base sequence number.
	RDONLY	Input	logical	.TRUE. if the data base should be opened as read only.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.

SDBIRES
Function

Name	SDBIRES - Compare two integers			
Description	SDBIRES returns the logical result (.TRUE. or .FALSE.) of a comparison of two integers, where the relational operator is a variable and the integers come from a data base or user input.			
Syntax	logical = SDBIRES (IVAR, OP, IVAL, ERROR) or IF (SDBIRES (IVAR, OP, IVAL, ERROR)) ...			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IVAR	Input	integer	Integer variable or value
	OP	Input	character (length≤2)	Symbolic relational operator: =, !=, >, >=, <, or <=, where ! means NOT
	IVAL	Input	character	Integer variable or value
	ERROR	Output	logical	.FALSE. if OP is in the above list, .TRUE. otherwise
Return Value	The value of logical expression IVAL OP IVAR			

SDBNINFO

Subroutine

Name SDBNINFO - Get identifiers

Description SDBNINFO returns identifier names contained in the data base descriptor file.

Syntax CALL SDBNINFO (DBNAME, NUQID, UQID, MAXNIDH, NIDH, IDENT, ERROR)

Variables in Call

<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
DBNAME	Input	character (length≤16)	The name of the data base.
NUQID	Input	integer	Count of identifiers needed to uniquely specify an entry.
UQID	Input	character array (length≤16)	Array of identifiers needed to uniquely specify an entry.
MAXNIDH	Input	integer	Count of maximum number of identifiers to be returned.
NIDH	Output	integer	Count of identifiers defined in the data base header.
IDENT	Output	character array (length≤16)	Array of identifier names.
ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.

SDBNUMDB

Subroutine

Name	SDBNUMDB - Return data base FORTRAN unit number			
Description	SDBNUMDB returns the FORTRAN unit number NUMDB corresponding to the data base DBNAME.			
Syntax	CALL SDBNUMDB (DBNAME, NUMDB, ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.
	NUMDB	Output	integer	The FORTRAN unit number corresponding to the data base specified by DBNAME.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.

SDBPUTL
Subroutine

Name	SDBPUTL - Write data			
Description	SDBPUTL writes values for identifiers IDENT(1) - IDENT(NID) for each of NLINES lines of data to a data base with name DBNAME.			
Syntax	CALL SDBPUTL (DBNAME, NID, IDENT, NLINES, LOCVAL, ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.
	NID	Input	integer	Count of identifiers to be written.
	IDENT	Input	character array (length≤16)	Array of identifier names.
	NLINES	Input	integer	Count of lines of data to be written.
	LOCVAL	Input	integer array	Array of locations of arrays to be written. There should be NID array locations in LOCVAL. NLINES values are written from each array whose location is in LOCVAL.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.
Comment	SDBPUTL will skip over any data base header lines.			

SDBRLOC
Function

Name	SDBRLOC - Locate a real variable			
Description	SDBRLOC returns the location in memory of a real (floating point) variable. SDBRLOC takes the place of the VAX-dependent function %LOC and is available to reduce the amount of machine-dependent coding.			
Syntax	location = SDBRLOC (RVAR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	RVAR	Input	real	Real variable.
Return Value	Memory location of RVAR.			
Comment	SDBPUTL will skip over any data base header lines.			

SDBSCMP

Function

Name	SDBSCMP - Compare the values in two text strings			
Description	The two strings may contain text, integer, or floating point data. SDBSCMP returns -1, 0, or 1, depending on the result of a comparison. For text, SDBSCMP determines whether the first string is identical to the second or whether the first string contains the other. For strings containing numerical data, SDBSCMP determines whether the first value is less than, equal to, or greater than the other.			
Syntax	integer = SDBSCMP (STYPE,STR1,STR2)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	STYPE	Input	character	A, C, or T if the strings are text, I if the strings are integers, or D, E, F, or R if the strings are floating point numbers.
	STR1	Input	character	Character string containing either text, an integer, or a floating point variable.
	STR2	Input	character	Character string containing either text, an integer, or a floating point variable.
Return Value	<p>If STR1 and STR2 contain text:</p> <ul style="list-style-type: none"> -1 if STR1 does not contain STR2 0 if STR1 = STR2 1 if STR1 contains STR2 <p>If STR1 and STR2 contain numeric values:</p> <ul style="list-style-type: none"> -1 if the value in STR1 is less than the value in STR2 0 if the values in STR1 and STR2 are equal 1 if the value in STR1 is greater than the value in STR2 			

SDBSKHDR

Subroutine

Name SDBSKHDR - Skip header

Description SDBSKHDR reads past any header on the data base DBNAME.

Syntax CALL SDBSKHDR (DBNAME, ERROR)

Variables in Call

<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
DBNAME	Input	character (length≤16)	The name of the data base.
ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.

SDBRWIND

Subroutine

Name	SDBRWIND - Rewind data base			
Description	SDBRWIND rewinds a data base. The next user read will read the first header line. Calls to SDBGETL or SDBGETF skip the header lines.			
Syntax	CALL SDBRWIND (DBNAME)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.

7.4.2 Advanced Routines

Brief descriptions of specialized routines are given on the following pages. These routines perform tasks that are necessary to data retrieval but are too specialized to be very useful to most application programmers.

SDBCONCR
Subroutine

Name	SDBCONCR - Concatenate retrieval condition			
Description	SDBCONCR concatenates the retrieval condition identifier and operator fields. This routine can be used to emulate the performance of the FFRDFLDS free-format reader (see subroutine FFRDFLDS in Chapter 8).			
Syntax	CALL SDBCONCR (NFIELD, KV, CV, NCH, IV, RV)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NFIELD	Input/ Output	integer	On entry, the number of fields sent to SDBCONCR. On exit, the number of fields returned by SDBCONCR.
	KV	Input/ Output	integer array	Array indicating the kind of value.
	CV	Input/ Output	character array	Array of character forms of the fields.
	NCH	Input/ Output	integer array	Array of character form lengths.
	IV	Input/ Output	integer array	Array of integer values of the fields.
	RV	Input/ Output	real array	Array of real values of the fields.

SDBMOV RV

Subroutine

Name	SDBMOV RV - Move retrieved values			
Description	SDBMOV RV extracts values to be retrieved from a line of data (LINE) from the data base and puts the values in arrays in common block SDBRTRVE.			
Syntax	CALL SDBMOV RV (LINE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	LINE	Input	character	A complete line of data from the data base.

SDBSETRC

Subroutine

Name	SDBSETRC - Set up retrieval condition			
Description	SDBSETRC sets up variables used to evaluate the retrieval condition CONDIT. This reduces the amount of computation that must be done in subroutine SDBTSTRC.			
Syntax	CALL SDBSETRC (DBNAME, CONDIT, ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.
	CONDIT	Output	character	The retrieval condition.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.

SDBSETRV
Subroutine

Name	SDBSETRV - Set up a table of variable identifier locations and types			
Description	SDBSETRV sets variables (identifier locations and types) related to selective retrieval. The actual return of variables is done by SDBGETF or SDBGETL.			
Syntax	CALL SDBSETRV (DBNAME, NID, RETRID, ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.
	NID	Input	integer	The count of identifiers to be retrieved.
	RETRID	Input	character array (length≤16)	Array of names of identifiers to be retrieved.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.

SDBTSTRC

Subroutine

Name	SDBTSTRC - Test retrieval condition			
Description	SDBTSTRC tests the validity of the latest retrieval condition for the data base line contained in LINE.			
Syntax	CALL SDBTSTRC (DBNAME, LINE, ERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DBNAME	Input	character (length≤16)	The name of the data base.
	LINE	Input	character	A complete line of data from the data base.
	ERROR	Output	logical	.TRUE. if an error was encountered. .FALSE. if no error was encountered.

8. CAMCON_LIB:

Quality Assurance Routine Library

This chapter describes the calls to quality assurance and numerous other routines repeatedly used in software developed specifically for the CAMCON system and collected into a FORTRAN library called CAMCON_LIB. The purpose of CAMCON_LIB is to simplify coding and to standardize the user interface to all programs.

8.1 General Guidelines on Use

8.1.1 Sponsorship and Version

<i>Authors:</i>	A. F. Gilkey, J. S. Rath, D. K. Rudeen, D. W. Osborn, H. J. Iuzzolino, and W. C. Mills-Curran
<i>Sponsor:</i>	A. P. Gilkey
<i>Version / Date:</i>	C-2.00VV/ March 1993
<i>Language:</i>	FORTRAN 77

8.1.2 Linking

CAMCON_LIB is intended to be used in conjunction with the CAMSUPES_LIB library, which includes dynamic memory management and common machine-specific routines. As assigned by the library sponsor, the logical symbol for CAMCON_LIB is CAMCON_LIB; hence, to link this library to another code, type

\$LINK *code_name*, CAMCON_LIB/LIB, CAMSUPES_LIB/LIB

A FLINT library for CAMCON_LIB is available for checking interfaces. It is in CAMCON\$ROOT:(LIBRARIES.CAMCON_LIB)CAMCON_LIB.LBT (see Section 12.5 for more information about the FLINT library).

8.1.3 Error Messages

CAMCON_LIB assumes that there is a diagnostic file where error messages are to be written. The user needs to set this file unit with the function IQAERRUNI. The user can retrieve this unit with IQAERRUNI (-1). If no file is defined or if this unit is 0, output is written to the terminal or standard output device (SYS\$OUTPUT on the VAX) with a "WRITE (*,...)" statement.

8.1.4 Summary

The CAMCON_LIB routines are described in detail in the next section. The following is a summary of the CAMCON_LIB routines.

QA and User Interface Routines

- IQAERRUNI - Define diagnostics file unit
- QAABORT - Abort program and print error message to terminal and diagnostics file (if desired)
- QABANNER - Print code banner and list credits (authors and code origin)
- QABATCH - Return batch or interactive flag
- QAEIGLET - Print characters (e.g., code name) in big letters
- QACPUS - Print CPU seconds used
- Q:DOEDIS - Print standard DOE legal disclaimer
- QAFETCH - Return the program QA information
- QAMAKREC - Assemble QA record to identify code on CAMDAT file
- QAMAXERR - Check integer value against maximum
- QAMEMERR - Check dynamic memory error
- QAMESSAG - Print message of a specified type
- QAPAGE - Print QA information on output file (code name, software ID, and date)
- QAPRTSTR - Print message
- QASETUP - Startup program and place code name, software ID, revision date, current date and time, software author, and software sponsor into a common block for use by other routines

File Processing Routines

- FILCMDLIN - Read and parse command line
- FILDFNAM - Define a file for use by FILRDNAMS
- FILECHO - Read formatted file and write listing
- FIOPEN - Open a file
- FILPARSE - Create file name from input and default names
- FILRDNAMS - Read the files defined by FILDFNAM
- FILWRNAMS - Write the file names read by FILRDNAMS

Free-Field Input Routines

- FFGETLIN - Return line read by free-field routine
- FFPAREQN - Equation parsing routine
- FFPARSE - Free-field parsing routine (called by FFRDFLDS)
- FFRDFLDD - Free-field input routine (double precision)
- FFRDFLDG - Free-field input routine (double precision)
- FFRDFLDS - Free-field input routine (single precision)
- FFRDKEY - Free-field keyword-parameter input routine
- FFRDLIN - Get literal input line

String Processing Routines

- ISTRFIND - Find string in list
- ISTRLEN - Return string length
- STRCMPRS - Remove extra blanks from string

- STRLIMIT - Strip leading/trailing blanks
- STRPACK - Remove all blanks from string
- STRUPCASE - Convert string to upper case

Common Internal Routines

- FEELEM - Calculate element number associated with node
- FEIJK - Determine I,J,K index from node/element number
- FEMINMAX - Calculate min/max value
- FENENUM - Determine node/element number from I,J,K index

Obsolete Routines

- ABORT - Replaced by QAABORT
- BANNER - Replaced by QABANNER
- BATCH - Replaced by QABATCH
- BIGLET - Replaced by QABIGLET
- DEFFIL - Replaced by FILDFNAM
- DOEDIS - Replaced by QADOEDIS
- ECHO - Replaced by FILECHO
- ELEM - Replaced by FEELEM
- FFISTR - Replaced by FFPARSE
- FILDAT - Replaced by EXFILDAT (in CAMSUPES_LIB)
- FPARSE - Replaced by FILPARSE
- FREDBLD - Replaced by FFRDFLDD
- FREDBLG - Replaced by FFRDFLDG
- FREFLD - Replaced by FFRDFLDS
- FRELIN - Replaced by FFGETLIN
- GETINP - Replaced by FFRDLIN
- GETPRG - Replaced by QAFETCH
- IJK - Replaced by FEIJK
- ISTOUT - Replaced by IQAERRUNI
- LENSTR - Replaced by ISTRLEN
- LOCSTR - Replaced by ISTRFIND
- MAXERR - Replaced by QAMAXERR
- MEMERR - Replaced by QAMEMERR
- MINMAX - Replaced by FEMINMAX
- NENUM - Replaced by FENENUM
- OPNFIL - Replaced by FIOPEN
- PCKSTR - Replaced by STRPACK
- PRTMSG - Replaced by QAMESSAG
- PRTOUT - Replaced by QAPRTSTR
- QAPAGE - Replaced by QAPAGE
- QASSMB - Replaced by QAMAKREC
- RDCMDL - Replaced by FILCMDLIN
- RDFNAM - Replaced by FILRDNAMS
- SQZSTR - Replaced by STRCMPRS
- STRIPB - Replaced by STRLIMIT
- STRTUP - Replaced by QASETUP
- UPCASE - Replaced by STRUPCASE
- WRCBUS - Replaced by QACBUS
- WRFNAM - Replaced by FILWRNAMS

8.1.5 Example

The opening sections of most programs should be similar. The following code segment provides an example of the opening section.

```

C...  Load the/CAMCON_LIB/ common with the program information
      CALL QASETUP ('TESTPROG', 'X-1.00', '01/15/90'.
      $          'A. P. Gilkey', 'A. P. Gilkey')

C...  Write a welcome banner to the terminal
      CALL QABANNER (0, 'CAMCON_LIB test program', ' ', ' ')

C...  Define the files for FILRDNAMS
      CALL FILDFNAM ('CAMDAT data base', 'in', 'req', 'CAMDAT.CDB')
      CALL FILDFNAM ('output CAMDAT data base', 'out', 'req',
      $  'CAMDAT.CDB')
      CALL FILDFNAM ('diagnostics file', 'out', 'opt', 'TEST.DBG')

C...  Read in the names of the files defined above
      CALL FILRDNAMS (FILESP, IERR)
C...  If the file names could not be read, write the file assignments
C...  and abort
      IF (IERR .NE. 0) THEN
        CALL FILWRNAMS (0, FILESP)
        CALL QAABORT ('Incorrect file assignments')
      END IF

C...  If the optional diagnostics file is requested, open the file
      IF (FILESP(3) .NE. ' ') THEN
        NOUT = 6
        CALL FIOPEN (NOUT, 'OUT', 'FORM', FILESP(3), IERR)
      ELSE
        NOUT = 0
      END IF

C...  Set the unit number of the diagnostics file (may be the terminal)
      IDUM = IQAERRUNI (NOUT)

      IF (NOUT .GT. 0) THEN
C...  Write the header to the diagnostics file, including the page header,
C...  the welcome banner, the DOE disclaimer, and the file assignments
        CALL QAPAGE (NOUT, ' ')
        CALL QABANNER (NOUT, ' ', ' ', ' ')
        CALL QADOEDIS (NOUT, '**')
        CALL FILWRNAMS (NOUT, FILESP)
      ENDIF

```


An example of a diagnostics file header generated by this program segment is shown below.

```

TESTPROG 1.00VV (01/15/90)                                     11/09/92 13:04:38

  TTTTTT  EEEEEEE  SSSSSS  TTTTTT  PPPPPP  RRRRRR  OOOOOO  GGGGG
    TT    EE      SS      TT    PP  PP  RR  RR  OO  OO  GG
    TT    EEEEE  SSSSS  TT    PPPPPP  RRRRRR  OO  OO  GG
    TT    EE      SS      TT    PP      RRRRR  OO  OO  GG  GGG
    TT    EE      SS      TT    PP      RR  RR  OO  OO  GG  GG
    TT    EEEEEEE SSSSSS  TT    PP      RR  RR  OOOOO  GGGGG

                                Version 1.00VV
                                Revised 01/15/90
                                Written by A. P. Gilkey
                                Sponsored by A. P. Gilkey

                                Run on 11/09/92 at 13:04:38
*****
Prepared for
Sandia National Laboratories
Albuquerque, New Mexico 87185-5800
for the United States Department of Energy
under Contract DE-AC04-76DP00789
*****

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                                -----

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*****

FILE ASSIGNMENTS:
-----
CAMDAT data base file:
  U2:[APGILKE.CAMDAT]CAMDAT.CDB;1
  Written on 05/31/90 14:22:29
output CAMDAT data base file:
  U2:[APGILKE.PROGRAMS.CAMCON_LIB]CAMDAT.CDB
diagnostics file:
  U2:[APGILKE.PROGRAMS.CAMCON_LIB]TEST.DBG

```

8.2 Description of Routine Calls

8.2.1 QA and User Interface Routines

Detailed descriptions of the ten routines for properly identifying the software and providing a uniform user interface are given on the following pages.

IQAERRUNI***Integer Function***

Name	IQAERRUNI - Define or return diagnostics file unit number			
Description	IQAERRUNI defines the diagnostics file unit number. IQAERRUNI returns the new unit number. If the given unit number is negative, IQAERRUNI returns the current unit number without resetting it. If this routine is not called the standard output device is the default diagnostics file.			
Syntax	integer = IQAERRUNI (IUNIT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The output file unit: >0 for unit number for the diagnostics file =0 for the standard output device <0 to return the unit number for the diagnostics file without resetting

QAABORT
Subroutine

Name	QAABORT - Abort program			
Description	QAABORT prints a fatal error message to the terminal and to the diagnostics file (if defined). It then aborts the program (with EXIT code 46).			
	QAABORTP prints a program (versus a fatal) error message. A program error indicates a program bug and instructs the user to contact the code sponsor.			
Syntax	CALL QAABORT (ERRMSG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ERRMSG	Input	char*(*)	The error message.

QABANNER**Subroutine**

Name	QABANNER - Print program banner			
Description	QABANNER prints the program banner to the terminal or an output file. The banner includes the program name in large letters, the program description, the version date, the author, the sponsor, and the current run date and time. QASETUP must be called to set up the CAMCON_LIB common block before QABANNER is called.			
Syntax	CALL QABANNER (IUNIT, LINE1, LINE2, LINE3)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The output file unit: >0 for output to file unit IUNIT =0 for the standard output device <0 for the defined diagnostics file.
	LINE <i>n</i>	Input	char*(*)	The three-line program description.
See Also	QASETUP, IQAERRUNI			

QABATCH
Logical Function

Name	QABATCH - Return batch versus interactive flag
Description	QABATCH returns .TRUE. if the program is in the batch mode and .FALSE. if in the interactive mode. The function should be declared LOGICAL in any routine that calls it.
Syntax	logical = QABATCH ()

QABIGLET

Subroutine

Name	QABIGLET - Print line in big letters			
Description	QABIGLET prints the input line in big letters to the terminal or an output file.			
Syntax	CALL QABIGLET (IUNIT, NCOLS, INLINE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The output file unit: >0 for output to file unit IUNIT =0 for the standard output device <0 for the defined diagnostics file
	NCOLS	Input	integer	The maximum number of columns (usually 80).
	INLINE	Input	char*(*)	The input line; a maximum of NCOLS/9 characters are printed.
See Also	QABANNER			

QACPUS
Subroutine

Name	QACPUS - Print CPU seconds used			
Description	QACPUS prints the approximate number of CPU seconds used so far to the terminal or an output file. QASETUP must be called at the start of the program to initialize the CPU seconds.			
Syntax	CALL QACPUS (IUNIT, CPUSEC)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The output file unit: > 0 for output to file unit IUNIT = 0 for the standard output device < 0 for the defined diagnostics file
	CPUSEC	Output	real	The number of CPUseconds used so far (accurate to 0.01 seconds on the VAX).

QADOEDIS
Subroutine

Name	QADOEDIS - Print standard DOE disclaimer			
Description	QADOEDIS prints the Sandia DOE contract statement and the DOE disclaimer to the terminal or an output file.			
Syntax	CALL QADOEDIS (IUNOUT, CONTR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNOUT	Input	integer	The output file unit: >0 for output to file unit IUNOUT =0 for the standard output device <0 for the defined diagnostics file
	CONTR	Input	char(*)	The DOE contract number. If CONTR is '*', the contract number DE-AC04-76DP00789 is printed; if CONTR is ' ', the contract statement is not printed.

QAFETCH

Subroutine

Name	QAFETCH - Return the program QA information			
Description	QAFETCH returns the program QA information. QASETUP must be called to set up the CAMCON_LIB common block before QAFETCH is called.			
Syntax	CALL QAFETCH (TPROG, TVERS, TDATE, TRDAT, TRTIM, TAUTH, TSPON)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	TPROG	Output	char*(*)	Program name.
	TVERS	Output	char*(*)	Program version number.
	TDATE	Output	char*(*)	Program revision date (mm/dd/yy).
	TRDAT	Output	char*(*)	Program run date (mm/dd/yy).
	TRTIM	Output	char*(*)	Program run time (hh:mm:ss).
	TAUTH	Output	char*(*)	Program author.
	TSPON	Output	char*(*)	Program sponsor.
See Also	QASETUP			

QAMAKREC

Subroutine

Name	QAMAKREC - Assemble QA record for program			
Description	QAMAKREC assembles a QA record for the program run. QASETUP must be called to set up the CAMCON_LIB common block before QAMAKREC is called.			
Syntax	CALL QAMAKREC (NQAREC, QAREC)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NQAREC	I/O	integer	The number of QA records (incremented by QAMAKREC).
	QAREC	I/O	char*8	The QA records: QAREC(n,NQAREC+1). QAREC (n,NQAREC+1) is set by QAMAKREC. The QA records (first array subscript n) are as follows: 1. Analysis code name 2. Analysis QA code descriptor 3. Analysis date 4. Analysis time
See Also	QASETUP and in CAMDAT_LIB: DBIQAREC, DBOQAREC, DBPQAREC			

QAMAXERR
Logical Function

Name	QAMAXERR - Check integer value against maximum			
Description	QAMAXERR checks an integer value against a maximum value. It returns .TRUE. if and only if the value is greater than the maximum. If the value is over the maximum, an error message is printed and QAABORT is called (if requested). The function should be declared logical in any routine which calls it.			
Syntax	logical = QAMAXERR (DOABRT, INTNAM, MAXNAM, INTVAL, MAXVAL)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DOABRT	Input	logical	QAABORT is called when the check fails only if DOABRT is .TRUE.
	INTNAM	Input	char*(*)	The description of the value being checked.
	MAXNAM	Input	char*(*)	The variable name of the maximum value.
	INTVAL	I/O	integer	The value.
	MAXVAL	input	integer	The maximum value.
See Also	QAABORT			

QAMEMERR
Logical Function

Name	QAMEMERR - Check dynamic memory error			
Description	QAMEMERR returns .TRUE. if and only if there is a dynamic memory error. If there is an error, an error message is printed and QAABORT is called (if requested). The function should be declared logical in any routine that calls it.			
Syntax	logical = QAMEMERR (DOABRT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DOABRT	Input	logical	QAABORT is called when the check fails only if DOABRT is .TRUE.
See Also	QAABORT			

QAMESSAG

Subroutine

Name	QAMESSAG - Print message of a specified type			
Description	QAMESSAG prints a message to the terminal or an output device.			
Syntax	CALL QAMESSAG (IUNIT, MSGTYP, MSG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The output file unit: > 0 for output to file unit IUNIT = 0 for the standard output device < 0 for the defined diagnostics file
	MSGTYP	Input	char*(*)	The type of message (all characters are checked; case is unimportant): FATAL - a fatal error message PROGRAM - a program error message ERROR - an error message WARNING - a warning CMDERR - a user input error message CMDWARN - a user input warning CMD - a user input message CENTER - a centered message CONT - a continuation line blank - a message If a message type is preceded by a +, a blank line is printed before the message is printed.
	MSG	Input	char*(*)	The message.
See Also	QAPRTSTR			

QAPAGE**Subroutine**

Name	QAPAGE - Print QA information on output file			
Description	QAPAGE should be called to start each page of output and to end the output file. It starts a new page (except for the first call) and puts the QA information (program name, run time, etc.) at the top of each page. A page number (which is maintained internally) may be printed in the header. At the the end of the file, it puts the ending QA information. QASETUP must be called to set up the CAMCON_LIB common block before QAPAGE is called.			
Syntax	CALL QAPAGE (IUNIT, FLAG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The output file unit: >0 for output to file unit IUNIT =0 for the standard output device <0 for the defined diagnostics file
	FLAG	Input	char*(*)	The type indicator (only the first character is checked; case is unimportant): blank - print at the top w/ no page number PAGE - print at the top w/ page number END - print ending QA information
See Also	QASETUP			

QAPRTSTR
Subroutine

Name	QAPRTSTR - Print message			
Description	QAPRTSTR prints a message to the terminal or an output device.			
Syntax	CALL QAPRTSTR (IUNIT, MSG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The output file unit: >0 for output to file unit IUNIT =0 for the standard output device <0 for the defined diagnostics file
	MSG	Input	char*(*)	The message.
See Also	QAMESSAG			

QASETUP
Subroutine

Name	QASETUP - Startup routine for a code			
Description	<p>QASETUP initializes details common to all programs. QASETUP should be called at the start of any program. (Several of the other CAMCON_LIB routines assume that the CAMCON_LIB common area contains information about the code, such as code name. If you need to access information in the CAMCON_LIB common area, use the routine QAFETCH.)</p> <p>Specifically, QASETUP does the following:</p> <ul style="list-style-type: none"> • Initializes the CPU time • Adds the machine specifier to the code version • Sets the current run date and time • Starts a new page on the terminal • Sets the CAMCON_LIB common area with the information passed via the parameters INPROG, INVERS, INDATE, INAUTH, and INSPON, and the current date (mm/dd/yy) and time (hh:mm:ss) of the run 			
Syntax	CALL QASETUP (INPROG, INVERS, INDATE, INAUTH, INSPON)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INPROG	Input	char*(*)	Code name (up to 12 characters).
	INVERS	Input	char*(*)	Code version number without computer or operating system (for example, C-1.00).
	INDATE	Input	char*(*)	Code revision date (mm/dd/yy).
	INAUTH	Input	char*(*)	Code author (may be omitted if same as sponsor) (up to 80 characters).
	INSPON	Input	char*(*)	Code sponsor (up to 80 characters).
See Also	QABANNER, QAFETCH, QAMAKREC			

8.2.2 File Processing Routines

Detailed descriptions of the twelve routines for reading and writing file names and contents are given on the following pages.

FILCMDLIN**Subroutine**

Name	FILCMDLIN - Read and parse command line			
Description	<p>FILCMDLIN reads and parses the command line fields. Fields may be enclosed by quotes (which are stripped).</p> <p>When command line arguments are used, the program must be run as a "foreign command." If the executable is PROG.EXE, define it as a foreign command by the assignment</p> <pre>PROG == "\$disk:[dir]PROG"</pre> <p>To run the program with command line arguments, type</p> <pre>PROGarg1 arg2 arg3</pre> <p>Note:</p> <ol style="list-style-type: none">1. No commas between arguments.2. To omit an argument, (e.g., to select a default value within the program) the argument should be "" (consecutive double quotes).			
Syntax	CALL FILCMDLIN (MAXFLD, NUMFLD, FIELDS)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	MAXFLD	Input	integer	The maximum number of command line arguments to be read.
	NUMFLD	Output	integer	The number of fields read, including null arguments.
	FIELDS	Output	char*(*)	The command line fields: FIELDS(NUMFLD).
See Also	FILRDNAMS			

FILDFNAM

Subroutine

Name	FILDFNAM - Define a file for use by RDFILN			
Description	FILDFNAM defines a file whose name will be read by FILRDNAMS. Each time FILDFNAM is called, a file description is added to a table used by FILRDNAMS.			
Syntax	CALL FILDFNAM (FILDSC, INOUT, OPTREQ, DEFSPC)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FILDSC	Input	char*(*)	The file description for prompts and messages
	INOUT	Input	char*(*)	The file status (only the first character is checked; case is unimportant): INPUT - an input file OUTPUT - an output file TEXT - a non-file entry (text string)
	OPTREQ	Input	char*(*)	The optional/required file flag (only the first character is checked; case is unimportant): OPTIONAL -for an optional file REQUIRED -for a required file
	DEFSPC	Input	char*(*)	The default file name.
See Also	FILRDNAMS			

FILECHO
Subroutine

Name	FILECHO - Read formatted file and write listing			
Description	FILECHO reads a formatted ASCII input file and echoes the file, line by line, to a formatted listing file. FORTRAN carriage control is added to the beginning of each line. The listing may optionally include line numbers and paging.			
Syntax	CALL FILECHO (IUNINF, IUNFMT, FLAG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNINF	Input	integer	Input file unit.
	IUNFMT	Input	integer	Output file unit.
	FLAG	Input	char*(*)	Listing type indicator (only the first character is checked; case is unimportant): blank - echo the file NUMBER - echo the file with line numbers PAGE - echo the file with line numbers and paging
Limitations	FILECHO writes only the first 128 characters from an input file record.			

FILOPEN
Subroutine

Name	FILOPEN - Open a file			
Description	FILOPEN opens an input or output file. The file is rewound after opening.			
Syntax	CALL FILOPEN (IUNIT, INOUT, FORMT, INFILE, IERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The file unit number.
	INOUT	Input	char(*)	The file status (only the first character is checked; case is unimportant): INPUT - an input file (status = old) OUTPUT - an output file (status = new) SCRATCH - a scratch file (status = scratch)
	FORMT	Input	char(*)	The file form (only the first character is checked; case is unimportant): FORMATTED - a formatted file UNFORMATTED - an unformatted file LISTING - formatted file with no FORTRAN carriage control
	INFILE	Input	char(*)	The file name; if INFILE is ' ', EXNAME of CAMSUPES_LIB is called with the unit number to get the file name
	IERROR	Output	integer	The returned OPEN error status; 0 if no error

FILPARSE
Subroutine

Name	FILPARSE - Create a new file name from input and default			
Description	FILPARSE takes an input file name and a default file name and creates an output file name by substituting the input fields into the default file name. Either the file name or a requested field are returned.			
Syntax	CALL FILPARSE (FIELD, INNAM, DEFNAM, OUTNAM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FIELD	Input	char(*)	The requested file fields (only the first 3 characters are checked; case is unimportant): blank -return the entire file name DISK -return the disk name DIRECTORY -return the directory name NAME -return the base file name EXTENSION -return the extension VERSION -return the version
	INNAM	Input	char(*)	The input file name.
	DEFNAM	Input	char(*)	The default file name.
	OUTNAM	Output	char(*)	The output file name or field (see FIELD).

FILRDNAMS

Subroutine

Name	FILRDNAMS - Read the files defined by FILDFNAM			
Description	<p>FILRDNAMS requests the names of all files previously defined by FILDFNAM. The file names are read from the command line. Any file names not found on the command line are requested from the user (if running interactively). If the file is an input file, it must exist.</p> <p>Some special inputs for the file names are allowed:</p> <ul style="list-style-type: none"> • CANCEL specifies that a file (which must be optional) is not needed • INTERACTIVE specifies that the input will be entered interactively (if allowed) • DEFAULT requests that the specified file (and all following files if this is the last entry on the command line) should use the default 			
Syntax	CALL FILRDNAMS (FILTBL, IERROR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FILTBL	Output	char*(*) array	The returned file names. (' ' for an optional file that is not needed, INTERACTIVE for interactive).
	IERROR	Output	integer	Returned > 0 if and only if the returned file names are not correct; if running interac- tively, this flag should always be 0.
See Also	FILDFNAM, FILWRNAMS, FILCMDLIN			

FILWRNAMS**Subroutine**

Name	FILWRNAMS - Write the file names read by FILRDNAMS			
Description	FILWRNAMS writes the file names defined by FILDFNAM and read by FILRDNAMS to the terminal or an output file.			
Syntax	CALL FILWRNAMS (IUNIT, FILTBL)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FILTBL	Input	char*(*) array	The file names.
	IUNIT	Input	integer	The output file unit: > 0 for output to file unit IUNIT = 0 for the standard output device < 0 for the defined diagnostics file
See Also	FILDFNAM, FILRDNAMS			

8.2.3 Free-Field Input

Syntax Rules. The syntax rules for the free-field input structure are listed below. This syntax describes how input records/strings are parsed into data fields. Both the end user and the applications programmer should clearly understand these few rules (see also Section 4.3, "Parameter Input").

1. A data field is any sequence of data characters within an input line. A data field is broken by (does not include) any non-data character or the end of the input line. A non-data character is a field separator, a comment indicator, or a continuation indicator. Any other character is a data character.
2. A field separator is a comma (,), an equal sign (=), or a series of one or more spaces not adjacent to another separator. Tabs are treated as spaces.
3. An exclamation point (!) indicates a comment. All characters after and including the comment indicator are ignored.
4. An ampersand (&) preceded by a separator indicates that the next input record/string will be treated as a continuation of the current line. All characters after and including the continuation indicator on the current line are ignored. Multiple records/strings that are "joined" by continuation indicators are treated as a single logical record.
5. A null field does not contain any data characters. A null field can be defined explicitly only by a field separator (spaces cannot act as a field separator for an explicit null field). Fields that are not defined on the input line are implicitly null.
6. Lowercase letters not contained in a quoted string are converted to uppercase.
7. A numeric field is a data field which adheres to an ANSI FORTRAN numeric format. A numeric field cannot be longer than 32 characters. A numeric field always defines a REAL (floating point) value; it also defines an INTEGER (fixed point) value if it adheres to a legal INTEGER format.
8. A quoted string is a data field in which the apostrophe (') or the quotation mark (") is the first nonblank character. An internal quote is indicated with two consecutive quote characters. If an end quote character is not included, then the remainder of the record (excluding any trailing blanks) is treated as part of the quoted string. Within a quoted string, no character conversion to uppercase is performed. Delimiters (other than quotes) are treated as part of the string. Interpretation of data to numeric data will be performed, if possible.
9. A data field that does not begin with the quote character, but has a quote within the field (e.g., MOM'S) is not considered a quoted string. In this case, the internal quote is not a special character.
10. The maximum length of an input record (FFRDFLDS only) is 132 characters. Input strings to FFPARSE may be any length.

Some important points that are not obvious from the above rules are noted below.

- Spaces have no significance except when they act as field separators.

- Only the first occurrence of a comment or continuation character is significant; subsequent characters are considered part of the comment.
- A blank line has no data fields.
- If no data characters appear after the last field separator, the field after that separator will not be counted.
- The free field clearly distinguishes between integer and real values. (Using Ivars = RVALUE() overrides this and permits users to input values with or without a decimal point, a capability that is sometimes useful.)

Free-Field Input Examples. The following two examples illustrate the operation of the FFRDFLDS routines in the CAMCON_LIB library.

Example 1

Input record:

```
'Quoted strings ',quotes's,, '50', '!*,=''' ! The rest is comment
```

Results returned from FFRDFLDS:

NFIELD = 5

I	KVALUE(I)	CVALUE(I)	RVALUE(I)	IValue(I)
1	0	Quoted#strings##	0.000E+00	0
2	0	QUOTES'S#####	0.000E+00	0
3	-1	#####	0.000E+00	0
4	0	50#####	0.000E+00	0
5	0	!*,='''#####	0.000E+00	0
6	-1	#####	0.000E+00	0

Example 2

The following example illustrates the use of the CAMCON_LIB free-field input parser in more detail. Shown below is a fragment of a typical input file, a table of values returned by the routine FFRDFLDS and a fragment of FORTRAN source code used to interpret those values. A couple of cautions are worth further discussion. It is important that the coding logic be able to distinguish between parameters and values (the equal sign has no special significance to the parser). For example, the string 'POROSITY' is used both as a parameter and a value in fields 4 and 5. Poor coding logic such as a DO-loop scanning all fields would pick up the second occurrence as a keyword. Care must also be exercised

when picking the number of unique characters allowed for parameter abbreviation, particularly when new input parameters are added to existing code.

The free-field parser allows for simple programming for user as well as programmer convenience. In the CAMCON system, input values are often defined in data base files (e.g., PROPERTY.SDB or CAMDAT) and must be accessed by name. However, it sometimes becomes necessary to override them with a value. The KVALUE array provides this flexibility.

Another user convenience can be implemented by setting integer values with the RVALUE array rather than the IVALUE array. This allows the user to input integers with or without a decimal point. Using IVALUE forces the user to input integers without a decimal point.

Input Records:

```
*MATERIAL
ATTRIBUTE HYCND_X=1.0E-12, POROSITY=POROSITY &      ! Only these two lines
          LRAND=1, 50                                ! are parsed below
PROPERTY  MATRIX_RD=RTRD, FRACTURE_RD=1.0
```

Record as parsed by FFRDFLDS:

NFIELD = 8

I	CVALUE(I)	KVALUE(I)	RVALUE(I)	IValue(I)
1	ATTRIBUTE	0	0.	0
2	HYCND_X	0	0.	0
3	1.0E-12	1	1.0E-12	0
4	POROSITY	0	0.	0
5	POROSITY	0	0.	0
6	LRAND	0	0.	0
7	1	2	1.0	1
8	50	2	50.0	50

FORTTRAN code fragment used to read input record:

```
C ...Read next record
10 CALL FFRDFLDS(KIN, KOUT, PROMPT, MFIELD, IOSTAT, NFIELD,
+              KVALUE, CVALUE, IVALUE, RVALUE)

C ...EOF encountered, all done
  IF (IOSTAT .LT. 0) THEN
    RETURN

C ...error, stop
  ELSEIF (IOSTAT .GT. 0) THEN
    STOP 'ERROR reading properties'
  ELSE

C ...I is field pointer
  I = 1
  IF (CVALUE(1)(1:4) .EQ. 'ATTR') THEN
20    I = I + 1
C    ...porosity
      IF (CVALUE(I)(1:5) .EQ. 'POROS') THEN

        I = I + 1
C        ...field is a string, use it to get porosity from DB
          IF (KVALUE(I) .EQ. 0) THEN
            NAMPHI = CVALUE(I)

C        ...field is a number, save it
          ELSE
            VALPHI = RVALUE(I)
            NAMPHI = ' '
          ENDIF

C        ...X-component of Hydraulic conductivity
          ELSEIF (CVALUE(I) (1:7) .EQ. 'HYCD_X') THEN

            I = I + 1
C            ...field is a string, save it to get value from DB
              IF (KVALUE(I) .EQ. 0) THEN
                NAMKXX = CVALUE(I)

C            ...field is a number, use it
              ELSE
                VALKXX = RVALUE(I)
                NAMKXX = ' '
              ENDIF
```

```
C      ...element range
      ELSEIF (CVALUE(I)(1:5) .EQ. 'LRANG') THEN
        I = I + 1
        IF (KVALUE(I) .GT. 0) THEN
          LSTRT = RVALUE(I)
        ELSE
          STOP ' LRange ERROR'
        END

        I = I + 1
        IF (KVALUE(I) .GT. 0) THEN
          LSTOP = RVALUE(I)
        ELSE
          STOP ' LRange ERROR'
        END

      ELSE
        WRITE(6,*) CVALUE(I), ' is not a keyword'
      ENDIF
C      ...process next field
      IF (I .LT. NFIELD) GO TO 20

      ELSEIF (CVALUE(1)(1:4) .EQ. 'PROP') THEN

//
C      ...field 1 is level 1 keyword, all done with this input block
      ELSEIF (CVALUE(1)(1:1) .EQ. '*') THEN
        BACKSPACE KIN
        GO TO 30

C      ...field 1 is not a recognized keyword
      ELSE
        WRITE(*,*) CVALUE(1), ' is not a keyword'
        STOP 'unrecognized keyword'
      ENDIF

C      ...process a new record
      GO TO 10

C      ...finished processing this block of input data
      30 CONTINUE

//
```

Free-Field Input Routines. The user interface to the CAMCON_LIB free field input system consists of two subroutines: FFRDFLDS and FFPARSE. Both routines perform parsing functions of strings. The main difference is that FFRDFLDS gets its input from a FORTRAN I/O unit while FFPARSE gets its input from a character string. In fact, FFRDFLDS uses FFPARSE to perform parsing functions once FFRDFLDS has read a record.

FFGETLIN
Subroutine

Name FFGETLIN - Return the line read by a free-field routine

Description FFGETLIN returns the line read by the last free-field input routine called.

Syntax FFGETLIN (RETLIN)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	RETLIN	Output	char*(*)	The line read by the free-field input routine.

See Also FFRDFLDS, FFRDKEY

FFPAREQN
Subroutine

Name	FFPAREQN - Equation parsing routine			
Description	<p>FFPAREQN converts a line to uppercase and parses the line into individual fields. A field is one of the following:</p> <p>A number - starts with 0-9 or a decimal point (.) and continues with 0-9, a decimal point (.), or an exponent (E, E+, or E-)</p> <p>A name - starts with A-Z and continues with A-Z, 0-9, or underscores (_)</p> <p>A non-number or non-name character; ** is converted to ^.</p>			
Syntax	CALL FFPAREQN (STVERB, LINE, MAXFLD, IDCONT, NUMFLD, INTYP, CFIELD, IFIELD, RFIELD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	STVERB	Input	logical	This variable is true if and only if the input line starts with a command verb that must be stripped from the equation line.
	LINE	Input/ Output	char*(*)	The input string, which is returned with the command verb stripped if STVERB is true.
	MAXFLD	Input	integer	Maximum number of data fields to be returned.
	IDCONT	Input	integer	Continuation flag (0 = no continuation).
	NUMFLD	Output	integer	Number of data fields found.
	INTYP	Output	integer	Translation states of the data fields: INTYP (MAXFLD) -1 = a null field 0 = a nonnumeric field 1 = a real numeric field 2 = an integer numeric field 3 = a character string
	CFIELD	Output	char*(*)	Character values of the data fields: CFIELD (MAXFLD)
	IFIELD	Output	integer	Integer values of the data fields: IFIELD (MAXFLD)
	RFIELD	Output	real	Floating-point values of the data fields: RFIELD (MAXFLD)

FFPAREQN
Subroutine

See Also | FFRDFLDS for a more complete description of some of the variables in the call

FFPARSE***Subroutine***

Name	FFPARSE - Free-field parse routine			
Description	FFPARSE returns the parsed data field values defined in the input string. If a string contains a continuation character, a flag is returned to the user indicating that another string should be supplied to complete the logical record.			
Syntax	CALL FFPARSE (LINE, MFIELD, IDCONT, NFIELD, KVALUE, CVALUE, IVALUE, RVALUE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	LINE	Input	char*(*)	The input string containing the data to be parsed.
	MFIELD	Input	integer	Maximum number of data fields to be returned.
	IDCONT	I/O	integer	Continuation flag. 0 means no continuation. On input, this flag indicates whether the previous string contained a continuation indicator. In this case, the current string will be treated as part of the same logical record as the previous string.
	NFIELD	Output	integer	Number of data fields found on this logical record.
	KVALUE	Output	integer	Translation states of the data fields: KVALUE(MFIELD). The value of each element of this array is interpreted as follows: -1 = null field. 0 = a nonnumeric field; only CVALUE contains a specified value 1 = a real numeric field; CVALUE and RVALUE contain specified values 2 = an integer numeric field; CVALUE, RVALUE, and IVALUE contain specified values
	CVALUE	Output	char*(*)	Character values of the data fields: CVALUE(MFIELD).

FFPARSE
Subroutine

Variables in Call (cont.)	IVALUE	Output	integer	Integer values of the data fields: IVALUE(MFIELD).
	RVALUE	Output	real	Floating-point values of the data fields: RVALUE(MFIELD).

See Also	FFRDFLDS for a more complete description of some of the variables in the call
-----------------	---

FFRDFLDD
Subroutine

Name	FFRDFLDD - Free-field input routine (double precision)			
Description	FFRDFLDD is a special version of FFRDFLDS that returns double-precision values (compiled with /NOG_FLOATING on the VAX).			
Syntax	CALL FFRDFLDD (KIN, KOUT, PROMPT, MFIELD, IOSTAT, NFIELD, KVALUE, CVALUE, IVALUE, DVALUE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	KIN	Input	integer	Unit from which to read input.
	KOUT	Input	integer	Unit to which to echo input.
	PROMPT	Input	char(*)	Prompt string.
	MFIELD	Input	integer	Maximum number of data fields to be returned.
	IOSTAT	Output	integer	ANSI FORTRAN I/O status: IOSTAT < 0 End of File IOSTAT = 0 Normal IOSTAT > 0 Error
	NFIELD	Output	integer	Number of data fields found on this logical record.
	KVALUE	Output	integer	Translation states of the data fields: KVALUE(MFIELD). The value of each element of this array is interpreted as follows: -1 = null field 0 = a non-numeric field; only CVALUE contains a specified value 1 = a real or double-precision numeric field; CVALUE and DVALUE contain specified values 2 = an integer numeric field; CVALUE, DVALUE, and IVALUE contain specified values

FFRDFLDD

Subroutine

Variables in Call (cont.)	CVALUE	Output	char*(*)	Character values of the data fields: CVALUE(MFIELD).
	IVALUE	Output	integer	Integer values of the data fields: IValue(MFIELD).
	DVALUE	Output	double precision	Floating-point values of the data fields: DVALUE(MFIELD).

See Also FFRDFLDG
FFRDFLDS for a more complete description of the variables in the call

FFRDFLDG**Subroutine**

Name	FFRDFLDG - Free-field input routine (double precision)			
Description	FFRDFLDG is a special version of FFRDFLDS that returns double-precision values (compiled with /G_FLOATING on the VAX).			
Syntax	CALL FFRDFLDG (KIN, KOUT, PROMPT, MFIELD, IOSTAT, NFIELD, KVALUE, CVALUE, IVALUE, DVALUE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	KIN	Input	integer	Unit from which to read input.
	KOUT	Input	integer	Unit to which to echo input.
	PROMPT	Input	char(*)	Prompt string.
	MFIELD	Input	integer	Maximum number of data fields to be returned.
	IOSTAT	Output	integer	ANSI FORTRAN I/O status: IOSTAT < 0 End of File IOSTAT = 0 Normal IOSTAT > 0 Error
	NFIELD	Output	integer	Number of data fields found on this logical record.
	KVALUE	Output	integer	Translation states of the data fields: KVALUE(MFIELD). The value of each element of this array is interpreted as follows: -1 = null field 0 = non-numeric field; only CVALUE contains a specified value 1 = a real or double-precision numeric field; CVALUE and DVALUE contain specified values 2 = an integer numeric field; CVALUE, DVALUE, and IVALUE contain specified values

Variables in Call (cont.)	CVALUE	Output	char*(*)	Character values of the data fields: CVALUE(MFIELD).
	IVALUE	Output	integer	Integer values of the data fields: IValue(MFIELD).
	DVALUE	Output	double precision	Floating-point values of the data fields: DVALUE(MFIELD).

See Also

FFRDFLDD

FFRDFLDS for a more complete description of variables in the call

FFRDFLDS
Subroutine

Name	FFRDFLDS - Free-field input routine			
Description	Input is prompted for, read, and echoed by FFRDFLDS using specified I/O units. FFRDFLDS returns the parsed data field values defined on the next input record and any continuation records. All I/O is accomplished by the utility routine FFRDLIN, while the parsing is performed by FFPARSE.			
Syntax	CALL FFRDFLDS (KIN, KOUT, PROMPT, MFIELD, IOSTAT, NFIELD, KVALUE, CVALUE, IVALUE, RVALUE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	KIN	Input	integer	Unit from which to read input. >0 - read from the file whose unit is given; the caller is responsible for opening/closing this unit =0 - read from the standard input device (terminal or batch deck) and echo to the standard output device (terminal or batch log) <0 - read from the command line
	KOUT	Input	integer	Unit to which to echo input. >0 - echo to the file whose unit is given; the caller is responsible for opening/closing this unit =0 - do not echo other than to the standard output device as described for KIN <0 - echo to the standard output device
	PROMPT	Input	char(*)	Prompt string. This string will be used to prompt for data from an interactive terminal and/or will be written as a prefix to the input line for echo. If the string 'AUTO' is specified, a prompt of the form 'n:', where "n" is the current input line number (only lines read under the AUTO feature are counted), will be generated.

FFRDFLDS
Subroutine

Variables in Call (cont.)	MFIELD	Input	integer	Maximum number of data fields to be returned. The dimensions of each of the output arrays described below must be greater than or equal to this number.
	IOSTAT	Output	integer	ANSI FORTRAN I/O status: IOSTAT < 0 End of File IOSTAT = 0 Normal IOSTAT > 0 Error
	NFIELD	Output	integer	Number of data fields found on this logical record. If this value is less than MFIELD, the excess fields are implicitly defined as null fields. If this value is greater than MFIELD, the extra data fields are ignored.
	KVALUE	Output	integer	Translation states of the data fields: KVALUE(MFIELD). The value of each element of this array is interpreted as follows: -1 = null field 0 = non-numeric field; only CVALUE contains a specified value 1 = a real numeric field; CVALUE and RVALUE contain specified values 2 = an integer numeric field; CVALUE, RVALUE, and IVALUE contain specified values
	CVALUE	Output	char*(*)	Character values of the data fields: CVALUE(MFIELD). The data will be left-justified and either blank-filled or truncated. The value in this array is set blank for a null field. The character element size can be any value set by the caller.
	IVALUE	Output	integer	Integer values of the data fields: IVALUE(MFIELD). The value in this array is set to zero for a null or non-INTEGER field.
	RVALUE	Output	real	Floating-point values of the data fields: RVALUE(MFIELD). The value in this array is set to zero for a null or nonnumeric field.

See Also FFRDFLDD and FFRDFLDG

FFRDKEY**Subroutine**

Name	FFRDKEY - Free-field keyword parameter input routine			
Description	FFRDKEY reads a record and parses the record into fields. The record should be in the form: $\text{keyword param}_1 = \text{value}_1, \dots, \text{value}_n \dots \&$ $\text{param}_n = \text{value}_1, \dots, \text{value}_n$			
Syntax	CALL FFRDKEY(KIN, KOUT, PROMPT, IOSTAT, KEYWRD, MAXPRM, NUMPRM, CPARAM, MAXVAL, NUMVAL, ITYVAL, CVALUE, IVALUE, RVALUE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	KIN	Input	integer	Unit from which to read input.
	KOUT	Input	integer	Unit to which to echo input.
	PROMPT	Input	char(*)	The prompt string.
	IOSTAT	Output	integer	ANSI FORTRAN I/O status 1000 - number of parameters or values over-runs maximum
	KEYWRD	Output	char(*)	The input keyword.
	MAXPRM	Input	integer	Maximum number of parameters allowed.
	NUMPRM	Output	integer	Number of input parameters <0 - no keyword or parameter (blank line)
	CPARAM	Output	char(*)	The input parameters: CPARAM(MAXPRM)
	MAXVAL	Input	integer	Maximum number of values per parameter.
	NUMVAL	Output	integer	Number of input values for each parameter: NUMVAL (MAXPRM)
	ITYVAL	Output	integer	Translation states of the parameter values: ITYVAL (MAXVAL, MAXPRM) -1 = a null field 0 = a non-numeric field 1 = a real numeric field 2 = an integer numeric field

FFRDKEY
Subroutine

Variables in Call (cont.)	CVALUE	Output	char*(*)	Character values of the parameter values: CVALUE (MAXVAL, MAXPRM)
	IVALUE	Output	integer	Integer values of the parameter values: IVALUE (MAXVAL, MAXPRM)
	RVALUE	Output	real	Floating-point values of the parameter values: RVALUE (MAXVAL, MAXPRM)

See Also FFRDFLDS for a more complete description of some of the variables in the call

FFRDLINE***Subroutine***

Name	FFRDLINE - Get literal input line			
Description	All I/O for FFRDFLDS is done through this subroutine. This routine was intentionally separated from FFRDFLDS so that the caller can obtain an unmodified line of input (such as a problem title) via the same I/O stream. Applications that require a more complex syntax than the free-field reader provides (e.g., algebraic operations) may find FFRDLINE advantageous.			
Syntax	CALL FFRDLINE (KIN, KOUT, PROMPT, LINE, IOSTAT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	KIN	Input	integer	Unit from which to read input. >0 - read from the file whose unit is given; the caller is responsible for opening/closing this unit =0 - read from the standard input device (terminal or batch deck) and echo to the standard output device (terminal or batch log) <0 - read from the command line
	KOUT	Input	integer	Unit to which to echo input. >0 - echo to the file whose unit is given; the caller is responsible for opening/closing this unit =0 - do not echo other than to the standard output device as described for KIN <0 - echo to the standard output device
	PROMPT	Input	char*(*)	Prompt string. This string will be used to prompt for data from an interactive terminal and/or will be written as a prefix to the input line for echo. If the string 'AUTO' is specified, a prompt of the form 'n:', where "n" is the current input line number (only lines read under the AUTO feature are counted), will be generated.

FFRDLINE
Subroutine

Variables in Call (cont.)	LINE	Output	char(*)	Line of input. This string will be blank-filled or truncated, if necessary. The length of the string is set by the caller, but should not exceed 132.
	IOSTAT	Output	integer	ANSI FORTRAN I/O status: IOSTAT < 0 End of File IOSTAT = 0 Normal IOSTAT > 0 Error
See Also	FILCMDLIN for command line information			

8.2.4 String Processing Routines

Detailed descriptions of the four routines for processing strings are given on the following pages.

ISTRFIND
Integer Function

Name ISTRFIND - Find string in list

Description ISTRFIND returns the index of the first occurrence of the given string in a list of strings. If the string is not in the list, ISTRFIND returns 0. Trailing blanks are ignored in both the given string and the list of strings. This function is used to locate a keyword in a list of keywords.

Syntax integer = ISTRFIND (STR, LENLST, STRLST)

**Variables in
Call**

<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
STR	Input	char(*)	The string to be searched for.
LENLST	Input	integer	The number of strings in the list.
STRLST	Input	char(*)	The list of strings to be searched.

ISTRLEN

Integer Function

Name	ISTRLEN - Return string length			
Description	ISTRLEN returns the length of a given string excluding trailing blanks. There can be blanks embedded within the string. ISTRLEN returns a length of 0 for a blank string.			
Syntax	integer = ISTRLEN (STRING)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	STRING	Input	char*(*)	The string.
Comments	ISTRLEN differs from the FORTRAN LEN intrinsic function in that LEN returns the declared length of the string, but the ISTRLEN length does not include trailing blanks.			

STRCMPRS
Subroutine

Name	STRCMPRS - Remove extra blanks from string			
Description	STRCMPRS left justifies a string and removes extra blanks. An extra blank is any blank that follows another blank.			
Syntax	CALL STRCMPRS (STRING, LSTR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	STRING	I/O	char*(*)	The string to be compressed (returned, may be up to 132 characters long).
	LSTR	Output	integer	The length of the compressed string.
See Also	PCKSTR			

STRLIMIT
Subroutine

Name	STRLIMIT - Strip leading/trailing blanks			
Description	STRLIMIT does not modify the input string, but simply returns the location of the first and last non-blank characters.			
Syntax	CALL STRLIMIT (STRING, ILEFT, IRIGHT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	STRING	Input	char*(*)	Any character string.
	ILEFT	Output	integer	Relative index of the first non-blank character in STRING. ILEFT > IRIGHT if STRING = ''.
	IRIGHT	Output	integer	Relative index of the last non-blank character in STRING. IRIGHT = 0 if STRING = ''.

STRPACK
Subroutine

Name STRPACK - Remove all blanks from string

Description STRPACK left justifies a string and removes all embedded blanks.

Syntax CALL STRPACK (STRING, LSTR)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	STRING	I/O	char*(*)	The string, returned packed (may be up to 132 characters long).
	LSTR	Output	integer	The length of the packed string.

See Also STRCMPRS

STRUPCASE

Subroutine

Name	STRUPCASE - Convert string to upper case			
Description	STRUPCASE converts a string to upper case.			
Syntax	CALL STRUPCASE (STRING)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	STRING	I/O	char*(*)	Character string for which lowercase letters will be translated to uppercase.

8.2.5 Common Internal Routines

Detailed descriptions of seven routines commonly used with CAMCON system codes are given on the following pages.

FEELEM
Subroutine

Name	FEELEM - Calculate element number associated with node			
Description	FEELEM uses routines FEIJK and FENENUM to calculate the element number associated with the given node number. Nodes and elements are assumed to be numbered first in order of increasing X (I-index), then Y (J-index), and then Z (K-index).			
Syntax	CALL FEELEM (NODE, NX, NY, NZ, IELEM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NODE	Input	integer	The node number of the first node and smallest node number in the connectivity list for the element.
	Nn	Input	integer	The number of nodes in the n (X, Y, Z or I, J, K) directions, respectively.
	IELEM	Output	integer	The corresponding element number.
See Also	FEIJK, FENENUM			

FEIJK
Subroutine

Name	FEIJK - Determine I, J, K index from node/element number			
Description	FEIJK determines the I, J, K index for the given node or element number, assuming a two- or three-dimensional rectilinear grid where nodes and elements are numbered first in order of increasing X (I index), then Y (J index), and then Z (K index).			
Syntax	CALL FEIJK (N, NX, NY, NZ, I, J, K)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	The node or element number.
	Nn	Input	integer	For a node, the number of nodes in the n (X, Y, Z) direction; for an element, the number of elements in the n (X, Y, Z) direction (number of nodes minus one).
	I, J, K	Output	integer	For a node, the I, J, K index of the node; for an element, the first node and smallest node number in the connectivity list for the element (assumes WIPP connectivity convention).
See Also	FEELEM, FENENUM			

FEMINMAX
Subroutine

Name	FEMINMAX - Calculate minimum/maximum value			
Description	FEMINMAX calculates the minimum and maximum value of the data.			
Syntax	CALL FEMINMAX (NPTS, PTS, VMIN, VMAX)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NPTS	Input	integer	The number of points.
	PTS	Input	real array	The points
	VMIN	Output	real	The minimum value of the points.
	VMAX	Output	real	The maximum value of the points.

FENENUM
Subroutine

Name	FENENUM - Determine node or element number from I, J, K, index			
Description	FENENUM determines the node or element number from the given I, J, K, index assuming a two- or three-dimensional rectilinear grid where nodes and elements are numbered first in order of increasing X (I index), then Y (J index), and then Z (K index).			
Syntax	CALL FENENUM (I, J, K, NX, NY, NZ, N)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	I, J, K	Input	integer	For a node, the I, J, K index of the node; for an element, the first node and smallest node number in the connectivity list for the element.
	NX, NY, NZ	Input	integer	For a node, the number of nodes in the X, Y, and Z directions, respectively; for an element, the number of elements in the X, Y, and Z, directions, respectively (the number of nodes minus one).
	N	Output	integer	The node or element number.
See Also	FEIJK and FEELEM			

9. CAMSUPES_LIB: Routines for Dynamic Memory Allocation and Other FORTRAN Extensions

9.1 General Description

The CAMSUPES_LIB library is a collection of routines that perform two frequently needed functions: (1) accessing computer-system-dependent parameters (e.g., the clock) and (2) allocating memory for arrays at run time for FORTRAN77.

9.1.1 Sponsorship and Version

Authors: D. P. Flanagan, W. C. Mills-Curran, L. M. Taylor, J. R. Red Horse
Sponsor: A. P. Gilkey
Version / Date: C-2.10VV/March 1993
Version Base Case: C-2.00VV equivalent to Version 2.1 acquired from authors May 1989
Language: FORTRAN77

9.1.2 Overview of CAMSUPES_LIB

The routines were originally developed within another area of Sandia under the name SUPES (Red-Horse et al., 1990; Flanagan et al., 1986) and adopted for use by the PA Department. Hence, the original documentation on the SUPES library (Red-Horse et al., 1990) provides the primary source of information on use of these routines. The original SUPES routines for parsing an input record have been modified and moved to CAMCON_LIB (Chapter 8).

9.1.3 Linking

The CAMSUPES_LIB routines are an object library in the [LIBRARIES] subdirectory (see Section 2.10, "Software Libraries"). To link a code with CAMSUPES_LIB, type (the logical name of the library is assigned by the library sponsor):

\$LINK *code_name*, ..., CAMSUPES_LIB/LIB

A FLINT library is available for checking interfaces. It is in CAMCON\$ROOT: [LIBRARIES.CAMSUPES_LIB] CAMSUPES_LIB.LBT.

9.1.4 Summary

Library CAMSUPES_LIB has routines that provide: system queries, system-dependent utilities, and dynamic memory management. The following is a brief description of the CAMSUPES_LIB routines.

System Queries

- EXCPUS - Get accumulated processor time
- EXDATE - Get today's date
- EXFILDAT - Return last update date and time for a file
- EXNAME - Get unit file name or symbol value
- EXPARAM - Get operating environment parameters
- EXTIME - Get time of day

Memory Management

- MDDEL / MCDEL - Delete dynamic array
- MDEROR / MCEROR - Print dynamic memory error summary
- MDFILL / MCFILL - Enable data initialization
- MDFOFF / MCFOFF - Cancel data initialization
- MDGET / MCGET - Reserve memory block
- MDGIVE / MCGIVE - Release unallocated memory
- MDINIT / MCINIT - Initialize dynamic memory
- MDRSRV / MCRSRV - Define dynamic array
- MDSTAT / MCSTAT - Obtain dynamic memory statistics

Advanced Memory Management Routines

- MDCOMP / MCCOMP - Compress storage
- MDEFIX / MCEFIX - Modify dynamic memory error count
- MDERPT / MCERPT - Dynamic memory error flag query
- MDEXEC / MCEXEC - Execute deferred memory requests
- MDFIND / MCFIND - Locate dynamic array
- MDLAST / MC LAST - Report last dynamic memory error
- MDLONG / MCLONG - Adjust dynamic array length
- MDMEMS / MCMEMS - Report storage information
- MDNAME / MCNAME - Rename dynamic array
- MDWAIT / MCWAIT - Enable deferred memory mode

Memory Management Debugging Routines

- MDDEBG / MCDEBG - Enable debug printing for dynamic memory
- MDLIST / MC LIST - List dynamic memory storage tables
- MDPRNT / MCP RNT - Print dynamic array

Detailed descriptions of these routines are provided on the pages that follow in this chapter.

9.2 Description of Routine Calls

9.2.1 System Queries

This section prescribes the calling sequence for FORTRAN extension routines that are meant to be called directly from application programs.

The CAMSUPES_LIB System Queries (FORTRAN extensions) provides a uniform interface to necessary operating system functions that are not included in the ANSI FORTRAN-77 standard. This package makes it possible to maintain many codes on different operating systems with a single point of support for system dependencies. Moreover, this maintenance is done by a single set of source files which should not only reduce the time involved in bookkeeping, but allow for standard procedures for building a CAMSUPES library. These routines provide very basic operating system support; they are not intended to implement clever features of a favorite system, to make FORTRAN behave like another language, or to improve execution efficiency.

Each module included in the CAMSUPES_LIB System Queries must satisfy the following criteria:

1. The routine must provide a service that is beneficial to a wide range of users.
2. This task cannot be accomplished by standard FORTRAN.
3. This capability must be generic to scientific computers. System query routines must be supportable on virtually any system.

EXCPUS
Subroutine

Name EXCPUS - Get accumulated processor time

Description EXCPUS returns accumulated processor time.

Syntax CALL EXCPUS (CPUSEC)

Variables in Call

<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
CPUSEC	Output	real	Accumulated CPU time in seconds (accurate to 0.01 seconds on the VAX). The base time is undefined; only relative times are valid. This is an unweighted value which measures performance rather than cost.

EXDATE
Subroutine

Name	EXDATE - Get today's date			
Description	EXDATE returns the current date.			
Syntax	CALL EXDATE (STRING)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	STRING	Output	char*(*)	Current date formatted as "MM/DD/YY" where "MM", "DD", and "YY" are two-digit integers representing the month, day, and year, respectively. For example, "07/04/86" would be returned on July 4, 1986.

EXFILDAT
Subroutine

Name	EXFILDAT - Return the file date and time			
Description	EXFILDAT returns the last update date and time for a file.			
Syntax	CALL EXFILDAT (FILNAM, FDATE, FTIME)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FILNAM	Input	char*(*)	The name of the file.
	FDATE	Output	char*(*)	The date the file was last updated (mm/dd/yy).
	FTIME	Output	char*(*)	The time the file was last updated (hh:mm:ss).

EXNAME
Subroutine

Name	EXNAME - Get unit file name or symbol value			
Description	EXNAME returns unit file name or symbol value. The unit file name or symbol must be set before the program is executed in a system-dependent fashion.			
Syntax	CALL EXNAME (IUNIT, NAME, LN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	Unit number if IUNIT > 0, or symbol ID if IUNIT < 0.
	NAME	Output	char*(*)	File name or symbol value obtained from the operating system. It is assumed that the unit/file name or symbol/value linkage will be passed to this routine at program activation.
	LN	Output	integer	Effective length of the string returned in NAME. Zero indicates that no name or value was available.
Comments	<p>This routine provides a standard interface for establishing execution time unit/file connection on operating systems that do not support pre-connection of FORTRAN I/O units. For example, on the VAX, the symbol is set up within a VAX DCL file before program execution as follows:</p> <pre>\$ASSIGN/USER CAMDAT.CDB FOR010</pre> <p>The returned string is used with the FILE specifier in an OPEN statement, as in the following example:</p> <pre>CALL EXNAME(10, NAME, LN) OPEN(10, FILE=NAME(1:LN),...)</pre>			

EXNAME
Subroutine

**Comments
(continued)**

The symbol mode of this routine provides a standard path through which to pass messages at program activation. The example below identifies the target graphics device for a VAX code that supports multiple devices. The global symbol is set up in a DCL file before program execution with

```
$EXT02=="PST"
```

EXNAME can then retrieve and use the string as follows:

```
CALL EXNAME (-2, DEV, LD)  
WRITE (*,*) 'Running on hardcopy device ' //DEV(1:LD)
```

EXPARM
Subroutine

Name	EXPARM - Get operating environment parameters			
Description	EXPARM returns the operating environment parameters			
Syntax	CALL EXPARM (HARD, SOFT, MODE, KCSU, KNSU, IDAU)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	HARD	Output	char(*)	System Hardware ID. For example, "CRAY-1S".
	SOFT	Output	char(*)	System Software ID. For example, "COS 1.11".
	MODE	Output	integer	Job mode: 0 = batch, 1 = interactive. For this purpose, an interactive environment means that the user can respond to unanticipated questions.
	KCSU	Output	integer	Number of character storage units per base system unit.
	KNSU	Output	integer	Number of numeric storage units per base system unit.
	IDAU	Output	integer	Units of storage which define the size of unformatted direct access I/O records: 0 = character, 1 = numeric. (For a more in-depth discussion of this topic, the reader is referred to the VAX FORTRAN language reference manual and VAX FORTRAN user's manual (DEC, 1988b, 1988c).
	<p>The ANSI FORTRAN standard defines a character storage unit as the amount of memory required to store one CHARACTER element. A numeric storage unit is the amount of memory required to store one INTEGER, LOGICAL, or REAL element. For this routine, a base system unit is defined as the smallest unit of memory that holds an integral number of both character and numeric storage units.</p> <p>The last three parameters above can be used to calculate the proper value for the RECL specifier on the OPEN statement for a direct access I/O unit. For example, if NUM is the number of numeric values to be contained on a record and IDAU = 0, set RECL = (NUM * (KCSU + DNSU - 1)) / KCSU.</p>			

EXTIME
Subroutine

Name	EXTIME - Get time of day			
Description	EXTIME returns the current time.			
Syntax	CALL EXTIME (STRING)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	STRING	Output	char*(*)	Current time formatted as "HH:MM:SS" where "HH", "MM", and "SS" are two-digit integers representing the hour (00-24), minute, and second, respectively. For example, "16:30:00" would be returned at 4:30 PM.

9.2.2 Memory Management Routines

The purpose of the memory management utilities is to allow an applications programmer to write standard, readable FORTRAN-77 code while employing dynamic memory management for REAL, INTEGER, LOGICAL and CHARACTER type arrays.

Because the array sizes in most programs are problem-dependent, a program's memory requirements are not known until the program is running. Since FORTRAN-77 does not provide for dynamic memory allocation, the programmer has to either predict the maximum memory requirement or use a machine-dependent request for memory. In addition, dynamic memory allocation is an error-prone exercise which tends to make the source code difficult to read and maintain.

In CAMSUPES_LIB, the memory manager utilities are written in standard FORTRAN-77 and provide an interface that encourages readable coding and efficient use of memory resources. Machine dependencies are isolated through the use of the extension library (Section 9.2.1). All memory requests are in terms of numeric storage units for numeric data (integer, real, or logical) and character storage units for character data (ANSPL FORTRAN, 1978).

An important design feature of the memory manager is that the memory manager can be supported even when the system-dependent dynamic memory request routines are not implemented on a system. In this case, the memory manager will operate, allocating space from a user-supplied work array. This mode is described as dynamic allocation of static memory. Thus, modification of a user's application program is minimal on systems where dynamic memory is not implemented.

All user entry points to memory manager routines begin with either "MD" or "MC." In most cases, the "MD" routines are used for numeric data, while the "MC" routines are for character data. In some cases, however, the routines are interchangeable. These routines are documented as synonyms.

In this document, the term "M α " is used to refer simultaneously to both "MD" and "MC" routines. Thus, M α RSRV is a reference to both MDRSRV and MCRSRV subroutines.

General Information. In order to use the memory manager properly, the user must first understand the concept of using a base array with indexes for accessing memory address locations. At the core of this concept is FORTRAN's convention of passing SUBROUTINE array references by address. The memory manager references all memory addresses relative to the addresses of user-supplied base arrays—one each for numeric and character data. A reference to memory is made in terms of a pointer to these base arrays. Specifically, the memory manager determines an indexing parameter by first determining the offset of the appropriate memory location relative to the address of the correct base array. The index is then computed in terms of the proper storage units (either character or numeric). Note that the resulting indexes may take on a wide range of values, including negative numbers.

The base arrays must comply with the following rules (allocating memory for these arrays is explained below):

1. Numeric base arrays must be of type INTEGER, REAL, or LOGICAL. Modified word length storage arrays such as INTEGER*2 or REAL*8 (double precision) will result in invalid indexes with no error message.
2. Character base arrays must be declared CHARACTER*1.

The following FORTRAN statements define valid base arrays:

```
DIMENSION NUMBAS (1)  
CHARACTER*1 CHRBAS (1)
```

Only one base array from each category (numeric and character) may be used in a program.

In order to use memory allocated by the memory manager, the user merely needs to pass the base array with the correct offsetting index to a subprogram. For example, for a base arrays NUMBAS and CHRBAS and indexes IP1 and IP2, a subroutine call would be:

```
CALL SUBBIE ( NUMBAS(IP1), CHRBAS(IP2) )
```

Although the programmer is not restricted to using the allocated memory in subprograms only, the recommended usage for the memory manager is to allocate dynamic arrays in the main program and then pass them to subroutines.

To allocate memory for a double precision array of n elements, call MDRSRV with a length of 2*n. Within SUBBIE, define the array corresponding to NUMBAS (IP1) as DOUBLE PRECISION. Similar to allocating a CHARACTER*c array of n elements, call MCRSRV with a length of c*n and define the SUBBIE array corresponding to CHRBAS (IP2) as CHARACTER*c.

Basic Routines. The basic memory manager routines are those that are most commonly used and require little understanding of the internal workings of the utility. An example follows:

```
DIMENSION BASE(1)
CHARACTER*1 CBASE(1)
CALL MDINIT (BASE(1))
CALL MCINIT (CBASE(1))
CALL MDGET (20)
CALL MDFILL (0.)
CALL MCFILL ('Z')
CALL MDRSRV ('FIRST', I1, 10)
CALL MDRSRV ('SECOND', I2, 10)
CALL MCRSRV ('THIRD', I3, 10)
CALL MDDEL ('SECOND')
CALL MDGIVE ()
CALL MDSTAT (MNERRS, MNUSED)
IF (MNERRS .NE. 0) THEN
    CALL MDEROR (6)
    STOP
END IF
CALL SUBPRG (BASE(I1), CBASE(I3))

SUBROUTINE SUBPRG(FIRST, THIRD)
DIMENSION FIRST(*)
CHARACTER *(*) THIRD(*)
```

MαDEL
Subroutine

Name	MαDEL - Delete dynamic array			
Description	MDDEL and MCDEL release the memory that is allocated to a dynamic array for numeric and character storage, respectively.			
Syntax	CALL MDDEL (NAME) CALL MCDEL (NAME)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NAME	Input	char*(*)	The name of the dynamic array to be deleted. The array name must match an existing name in the dictionary and be of the correct type (numeric or character) for the operation. The first eight characters beginning with a nonblank are used for comparison. This comparison is case-insensitive and embedded blanks are significant.

MαEROR***Subroutine***

Name	MαEROR - (CAMSUPES_LIB) Print error summary			
Description	MαEROR prints a summary of all errors detected by the memory manager. The return status of the last memory manager routine called is also printed. MαEROR should be called any time an error is detected by a call to MαSTAT. MDEROR and MCEROR are synonymous.			
Syntax	CALL MDEROR (IUNIT) CALL MCEROR (IUNIT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	FORTTRAN unit number of output device.
Error Codes	<i>Code</i>	<i>Description</i>		
	1	Successful completion		
	2	Unable to get requested space from system		
	3	Data manager not initialized		
	4	Data manager was previously initialized		
	5	Name not found in dictionary		
	6	Name already exists in dictionary		
	7	Illegal length request		
	8	Unknown data type		
	9	Dictionary is full*		
	10	Void table is full*		
	11	Memory block table is full*		
	12	Overlapping voids - internal error*		
	13	Overlapping memory blocks - internal error*		
	14	Invalid memory block - extension library error*		
	15	Invalid error code		
	16	Invalid input name		
	17	Illegal call while in defer mode		
	18	Name is of wrong type for operation		
<hr/>				
*These are not user errors.				
Several of the error codes are not a result of a user error, but are used to signal an internal error, or that an internal array is full. For example, the table that records the names of the arrays allocated with MαRSRV may not be large enough for the application. In this case, the memory manager subroutines must be modified to accommodate the user. The CAMSUPES LIB sponsor should perform this task.				

MαFILL
Subroutine

Name	MαFILL - Enable data initialization			
Description	MαFILL defines a fill/initialization pattern that is to be used for newly allocated storage. MDFILL and MCFILL are in effect until cancelled by MDFOFF and MCFOFF, respectively. MDFILL and MCFILL operate independently.			
Syntax	CALL MDFILL (NUMDAT) CALL MCFILL (CHRDAT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NUMDAT	Input	integer	The initialization datum for new storage allocated with MDRSRV or extended with MDLONG. The memory manager makes no attempt to identify the type (INTEGER, REAL, or LOGICAL) of either the initialization datum or of a newly allocated array. Instead, the bit of the initialization datum is stored without interpretation. This pattern is then used to initialize new storage. Since the internal machine representation of REAL data is different from INTEGER data (or LOGICAL data), the user may experience unexpected results when dynamic memory is used as a numeric type that is different from the type of the initialization datum.
	CHRDAT	Input	char*(*)	The initialization data for new storage allocated with MCRSRV or extended with MCLONG. Only the first character of CHRDAT is used.

MαFOFF
Subroutine

Name	MαFOFF - Cancel data initialization
Description	MDFOFF and MCFOFF cancel the data initialization for numeric and character data, respectively. MDFOFF and MCFOFF operate independently.
Syntax	CALL MDFOFF () CALL MCFOFF ()

MCGET
Subroutine

Name	MαGET - Reserve memory Block			
Description	MDGET and MCGET reserve a contiguous block of memory without associating the block of memory with an array. MαGET should be called prior to a series of calls to MαRSRV to improve efficiency and to reduce memory fragmentation.			
Syntax	CALL MDGET (MNGET) CALL MCGET (MNGET)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	MNGET	Input	integer	Specifies the desired continuous block size in numeric storage units for MDGET or character storage units for MCGET.

MαGIVE
Subroutine

Name	MαGIVE - Release unallocated memory
Description	MαGIVE causes the memory manager to return unused storage to the operating system, if possible. MDGIVE and MCGIVE are synonymous.
Syntax	CALL MDGIVE () CALL MCGIVE ()

MαINIT
Subroutine

Name	MαINIT - Initialize dynamic memory base arrays			
Description	The memory manager must be initialized with calls to MDINIT and MCINIT before any memory can be allocated. The main purpose of the initialization is to determine the location of the numeric and character base arrays in memory. MDINIT must be called first, and MCINIT second. In the case where character dynamic memory is not used, MCINIT need not be called. When calling MαINIT, the user must pass (explicitly or implicitly) subscript 1 of the base array.			
Syntax	CALL MDINIT (NUMBAS(1)) CALL MCINIT (CHRBAS(1))			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NUMBAS	Input	array	This array is used as a base reference to all dynamically allocated numeric memory.
	CHRBAS	Input	array	This array is used as a base reference to all dynamically allocated character memory.

MαRSRV
Subroutine

Name	MαRSRV - Define dynamic array			
Description	MDRSRV and MCRSRV declare new dynamic numeric and character arrays, respectively. The user specifies the space required, and an index to the new space is returned. Note that, by default, the contents of the new storage are not initialized to any specific value. MαFILL may be used for data initialization.			
Syntax	CALL MDRSRV (NAME, NEWIDX, NEWLEN) CALL MCRSRV (NAME, NEWIDX, NEWLEN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NAME	Input	char: *(*)	Name of the new dynamic array. The memory manager will add this name to its internal dictionary; each array must have a unique name. The first eight characters beginning with a nonblank are used for comparison. This comparison is case-insensitive and embedded blanks are significant.
	NEWIDX	Output	integer	Index to storage allocated to this dynamic array relative to the base array. The index for numeric data is to be used with the numeric array supplied to MDINIT, and character data is to be used with the character array supplied to MCINIT.
	NEWLEN	Input	integer	Length to be reserved for the new array. Any nonnegative number is acceptable. A zero length does not cause any storage to be allocated and returns an index equal to one. The value of NEWLEN is in terms of numeric storage units for numeric data and character storage units for character data.

MαSTAT
Subroutine

Name	MαSTAT - Obtain statistics			
Description	MαSTAT returns memory manager statistics. MαSTAT provides a method for error checking, and thus should be used after other calls to the memory manager to assure no errors have occurred.			
Syntax	CALL MDSTAT(MNERRS,MNUSED) CALL MCSTAT (MNERRS, MNUSED)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	MNERRS	Output	integer	Total number of errors detected by the memory manager during the current execution.
	MNUSED	Output	integer	Total number of storage units that are currently allocated to dynamic arrays. MDSTAT returns the numeric storage in numeric storage units, and MCSTAT returns the character storage in character storage units. If any storage has been requested in the deferred mode and not yet allocated by the memory manager (Section 4.3.8), this storage is counted as though it were actually allocated.

9.2.3 Advanced Memory Management Routines

The advanced routines are supplied to give added capability to the user who is interested in more sophisticated manipulation of memory. These routines are never necessary, but may be very desirable.

MαCOMP
Subroutine

Name	MαCOMP - Compress storage
Description	MαCOMP causes fragmented memory to be consolidated. Note that this may cause array storage locations to change. It is important to realize that all indexes must be recalculated by calling MαFIND after a compress operation. A call to MαCOMP prior to MαGIVE will result in the return of the maximum memory to the system. MDCOMP and MCCOMP are synonymous.

Syntax	CALL MDCOMP () CALL MCCOMP ()
---------------	----------------------------------

MαEFIX
Subroutine

Name	MαEFIX - Modify error count			
Description	MαEFIX allows the error count for a particular error flag to be set to a specified value. MDEFIX and MCEFIX are synonymous.			
Syntax	CALL MDEFIX (IFLAG, NERRS) CALL MCEFIX (IFLAG, NERRS)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IFLAG	Input	integer	IFLAG specifies the number of the error flag that will be set. See MαEROR for a description of these flags.
	NERRS	Input	integer	NERRS is the new value for the error count.

MαERPT
Subroutine

Name	MαERPT - Error flag query			
Description	MαERPT requests the memory manager to report the number of errors accumulated for a particular error flag. A programmer may use this to determine more detailed information than what is available from MαSTAT. MDERPT and MCERPT are synonymous.			
Syntax	CALL MDERPT (IFLAG, NERRS) CALL MCERPT (IFLAG, NERRS)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IFLAG	Input	integer	IFLAG specifies the flag number for which the user wishes an error count. See MαEROR for a description of these flags.
	NERRS	Output	integer	The error count.

MαEXEC
Subroutine

Name	MαEXEC - Execute deferred memory requests
Description	<p>MαEXEC causes all deferred mode memory requests to be satisfied with a single call to the operating system for the required memory. The deferred mode is also cancelled. MDEXEC and MCEXEC are synonymous.</p> <p>After returning from MαEXEC, all indexes to array space which was deferred are updated.</p>
Syntax	<p>CALL MDEXEC () CALL MCEXEC ()</p>
See Also	MαWAIT

MαFIND
Subroutine

Name MαFIND - Locate dynamic array

Description MαFIND returns the index and length of storage allocated to a dynamic array. This routine would be used if the index from an earlier call to MαRSRV was not available in a particular program segment. MDFIND is used for numeric arrays and MCFIND is used for character arrays.

Syntax CALL MDFIND (NAME, NEWIDX, NEWLEN)
CALL MCFIND (NAME, NEWIDX, NEWLEN)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NAME	Input	char*(*)	Name of the dynamic array to be located.
	NEWIDX	Output	integer	Index to the dynamic array relative to the user's reference array. Because an index can take any value, the returned value cannot be used as an indication of success or failure of MαFIND. MαSTAT should always be used for error checking.
	NEWLEN	Output	integer	Length of the dynamic array in numeric or character storage units for MDFIND and MCFIND, respectively.

MαLAST
Subroutine

Name	MαLAST - Report last error			
Description	MαLAST requests the flag number of the last error. MDLAST and MCLAST are synonymous.			
Syntax	CALL MDLAST (IFLAG) CALL MCLAST (IFLAG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IFLAG	Output	integer	IFLAG is the number of the last error caused by a previous call to the memory manager. See MαEROR for a description of these flags.

MαLONG
Subroutine

Name	MαLONG - Adjust dynamic array length*			
Description	MαLONG changes the length of a dynamic array. The memory manager will relocate the array and move its data if storage cannot be extended at the array's current location. The user should assume that MαLONG invalidates the previous index to this array if the array is extended. MDLONG is used for numeric arrays and MCLONG is used for character arrays.			
Syntax	CALL MDLONG (NAME, NEWIDX, NEWLEN) CALL MCLONG (NAME, NEWIDX, NEWLEN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NAME	Input	char*(*)	Name of the dynamic array to be shortened.
	NEWIDX	Output	integer	New index to the dynamic array.
	NEWLEN	Input	integer	New length for the dynamic array in numeric storage units for MDLONG and in character storage units for MCLONG.

MαMEMS
Subroutine

Name	MαMEMS - Report storage information			
Description	MαMEMS reports numeric or character storage information. This information may be useful for planning storage strategies during code development and for flow control during code execution.			
Syntax	CALL MDMEMS (NSUA, NSUD, NSUV, NSULV) CALL MCMEMS (NSUA, NSUD, NSUV, NSULV)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NSUA	Output	integer	NSUA is the number of numeric/character storage units currently allocated and not deferred.
	NSUD	Output	integer	NSUD is the number of numeric/character storage units currently deferred.
	NSUV	Output	integer	NSUV is the amount of void space in numeric or character storage units. Note that MDMEMS and MCMEMS may be reporting the same space for NSUV, but in different units.
	NSULV	Output	integer	NSULV is the size of the largest void space in numeric or character storage units. Note that MDMEMS and MCMEMS may be reporting the same space for NSULV, but in different units.

MαNAME
Subroutine

Name	MαNAME - Rename dynamic array			
Description	MαNAME renames a dynamic array from NAME1 to NAME2. The location of the array is not changed, nor is its length. MDNAME is used for numeric arrays and MCNAME is used for character arrays.			
Syntax	CALL MDNAME (NAME1, NAME2) CALL MCNAME (NAME1, NAME2)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NAME1	Input	char*(*)	The old name of the array. The first eight characters after the first nonblank are used for comparison. This comparison is case-insensitive and embedded blanks are significant.
	NAME2	Input	char*(*)	The new name of the array. The first eight characters starting from a nonblank are used for the new name. This comparison is case-insensitive and embedded blanks are significant.

MαWAIT
Subroutine

Name	MαWAIT - Enable deferred memory mode
Description	<p>MαWAIT enables the deferred memory mode of the memory manager. In this mode, any requests for additional memory with MαRSRV are satisfied only if a system call is not required. If a system call is required, the request for memory is deferred and will be satisfied when the deferred mode is cancelled by calling MαEXEC or a call to MαLONG requires a system call for memory for an existing array. MDWAIT and MCWAIT are synonymous.</p> <p>Because the deferred mode may not actually provide array space at the time a call to MαRSRV is made, the base array pointer returned by MαRSRV may not be valid. In fact, for a deferred request, an invalid index is intentionally returned so that the requested array space cannot be erroneously used. When the deferred memory requests are eventually satisfied (by calling MαEXEC), the indexes are automatically, asynchronously updated by the memory manager. Thus, upon return from MαEXEC the indexes used in MαRSRV will have a valid value.</p> <p>The deferred mode is provided as a means of reducing the sometimes time-consuming calls to the operating system for new memory. A similar efficiency could be realized by judicious use of MαGET, but the deferred mode relieves the user of the burden of adding all memory requests before calling MαRSRV. The deferred mode is a sophisticated capability and should not be enabled if the user does not understand its implications.</p> <p>The deferred mode must be used as follows:</p> <ol style="list-style-type: none">1. The deferred mode begins with a call to MαWAIT.2. Except for MαPRNT, all memory manager calls are permissible in the deferred mode.3. Indexes returned by MαRSRV, MαFIND, and MαLONG may not be assigned to other variables while the deferred mode is in effect.4. Dynamic memory may not be accessed while the deferred mode is in effect.5. The deferred mode is cancelled by calling MαEXEC.
Syntax	<pre>CALL MDWAIT () CALL MCWAIT ()</pre>
See Also	MαEXEC

9.2.4 Memory Management Debugging Routines

The routines in this section are designed to aid the programmer during development of a program, and probably would not be used during execution of a mature program, except as a response to a memory management error.

MαDEBG

Subroutine

Name	MαDEBG - Debug printing			
Description	Debug printing causes error messages to be printed by the memory manager at the time an error is detected. The default is no debug printing—errors are detected, but are only reported when requested by MαSTAT and MαERPT. MDDEBG and MCDEBG are synonymous.			
Syntax	CALL MDDEBG (IUNIT) CALL MCDEBG (IUNIT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	IUNIT controls debug printing. A negative or zero value turns debug printing off. A positive value of IUNIT will cause any error messages to be printed to FORTRAN unit number IUNIT.

MαLIST
Subroutine

Name	MαLIST - List storage tables			
Description	MαLIST prints the contents of the memory manager's internal tables. MDLIST and MCLIST are synonymous.			
Syntax	CALL MDLIST (IUNIT) CALL MCLIST (IUNIT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	IUNIT	Input	integer	The FORTRAN unit number of the output device.

MαPRNT
Subroutine

Name	MαPRNT - Print dynamic array			
Description	MαPRNT prints the contents of an individual numeric and character array, respectively.			
Syntax	CALL MDPRNT (NAME, IUNIT, TYPE) CALL MCPRNT (NAME, IUNIT, NGRUP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NAME	Input	char*(*)	The name of the array to be printed.
	IUNIT	Input	integer	The FORTRAN unit number of the output device.
	TYPE	Input	char*(*)	TYPE indicates the data type of the data to be printed; "R" for REAL, or "I" for INTEGER. Note that this is not necessarily the declared type of the base array.
	NGRUP	Input	integer	NGRUP controls the number of characters that are grouped together without intervening spaces. Since the storage is declared as a CHARACTER*1 array, NGRUP allows the user to format the output consistent with longer character strings.

10. Graphics Libraries: PLT_LIB and HJIPLT_LIB

PLT_LIB is a general device-independent plotting package that uses SVDI (Sandia Virtual Device Interface) plot routines that perform basic graphic operations. PLT_LIB is described in Sections 10.1 and 10.2.

HJIPLT_LIB provides alternative mid-level plotting routines that also use SVDI plot primitives. HJIPLT_LIB is described in Sections 10.3 and 10.4.

The Sandia Virtual Device Interface (SVDI) is a library of graphics primitives designed to support graphics packages at Sandia National Laboratories. All routines with names that begin with VD are in the SVDI package. SVDI is described in Chapter 11.

10.1 General Guidelines on the Use of PLT_LIB Routines

10.1.1 Sponsorship and Version

<i>Authors:</i>	C. B. Selleck and P. M. Van Gulick
<i>Sponsor:</i>	A. P. Gilkey
<i>Version / Date:</i>	C-2.00VV/March 1993
<i>Language:</i>	FORTRAN 77

10.1.2 Overview of PLT_LIB

PLT_LIB is a collection of FORTRAN-callable routines that perform a variety of graphics tasks. PLT_LIB is divided into a number of modules. Each module contains subroutines related to the specific purpose of the module. The current modules are:

- Plot initialization and control
- Routines to set various PLT_LIB parameters
- Hardware and software text routines
- Two-dimensional graphing routines
- Device coordinate plotting primitives
- Two-dimensional and three-dimensional mapping routines that map from user to device space with perspective and orthogonal projections
- Clipping of two-dimensional and three-dimensional points, lines, and polygons
- Color palette routines

The PLT routines use three coordinate systems: the graph coordinate system, the eye coordinate system, and the device coordinate system. The graph coordinate system is the two- or three-dimensional right-hand system in which the user has defined the model to be plotted. For example, the mesh from

the CAMDAT data base would be in graph coordinates. The eye coordinate system defines how the graph coordinate system is viewed and is a right-hand coordinate system. The eye is at the origin of this system. The device coordinate system is the two-dimensional system that corresponds to the display device. The device coordinate system has its origin (0.0,0.0) at the lower left corner of the device and goes from 0.0 to *XDMAX* in the x direction and *YDMAX* in the y direction. *XDMAX* and *YDMAX* are dependent on the aspect ratio requested. The aspect ratio is the ratio of the x dimension to the y dimension, and the larger of these two must be 1.0.

Initializing and Controlling PLT_LIB. The standard method for initializing PLT_LIB is to call the PLTINT routine. PLTINT sets an aspect ratio of 1.33, which causes the device coordinate system to range from 0 to 1 in the x direction and 0 to 0.75 in the y direction. If the user wishes to set another aspect ratio, the routine PLTSTA may be used.

Terminal Input/Output. Before doing any terminal I/O, the user must call PLTFLU. This routine flushes the buffers, which ensures that the drawing on the screen is up-to-date and puts the terminal in alpha mode so the I/O will go to the right place.

Interrupting Plotting. Several routines in PLT_LIB let a user interrupt plotting by typing CONTROL_C under VMS (i.e., pressing and holding the Control key and pressing the C key). The user may wish to use this capability of interrupting a plot, especially a long plot, in interactive plotting codes. The routines that normally take a long time to plot (e.g., axis labeling) have this capability. Also, the programmer of an interactive code can use PLTCANCEL, a logical function in PLT_LIB, to check whether the interrupt character was entered. A simplified example follows (an interactive program would also have calls to PLTCANCEL with *false* arguments at lower levels).

```
PROGRAM TESTPLT

    PARAMETER (NPTS = 360)
    REAL X (NPTS), Y (NPTS)
    REAL BUF (6)
    LOGICAL OK, PLTSCALE, PLTSETDRW, PLTCURVE
    LOGICAL PLTCANCEL

    RADDEG = 180.0 / (4.0*ATAN (1.0))

C ... Initialize PLT.
    CALL PLTINT

C ... Reset the interrupt flag before plotting.
    OK = PLTCANCEL (.TRUE.)

C ... Set up the axis limits in graph coordinates.
    BUF (1) = 4
    BUF (2) = 0.0
    BUF (3) = 0.0
    BUF (4) = NPTS
    BUF (5) = 60.0
```

```

    BUF (6) = 6
    CALL PLTSETGPH ('X_SCALING_TYPE', BUF)
    CALL PLTSETGPH ('X_EXPONENT', 0.0)
    CALL PLTSETGPH ('X_DIGITS', 0.0)
    BUF (1) = 4
    BUF (2) = -1.1
    BUF (3) = -1.0
    BUF (4) = 1.1
    BUF (5) = 0.5
    BUF (6) = 5
    CALL PLTSETGPH ('Y_SCALING_TYPE', BUF)

C ... Begin a new plot
    CALL PLTBGN

C ... Draw the axes; define the graph coordinate to device coordinate
C ... mapping according the axes limits.
    CALL PLTAXES ('x', ' ', 'SIN(x) and COS(x)', ' ')

C ... Flush the plot so that plot is complete before interrupt.
    CALL PLTFLU

C ... Check if the interrupt flag was set; if so, skip to end of plot.
    IF (PLTCANCEL (.FALSE.)) GOTO 120

C ... Set up the curve data for the first curve.
    DO 100 I = 1, NPTS
        X(I) = FLOAT(I)
        Y(I) = SIN (X(I)/RADDEG)
    100 CONTINUE

C ... Set up the curve attributes and draw the curve.
    OK = PLTSETDRW ('COLOR', 1.0)
    OK = PLTSETDRW ('LINE_STYLE', 4.0)
    OK = PLTCURVE (NPTS, X, Y, ' ', 0)

C ... Flush the plot so that plot is complete before interrupt.
    CALL PLTFLU

C ... Check if the interrupt flag was set; if so, skip to end of plot.
    IF (PLTCANCEL (.FALSE.)) GOTO 120

C ... Set up the curve data for the next curve.
    DO 110 I = 1, NPTS
        X(I) = FLOAT(I)
        Y(I) = COS (X(I)/RADDEG)
    110 CONTINUE

C ... Set up the curve attributes and draw the curve.
    OK = PLTSETDRW ('COLOR', 2.0)
    OK = PLTSETDRW ('LINE_STYLE', 6.0)
    OK = PLTCURVE (NPTS, X, Y, ' ', 0)

```

```
120 CONTINUE

C ... Terminate PLT.
  CALL PLTEND

END
```

Terminating PLT_LIB. It is essential that the last PLT_LIB call be to PLT_END so that the output file is closed properly on batch devices.

Setting PLT_LIB Parameters. The PLTSETx routines (PLTSETGPH, etc.) are used to change the behavior of a particular routine and to change the basic graphics parameters, such as foreground color or line style. For instance, the routine PLTAXES draws a set of axes. All of the options associated with doing this, such as axis type, grid lines, etc., default to certain values. These values can be changed with the routine PLTSETGPH (set graph parameter). All subsequent calls to PLTAXES will use the new values. As another example, the routine PLTSETDRW (set basic graphics parameters) can be used to change the foreground color used when doing basic graphics primitives such as drawing lines.

Text Routines. Two types of characters are used by the text routines: hardware and software. The advantage of hardware characters is that they are displayed faster than software characters; however, hardware characters can be device dependent and so may not be readable on some devices. Also, some special escape symbols (see the list in Section 10.2.3) may not be available with hardware characters; in this case, the software characters are automatically displayed. The character type (i.e., hardware or software) and other text attributes are set in the routine PLTSETTXT.

Device Coordinate Plotting. The device coordinate plotting routines are the easiest way to plot and are helpful when a graph coordinate system is not defined (e.g., to outline the device plot window).

Two-Dimensional Graphing. The two-dimensional graphing routines are a straightforward means to plot a two-dimensional model. The user defines the world coordinate system by setting the viewing window with PLTSETGPH and then calling PLTAXES or PLTSCALE. A clipping window can also be defined (it defaults to the viewing window).

Mapping and Transformations. The mapping routines map from three dimensions to two dimensions and from two dimensions to two dimensions. These include modelling transformations (translate, rotate, and scale), viewing transformations (to locate the observer), projection transformations (to do perspective or orthogonal projections), and viewport transformations (to define a rectangular portion of the device to draw on). Two-dimensional models that do not require these transformations can be plotted with the more efficient two-dimensional graphing routines.

In addition to the coordinate systems, a viewport is used. The viewport is a rectangular area of the device that defines where to draw the output.

There are four types of transformation routines:

- **Modelling** - transforms the coordinate systems of objects (routines MPROTA, MPSCAL, and MPTRAN)
- **Viewing** - specifies a viewing position (routines MPPOLA and MPLOOK)
- **Projection** - transforms the eye coordinate system to device coordinates (routines MPPERS, MPWIND, MPORT2, and MPORT3)
- **Viewport** - defines a rectangular area of the device in which to display the results (routine MPVIEW)

There are drawing routines in addition to the transformation routines. The drawing routines map two- or three-dimensional points, vectors, or polygons to the device coordinates and then draw them on the device.

In a typical application, the user would call the mapping routines in the following order: projection, then viewing, and then modelling. That is, the user first defines the projection and the location of the eye, and after that, manipulates the object with the modelling routines. This order is not mandatory, however. The user can call the routines in any order provided the projection and viewing routines are called before the drawing routines.

All device coordinates are obtained as described below. The word “points” is used in this description, but the description is also true for vectors and polygons.

Two-dimensional:

First, the points are mapped by the model transformation. Then the points are clipped against any clip lines the user has specified with MPCLP2. Next these points are multiplied by the projection transformation. The viewing transformation does not make sense in two dimensions, so do not call a viewing routine in two dimensions. Finally, the points are mapped to the current viewport window and clipped against this same viewport window.

Three-dimensional:

First, the points are mapped by the model transformation. Then the points are clipped against any planes the user has specified with MPCLP3. Next these points are multiplied by the viewing transformation. Then the points are clipped against the near and far clipping planes. They are then multiplied by the projection transformation. Finally, the points are mapped and clipped to the current viewport.

Manipulating Output. The entire plot can be scaled, translated, and rotated. In addition, the user can specify a viewport in which to plot the data. The description of routine PLTSETMAP explains the options available here. Note that the entire plot (including the legend) is manipulated, not just the model being plotted. By default, all output is clipped to the full screen as defined by initialization calls, and no scaling, translation, or rotation is done. If the viewport aspect ratio is not the same as the aspect ratio specified in initializing PLT_LIB, the plot will be distorted.

10.1.3 Linking

The PLT_LIB routines are in an object library in the [LIBRARIES] subdirectory (see Section 2.10, "Software Libraries"). PLT_LIB must be linked with the DVDI_LIB graphics interface. To link a code with PLT_LIB, type (the logical names of the libraries are assigned by the library sponsor):

\$SELECT NULL

\$LINK *code_name*, ... , SHRPLT/LIB, CDRLIB/LIB/INCL - CDRABC

A FLINT library is available for checking interfaces. It is in
CAMCON\$ROOT: [LIBRARIES.DVDI_LIB] PLT_LIB.LBT.

10.1.4 Summary of Routines

The PLT_LIB routines are described in detail in the next section. The following is a summary of the PLT_LIB routines.

Plot Initialization and Control

- PLTBEL - Ring the terminal bell; ignored by batch devices
- PLTBGN - Begin a new frame and reset some values to defaults
- PLTCANCEL - Reset or check interrupt flag
- PLTCRS - Display a locator and wait for a key to be struck
- PLTEND - End the plotting
- PLTFLU - Flush the buffer so the plot is up to date
- PLTFRM - Draw a header or trailer frame
- PLTINT - Initialize with default values
- PLTIQD - Return an array of device capabilities
- PLTRDC - Return the maximum device coordinates
- PLTSTA - Initialize with user-specified device coordinates
- PLTWAI - Wait for the user to view the screen and signal when finished

Routines to Set PLT_LIB Parameters

- PLTSETCOL - Set color parameters
- PLTGETCOL - Get color parameters
- PLTSETDRW - Set basic graphics parameters
- PLTGETDRW - Get basic graphics parameters
- PLTSAVDRW - Save basic graphics parameters
- PLTRESDRW - Restore basic graphics parameters
- PLTSETGPH - Set graph parameters
- PLTGETGPH - Get graph parameters
- PLTSAVGPH - Save graph parameters
- PLTRESGPH - Restore graph parameters
- PLTSETMAP - Set global mapping parameters
- PLTGETMAP - Get global mapping parameters
- PLTSAVMAP - Save global mapping parameters
- PLTRESMAP - Restore global mapping parameters
- PLTSETSYM - Set symbol parameters

- PLTGETSYM - Get symbol parameters
- PLTSAVSYM - Save symbol parameters
- PLTRESSYM - Restore symbol parameters
- PLTSETTXT - Set text parameters
- PLTGETTXT - Get text parameters
- PLTSAVTXT - Save text parameters
- PLTRESTXT - Restore text parameters

Text Routines

- PLTTXTCEN - Plot text centered at the given location
- PLTTXTEND - Return the coordinates of the end of the last text output
- PLTTXTLEN - Return the length of the given character string using the current character size
- PLTTXTNXT - Return the coordinates of the beginning of the next line of text output
- PLTTXTSTR - Plot a character string

Two-Dimensional Graphing Routines

- PLTARROW - Draw an arrow on existing axes
- PLTAXES - Draw a set of axes and define the graph and clipping window
- PLTCIRCLE - Draw a circle on existing axes
- PLTCLIP - Convert and clip a vector within the clipping window
- PLTCURVE - Draw a curve with optional symbols on existing axes
- PLTD2G - Convert from device to graph coordinates
- PLTG2D - Convert from graph to device coordinates
- PLTINI - Return suitable numbers to use in axis scaling, inside the specified interval
- PLTINO - Return suitable numbers to use in axis scaling, outside the specified interval
- PLTPOLY - Draw a polygon on existing axes
- PLTSCALE - Define the graph window to fit curve points
- PLTSYMBOL - Draw a set of text symbols on existing axes
- PLTVECTOR - Draw a set of vectors on existing axes

Device Coordinate Plotting Primitives

- PLTARR - Draw an arrow
- PLTAXS - Draw a linear axis
- PLTDRW - Draw a vector from the current pen position to the specified position
- PLTMOV - Move the pen
- PLTPLY - Draw a filled polygon
- PLTPNT - Plot specified points
- PLTPTM - Plot specified points with masking
- PLTRXY - Return the current position of the pen
- PLTSYMCEN - Plot a character centered at the given locations
- PLTSYMMSK - Plot a symbol at each of the given points with masking
- PLTVCM - Draw vectors with masking
- PLTVCT - Draw vectors

Two-Dimensional and Three-Dimensional Mapping Routines

- MP2PG - Map two-dimensional polygons
- MP2PT - Map two-dimensional points
- MP2VC - Map two-dimensional vectors

- MP3PG - Map three-dimensional polygons
- MP3PT - Map three-dimensional points
- MP3VC - Map three-dimensional vectors
- MPCLP2 - Specify two-dimensional clipping lines
- MPCLP3 - Specify three-dimensional clipping lines
- MPD2PG - Map and draw two-dimensional polygons
- MPD2PT - Map and draw two-dimensional points
- MPD2SY - Map and draw two-dimensional symbols
- MPD2VC - Map and draw two-dimensional vectors
- MPD3PG - Map and draw three-dimensional polygons
- MPD3PT - Map and draw three-dimensional points
- MPD3VC - Map and draw three-dimensional vectors
- MPGETM - Return the current transformations and viewport
- MPINIT - Reset the modelling, viewing, and projection transformation to identity and set the viewport to 0,XNDC, 0,YNDC
- MPLOOK - Define the viewer's position by defining a viewport and a line of sight (viewing transformation)
- MPORT2 - Specify a two-dimensional viewing rectangle for orthographic projections; the z values are unchanged
- MPORT3 - Specify a three-dimensional viewing rectangle parallelepiped for orthographic projections
- MPPERS - Define a perspective projection transformation by specifying a field-of-view angle, an aspect ratio, and the near and far clipping planes
- MPPOLA - Define the viewer's position in polar coordinates (viewing transformation)
- MPPOPM - Pop the mapping stack
- MPPSHM - Push the current mapping parameters (stack is 10 deep)
- MPPUTM - Set the current modelling, viewing, and projection matrices, as well as the current viewport, to the user specified arrays
- MPRESE - Reset only the modelling transformation to identity
- MPRLC - Return the position of the eye, the point the eye is looking at, and the twist angle of the eye about its line of sight
- MPROTA - Rotate about an axis (modelling transformation)
- MPSCAL - Scale in a direction (modelling transformation)
- MPTRAN - Translate in a direction (modelling transformation)
- MPVIEW - Define the viewport
- MPWIND - Define a perspective projection transformation by specifying a rectangular viewing frustum in the near clipping plane and the far clipping plane

Clipping of Two-Dimensional and Three-Dimensional Points, Lines, and Polygons

- PLTCG2 - Clip a two-dimensional polygon against a line
- PLTCP2 - Clip two-dimensional points against a line segment
- PLTCP3 - Clip three-dimensional points against a plane
- PLTCV2 - Clip two-dimensional vectors against a line segment
- PLTCV3 - Clip three-dimensional vectors against a plane
- PLTVWG - Clip a polygon against a viewport
- PLTVWP - Clip points against a viewport
- PLTVWV - Clip vectors against a viewport
- PLTZCP - Clip points against two clipping planes
- PLTZCV - Clip vectors against two clipping planes

Color Palette Routines

- PLTCNM - Return the color name for a given color index
- PLTICL - Return the color index for a given color name
- PLTIQC - Return the red, green, and blue intensity for the given color
- PLTISP - Map a number between 0 and 1 into the spectrum
- PLTPAL - Set the color and intensity of a palette color
- PLTCOL - Set a color to the specified red, green, and blue values
- PLTSPC - Set a range of colors in a specified interval of the spectrum

Obsolete Routines (These routines are still available but have been made obsolete by new routines.)

- PLTSTC - Replaced by PLTSETCOL
- PLTGTC - Replaced by PLTGETCOL
- PLTSTD - Replaced by PLTSETDRW
- PLGTD - Replaced by PLTGETDRW
- PLTSVD - Replaced by PLTSAVDRW
- PLTRED - Replaced by PLTRESDRW
- PLTSTG - Replaced by PLTSETGPH, PLTSETDRW, and PLTSETSYM
- PLGTG - Replaced by PLTGETGPH, PLTGETDRW, and PLTGETSYM
- PLTSVG - Replaced by PLTSAVGPH, PLTSAVDRW, and PLTSAVSYM
- PLTREG - Replaced by PLTRESGPH, PLTRESDRW, and PLTRESSYM
- PLTSTM - Replaced by PLTSETMAP
- PLGTGM - Replaced by PLTGETMAP
- PLTSVM - Replaced by PLTSAVMAP
- PLTREM - Replaced by PLTRESMAP
- PLSTTT - Replaced by PLTSETTXT
- PLGTGT - Replaced by PLTGETTXT
- PLTSVT - Replaced by PLTSAVTXT
- PLTRET - Replaced by PLTRESTXT
- PLSTTV - Replaced by PLTSETDRW
- PLGTGV - Replaced by PLTGETDRW
- PLTSVV - Replaced by PLTSAVDRW
- PLTREV - Replaced by PLTRESDRW

- PLTSBM - Replaced by PLTSYMMSK
- PLTSYM - Replaced by PLTSYMCEN
- PLTXHE - Replaced by PLTTXTEND
- PLTXHL - Replaced by PLTTXTLEN
- PLTXHN - Replaced by PLTTXTNXT
- PLTXSE - Replaced by PLTTXTEND
- PLTXSL - Replaced by PLTTXTLEN
- PLTXSN - Replaced by PLTTXTNXT
- PLTXTC - Replaced by PLTTXTCEN
- PLTXTH - Replaced by PLTTXTSTR
- PLXTS - Replaced by PLTTXTSTR

- PLTCUR - Replaced by PLTCURVE
- PLTGPH - Replaced by PLTAXES

10.2 Description of Routine Calls

10.2.1 Plot Initialization and Control

Detailed descriptions of the routines that initialize and control plotting are given on the following pages.

May 1993

Subroutine

Name	PLTBGN - Begin a new frame
Description	PLTBGN begins a new frame and resets some parameters to default values.
Syntax	CALL PLTBGN

PLTCANCEL
Function

Name PLTCANCEL - Reset or check interrupt flag

Description PLTCANCEL checks whether an interrupt character was entered. Under VMS, the interrupt character is Control-C (press and hold the Control key and press the C key). A call to PLTCANCEL with .TRUE. resets the internal flag to indicate that no interrupt character has been entered after the interrupt flag has been returned.

Syntax logical = PLTCANCEL (FLAG)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FLAG	Input	logical	If .TRUE. reset the internal flag to indicate that no interrupt character has been entered.

Comments PLTCANCEL does not reset the internal interrupt flag until it is called with a value of .TRUE. Typically the user calls PLTCANCEL with .TRUE. before beginning a plot, then calls PLTCANCEL with .FALSE. in places where a lot of wall clock time will be spent on CPU or graphics work. PLTCANCEL allows the user to move out of low levels of a program all the way to the top.

PLTCRS
Logical Function

Name	PLTCRS - Display locator and wait			
Description	PLTCRS displays a locator and waits for a key to be struck.			
Syntax	logical = PLTCRS (X, Y, KEY)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Output	real	Device x-coordinate of locator.
	Y	Output	real	Device y-coordinate of locator.
	KEY	Output	char*1	Key that was struck (do not press carriage return).
Comments	Will return FALSE if there is an error (such as the cursor being out of the current viewport).			

PLTEND
Subroutine

Name	PLTEND - End plotting
Description	PLTEND ends the plotting. It should be called last. PLTEND calls VDFRAME with a value of 1 to produce an end frame on some devices, and then calls VDTERM. Calling VDTERM is essential to close the output file of batch devices properly.
Syntax	CALL PLTEND

PLTFLU
Subroutine

Name	PLTFLU - Flush the buffer
Description	PLTFLU flushes the buffer to ensure the plot is up-to-date.
Syntax	CALL PLTFLU

PLTFRM
Subroutine

Name	PLTFRM - Draw a header or trailer frame			
Description	PLTFRM draws a header or trailer frame.			
Syntax	CALL PLTFRM (ITYPE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ITYPE	Input	integer	The header or trailer flag: 0 - header 1 - trailer

PLTINT
Subroutine

Name	PLTINT - initializes PLT_LIB
Description	PLTINT initializes PLT_LIB and must be called first if it is used. It can be called as many times as required. This routine calls the SVDI initialization routine VDINIT with an aspect ratio of 1.33 and a justification of 5 and then calls VDFRAM with a 0 to draw a header frame (on some devices).
Syntax	CALL PLTINT
Comments	PLTINT is the same as routine PLTSTA except that PLTINT calls VDINIT with device coordinates from 0 to 1 in the x direction and from 0 to .75 in the y direction, ASPECT=1.0/0.75, and JUSTIF=5, and then calls VDFRAM with a 0. PLTSTA was added to allow the user to set up his own device coordinates.
See Also	PLTSTA

PLTIQD
Subroutine

Name	PLTIQD - Return an array of device capabilities			
Description	PLTIQD returns an array of device capabilities. See the SVDI routine VDIQDC for a description of the array.			
Syntax	CALL PLTIQD (ARRAY)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ARRAY	Output	real array	The array (dimensioned to at least 35) that contains the device capabilities.
See Also	VDIQDC (Section 10.6)			

PLTRDC
Subroutine

Name	PLTRDC - Return the maximum device coordinates			
Description	PLTRDC returns the maximum device coordinates.			
Syntax	CALL PLTRDC (XNDC, YNDC)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XNDC	Output	real	Maximum x-coordinate for the device. The device x-coordinates range from 0 to XNDC.
	YNDC	Output	real	Maximum y-coordinate for the device. The device y-coordinates range from 0 to YNDC.

PLTSTA
Subroutine

Name	PLTSTA - Initialize PLT_LIB									
Description	PLTSTA initializes PLT_LIB but does not call VDINIT and VDFRAM as PLTINT does. Either PLTSTA or PLTINT must be called before any other PLT_LIB routines. If PLTSTA is used, the user <i>must</i> call VDINIT directly <i>before</i> the call to PLTSTA (the call to VDFRAM is optional). PLTSTA can be called as many times as required. After the first call, subsequent calls simply reinitialize PLT_LIB; VDINIT is called the first time only.									
Syntax	CALL PLTSTA									
Comments	<p>The user must call VDINIT before the call to PLTSTA. The arguments to VDINIT are ASPECT and JUSTIF [CALL VDINIT (ASPECT, JUSTIF)]. ASPECT is the ratio of x-dimension to y-dimension and JUSTIF is an integer as shown in the following table:</p> <table><tr><td>7</td><td>8</td><td>9</td></tr><tr><td>4</td><td>5</td><td>6</td></tr><tr><td>1</td><td>2</td><td>3</td></tr></table> <p>This table tells VDI how to justify the plot. For example, 7 means to justify at the upper left on the device surface, 5 means center vertically and horizontally, 3 means lower right, etc. For more information, see VDINIT in Chapter 11.</p>	7	8	9	4	5	6	1	2	3
7	8	9								
4	5	6								
1	2	3								
See Also	PLTINT (PLTINT is the same as PLTSTA except that the first time PLTINT is called, it calls VDINIT with ASPECT=1.0/0.75 and JUSTIF=5 and then calls VDFRAM with a 0 to draw a header frame on some devices.)									

PLTWAI
Subroutine

Name	PLTWAI - Wait for a signal that the user is finished viewing the screen
Description	PLTWAI waits for the user to view the screen and signal that he is done, usually by pressing a key. The user must not press the carriage return.
Syntax	CALL PLTWAI
Warning	Do not press the carriage return to end the wait.

10.2.2 Setting PLT_LIB Parameters

Detailed descriptions of the routines that set PLT_LIB parameters are given on the following pages.

PLTSETCOL
Logical Function

Name	PLTSETCOL - Set color parameters			
Description	PLTSETCOL sets the color parameters according to the specified option and buffer values.			
Syntax	logical = PLTSETCOL (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	char*(*)	Color parameter to be set.
	BUFFER	Input	real	Values for color parameters (dependent on OPTION).
Parameter Values	Option	Action		
	RESET	Reset color parameters to default		
	RAINBOW	Set the color spectrum to rainbow order (default) (PLTGETCOL returns BUFFER(1) = 0.0 for this action)		
	REVERSE_RAINBOW	Set the color spectrum to reversed rainbow order (PLTGETCOL returns BUFFER(1) = -1.0 for this action)		
	LINEAR_VARIATION	Linearly vary the color spectrum from 0.0, 0.0, 0.0 to BUFFER(1) (1.0 - 15.0)		
See Also	PLTGETCOL			

PLTGETCOL
Logical Function

Name	PLTGETCOL - Get color parameters			
Description	PLTGETCOL returns the color parameters. See PLTSETCOL for option and buffer values.			
Syntax	logical = PLTGETCOL (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Output	char*(*)	Desired color parameters (only 1 is valid).
	BUFFER	Output	real	Values of color parameters (dependent on OPTION).
Note	Options RAINBOW, REVERSE_RAINBOW, and LINEAR_VARIATION are equivalent to PLTGETCOL.			
See Also	PLTSETCOL			

PLTSETDRW
Logical Function

Name	PLTSETDRW - Set basic graphics parameters			
Description	PLTSETDRW sets the basic graphics parameters such as color and line type according to the specified option and buffer values. The graphics buffer is flushed so that the changes are up-to-date.			
Syntax	CALL PLTSETDRW (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	char*(*)	Basic graphics parameters to be set.
	BUFFER	Input	real array	Values for basic graphics parameters (dependent on OPTION).
Parameter Values	Option	Action		
	RESET	Reset device parameters to default		
	BACK_COLOR	Set background color to BUFFER(1) (range 0.0 - 255.0)		
	COLOR	Set foreground color used to draw all lines, points, and filled areas to BUFFER(1) (range 0.0 - 255.0)		
	INTENSITY	Set intensity to BUFFER(1) (range 0.0 - 100.0), where 0.0 is invisible		
	LINE_STYLE	Set the line style based on BUFFER(1) as follows: 0.0 = no line 1.0 = solid 2.0 = dotted 3.0 = dot dash 4.0 = short dash 5.0 = long dash 6.0 = medium dash		
	LINE_WIDTH	Set the line width to BUFFER(1) (range is 0.0 - 1000.0, where 1000 is 0.01 in VDI space)		
See Also	PLTGETDRW			

PLTGETDRW
Logical Function

Name	PLTGETDRW - Get device parameters			
Description	PLTGETDRW return the device parameters. See PLTSETDRW for option and buffer values.			
Syntax	CALL PLTGETDRW (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	char*(*)	Desired device parameter.
	BUFFER	Output	real array	Values of device parameters (dependent on OPTION).
See Also	PLTSETDRW			

PLTSAVDRW
Subroutine

Name	PLTSAVDRW - Save device parameters
Description	PLTSAVDRW saves the device parameters in a local array.
Syntax	CALL PLTSAVDRW
See Also	PLTRESDRW. PLTRESDRW restores the device parameters saved by PLTSAVDRW.

PLTRESDRW
Subroutine

Name	PLTRESDRW - Restore device parameters
Description	PLTRESDRW restores the device parameters saved by PLTSAVDRW.
Syntax	CALL PLTRESDRW
See Also	PLTSAVDRW

PLTSETGPH
Logical Function

Name	PLTSETGPH - Set graph parameters			
Description	PLTSETGPH sets the graph parameters according to the specified option and buffer values.			
Syntax	CALL PLTSETGPH (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	integer	Graph parameter to set.
	BUFFER	Input	real array	Values for graph parameters (dependent on OPTION).
Parameter Values	Option	Action		
	RESET	Reset graph parameters to default		
	X_ORIGIN	Set x-origin of graph to BUFFER(1)		
	Y_ORIGIN	Set y-origin of graph to BUFFER(1)		
	X_LENGTH	Set length of x-axis to BUFFER(1)		
	Y_LENGTH	Set length of y-axis to BUFFER(1)		
	X_AXIS_TYPE	Set x-axis type based on BUFFER(1): 0 = normal, 1 = logarithmic		
	Y_AXIS_TYPE	Set y-axis type based on BUFFER(1): 0 = normal, 1 = logarithmic		
	FRAME	Turn on graph framing if BUFFER(1) is 1; turn off if BUFFER(1) is 0		
	AXIS_COLOR	Set axis color to BUFFER(1) (range 0.0-255.0)		
	AXIS_WIDTH	Set pen width of axes to BUFFER(1)		
	X_SCALING_TYPE	Set x-axis scaling type based on BUFFER(1) as follows: BUFFER(1) = 1.0 - autoscale with PLTSCALE, different x and y scaling possible; PLTGETGPH will return BUFFER(2-5) as defined for BUFFER(1) = 3.0 = 2.0 - autoscale with PLTSCALE, same x and y scaling forced; PLTGETGPH will return BUFFER(2-5) as defined for BUFFER(1) = 3.0		

PLTSETGPH
Logical Function

**Parameter
Values
(continued)**

BUFFER(1) = 3.0 - user defines scaling as follows:
BUFFER(2) - minimum x
BUFFER(3) - maximum x
BUFFER(4) - number of major x intervals
BUFFER(5) - number of minor intervals on x-axis
= 4.0 - user defines exact scaling as follows:
BUFFER(2) - minimum x
BUFFER(3) - first nice x
BUFFER(4) - maximum x
BUFFER(5) - x interval
BUFFER(6) - number of minor x intervals

Y_SCALING_TYPE Set y-axis scaling type based on **BUFFER(1)** as follows:
BUFFER(1)
= 1.0 - autoscale with **PLTSCALE**, different x and y scaling possible; **PLTGETGPH** will return **BUFFER(2-5)** as defined for **BUFFER(1) = 3.0**
= 2.0 - autoscale with **PLTSCALE**, same x and y scaling forced; **PLTGETGPH** will return **BUFFER(2-5)** as defined for **BUFFER(1) = 3.0**
= 3.0 - user defines scaling as follows:
BUFFER(2) - minimum y
BUFFER(3) - maximum y
BUFFER(4) - number of major y intervals
BUFFER(5) - number of minor intervals on y-axis
= 4.0 - user defines exact scaling as follows:
BUFFER(2) - minimum y
BUFFER(3) - first nice y
BUFFER(4) - maximum y
BUFFER(5) - y interval
BUFFER(6) - number of minor y intervals

CLIPPING_WINDOW Set clipping window based on **BUFFER(1)** as follows:
BUFFER(1)
= 0.0 - clipping window is the same as the graph window (set by **X/Y_SCALING_TYPE**)

PLTSETGPH
Logical Function

**Parameter
Values
(continued)**

	= 1.0	- clipping window is defined with respect to the graph window as follows: BUFFER(2) - amount to add to the x minimum and subtract from the x maximum (in graph units) BUFFER(3) - amount to add to the y minimum and subtract from the y maximum (in graph units)
	= 2.0	- clipping window is defined in graph units as follows: BUFFER(2) - minimum x BUFFER(3) - maximum x BUFFER(4) - minimum y BUFFER(5) - maximum y
X_AXIS_SCI		Set type of notation on x-axis based on BUFFER(1): 0 = normal, 1 = scientific
Y_AXIS_SCI		Set type of notation on y-axis based on BUFFER(1): 0 = normal, 1 = scientific
X_EXPONENT		Set x-exponent to BUFFER(1); this exponent is the exponent labelled in scientific notation on the linear axis (ignored if scientific notation is not set); -999999.0 to let the code determine the exponent
Y_EXPONENT		Set y-exponent to BUFFER(1); this exponent is the exponent labelled in scientific notation on the linear axis (ignored if scientific notation is not set); -999999.0 to let the code determine the exponent
X_DIGITS		Set number of decimal places in x-axis numbers to BUFFER(1) (range 0-9)
Y_DIGITS		Set number of decimal places in y-axis numbers to BUFFER(1) (range 0-9)
Y_VERTICAL		Set y number vertical or horizontal based on BUFFER(1) (1=vertical; otherwise horizontal)
X_NUMBER_SIZE		Set character size of x-axis number to BUFFER(1); 0 turns off drawing the numbers
Y_NUMBER_SIZE		Set character size of y-axis number to BUFFER(1); 0 turns off drawing the numbers
NUMBER_COLOR		Set color of axes number to BUFFER(1)
NUMBER_WIDTH		Set pen width of axes number to BUFFER(1)
X_LABEL_SIZE		Set character size of x-axis labels to BUFFER(1); 0 turns off drawing the label
Y_LABEL_SIZE		Set character size of y-axis labels to BUFFER(1); 0 turns off drawing the label
LABEL_COLOR		Set color for axes labels to BUFFER(1)
LABEL_WIDTH		Set pen width of axes labels to BUFFER(1)
GRID_COLOR		Set color for major grid to BUFFER(1)

PLTSETGPH
Logical Function

GRID_STYLE	Set line style for major grid to BUFFER(1) as follows: 0.0=no line 1.0=solid 2.0=dotted 3.0=dot dash 4.0=short dash 5.0=long dash 6.0=medium dash
GRID_WIDTH	Set pen width of major grid to BUFFER(1)
MINOR_COLOR	Set color of minor grid to BUFFER(1)
MINOR_STYLE	Set line style of minor grid to BUFFER(1) (see GRID_STYLE for valid types); 0 to turn off grid drawing
MINOR_WIDTH	Set pen width of minor grid to BUFFER(1)
TICK_COLOR	Set color of ticks to BUFFER(1)
TICK_WIDTH	Set pen width of ticks to BUFFER(1)
ZLINE_COLOR	Set color of line at zero to BUFFER(1)
ZLINE_STYLE	Set line style of line at zero to BUFFER(1)
ZLINE_WIDTH	Set pen width of line at zero to BUFFER(1)

See Also

PLTGETGPH

PLTGETGPH
Logical Function

Name	PLTGETGPH - Get graph parameters			
Description	PLTGETGPH returns the graph parameters. See PLTSETGPH for option and buffer values. The only exception is when getting scaling type (SCALING_TYPE). Here BUFFER(1) is checked: if it equals user scaling (3.0) then BUFFER(2) - BUFFER(9) are loaded with the user scaling; if it equals exact scaling (4.0), then BUFFER(2) - BUFFER(11) are loaded with the exact scaling.			
Syntax	logical = PLTGETGPH (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	char*(*)	Desired graph parameter.
	BUFFER	Output	real array	Values for graph parameters (dependent on OPTION).
See Also	PLTSETGPH			

PLTSAVGPH
Subroutine

Name	PLTSAVGPH - Save graph parameters
Description	PLTSAVGPH saves the graph parameters in a local array.
Syntax	CALL PLTSAVGPH
See Also	PLTRESGPH. PLTRESGPH restores the graph parameters saved by PLTSAVGPH.

PLTRESGPH
Subroutine

Name	PLTRESGPH - Restore graph parameters
Description	PLTRESGPH restores the graph parameters saved by PLTSVGPH.
Syntax	CALL PLTRESGPH
See Also	PLTSAVGPH

PLTSETMAP

Logical Function

Name	PLTSETMAP - Set global mapping parameters			
Description	<p>PLTSETMAP sets global mapping parameters, allowing you to perform the following two-dimensional transformations:</p> <ul style="list-style-type: none"> • Set a scale factor for the x and y directions. • Set a translation amount for the x and y directions. • Set a rotation angle to rotate the plot. • Set a viewport in which to draw the plot. A viewport is specified by giving the right, left, top, and bottom coordinates in the device space of a rectangle in which to draw vectors, polygons, etc. <p>The parameters are set according to the specified index and buffer values. The buffer is flushed so the changes are up-to-date.</p>			
Syntax	CALL PLTSETMAP (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	integer	Option for setting global mapping parameters.
	BUFFER	Input	real array	Values for global mapping parameters.
Parameter Values	Option	Action		
	RESET	Reset global mapping parameters to default		
	X_SCALE	Set global x-scaling factor to BUFFER(1)		
	Y_SCALE	Set global y-scaling factor to BUFFER(1)		
	X_TRANS	Set global x-translation amount to BUFFER(1)		
	Y_TRANS	Set global y-translation amount to BUFFER(1)		
	ROTATION	Set global rotation angle in degrees to BUFFER(1)		
	VIEWPORT	Set global viewport to BUFFER(1) - BUFFER(4), where BUFFER is an array indicating left, right, bottom, and top, of the viewport in device coordinates.		

PLTSETMAP
Logical Function

Note Remember that the PLT coordinates are only mapped into this new coordinate system and viewport. The current position of the pen is still in PLT space even though the coordinates are mapped into some different device space.

Caveats

- Hardware text cannot be rotated on some devices.
- The vectors, polygons, and text are clipped against the current viewport. Since the maximum x-coordinate can be larger than the maximum y-coordinate, you may have to scale the x-coordinate down if you rotate by 90 degrees, for example. It is recommended that you scale in the x and y directions by 1/ASPECT; this guarantees no distortion and makes sure everything still fits on the screen.

Comments The global mapping routines have nothing to do with the mapping routines that begin with MP, except that output is funnelled through the global mapping routines. These global mapping routines allow the user to rotate, scale, and translate the final output from all plotting routines (except hardware-text routines). For instance, this allows the user to rotate a graph by 90 degrees so that the output is in portrait mode as opposed to landscape mode.

See Also PLTGETMAP

PLTGETMAP

Logical Function

Name	PLTGETMAP - Get global mapping parameters			
Description	PLTGETMAP returns the global mapping parameters. See PLTSETMAP for option and buffer values.			
Syntax	logical = PLTGETMAP (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	char*(*)	Desired global mapping parameter.
	BUFFER	Output	real array	Values for global mapping parameters (dependent on OPTION).
See Also	PLTS .IMAP			

PLTSAVMAP
Subroutine

Name	PLTSAVMAP - Save global mapping parameters
Description	PLTSAVMAP saves the global mapping parameters in a local array.
Syntax	CALL PLTSAVMAP
See Also	PLTRESMAP. PLTRESMAP restores the global mapping parameters saved by PLTSAVMAP.

PLTRESMAP
Subroutine

Name	PLTRESMAP - Restore global mapping parameters
Description	PLTRESMAP restores the global mapping parameters saved by PLTSAVMAP.
Syntax	CALL PLTRESMAP
See Also	PLTSAVMAP

PLTSETSYM
Logical Function

Name	PLTSETSYM - Set symbol parameters			
Description	PLTSETSYM sets the symbol parameters according to the specified option and buffer values.			
Syntax	logical = PLTSETSYM (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	char*(*)	Symbol parameter to set.
	BUFFER	Input	real array	Values for symbol parameters (dependent on OPTION).
Parameter Values	Option	Action		
	RESET	Reset symbol parameters to default		
	SOFT_HARD	Select software versus hardware symbols based on BUFFER(1): 0 = software, 1 = hardware		
	SOFT_FONT	Set the font for software symbols based on BUFFER(1) as follows: 0.0 = default 1.0 = Roman 2.0 = stick 3.0 = sans serif		
	HARD_FONT	Set the font for hardware symbols based on BUFFER(1) as follows: 0.0 = default		
	SYMBOL_COLOR	Set the color for symbols to BUFFER(1)		
	SYMBOL_WIDTH	Set the pen width for symbols to BUFFER(1)		
	SYMBOL_SIZE	Set symbol size to BUFFER(1)		
	The buffer is flushed so the changes are up-to-date.			
See Also	PLTGETSYM			

PLTGETSYM
Logical Function

Name	PLTGETSYM - Get symbol parameters			
Description	PLTGETSYM returns the symbol parameters. See PLTSETSYM for option and buffer values.			
Syntax	logical = PLTGETSYM (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	char*(*)	Desired symbol parameter.
	BUFFER	Output	real array	Values for symbol parameters (dependent on OPTION).
See Also	PLTSETSYM			

PLTSAVSYM
Subroutine

Name	PLTSAVSYM - Save symbol parameters
Description	PLTSAVSYM saves the symbol parameters in a local array.
Syntax	CALL PLTSAVSYM
See Also	PLTRESSYM. PLTRESSYM restores the symbol parameters saved by PSTSAVSYM.

PLTRESSYM

Subroutine

Name	PLTRESSYM - Restore symbol parameters
Description	PLTRESSYM restores the symbol parameters saved by PLTSAVSYM.
Syntax	CALL PLTRESSYM
See Also	PLTSAVSYM

PLTSETTXT
Logical Function

Name	PLTSETTXT - Set text parameters			
Description	PLTSETTXT sets the text parameters according to the specified option and buffer values.			
Syntax	logical = PLTSETTXT (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	char*(*)	Text parameter to set.
	BUFFER	Input	real array	Values for text parameters (dependent on OPTION).
Parameter Values	Option	Action		
	RESET	Reset text parameters to default		
	SOFT_HARD	Select software versus hardware characters based on BUFFER(1): 0 = software, 1 = hardware		
	SOFT_FONT	Set the font for software text based on BUFFER(1) as follows: 0.0 = default 1.0 = F.oman 2.0 = stick 3.0 = sans serif		
	HARD_FONT	Set the font for hardware text based on BUFFER(1) as follows: 0.0 = default		
	TEXT_COLOR	Set the color for text to BUFFER(1)		
	TEXT_WIDTH	Set the pen width for text to BUFFER(1)		
	CHAR_SIZE	Set character size to BUFFER(1)		
	TEXT_ANGLE	Set angle for text to be written; BUFFER(1) is the angle in degrees		
	CHAR_ANGLE	Set angle for characters to be written; BUFFER(1) is the angle in degrees		
	TEXT_WINDOW	Set text window to BUFFER(1) - BUFFER(8); the buffer denotes the four points of the window in CCW Order		
	LINE_SPACE	Set space between lines of text; BUFFER(1) contains a factor by which to multiply the y character size to obtain the linefeed size		

PLTSETTXT
Logical Function

**Parameter
Values
(continued)**

CHAR_SPACE	Set spacing between characters; BUFFER(1) contains a factor by which to multiply the normal character spacing (included as part of the font) to obtain the actual character spacing
SUB_SIZE	Set reduction in y character size for sub- and superscripts. BUFFER(1) contains a factor by which to multiply the current y character size to obtain the size of the sub- and superscripts
SUPER_RAISE	Set the amount by which to raise the superscripts; BUFFER(1) contains a number which, when multiplied by the current character size, will give the amount to raise the superscript
SUB_LOWER	Set the amount by which to lower the subscripts; BUFFER(1) contains a number which, when multiplied by the current character size, will give the amount to lower the subscript

The buffer is flushed so the changes are up-to-date.

See Also

PLTGETTXT

PLTGETTXT
Logical Function

Name	PLTGETTXT - Get text parameters			
Description	PLTGETTXT returns the text parameters. See PLTSETTXT for option and buffer values.			
Syntax	logical = PLTGETTXT (OPTION, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	OPTION	Input	char(*)	Desired text parameter.
	BUFFER	Output	real array	Values for text parameters (dependent on OPTION).
See Also	PLTSETTXT			

PLTSAVTXT
Subroutine

Name	PLTSAVTXT - Save text parameters
Description	PLTSAVTXT saves the text parameters in a local array.
Syntax	CALL PLTSAVTXT
See Also	PLTRESTXT. PLTRESTXT restores the text parameters saved by PLTSAVTXT.

PLTRESTXT
Subroutine

Name	PLTRESTXT - Restore text parameters
Description	PLTRESTXT restores the text parameters saved by PLTSAVTXT.
Syntax	CALL PLTRESTXT
See Also	PLTSAVTXT

10.2.3 Hardware and Software Text

Detailed descriptions of the routines that plot hardware and software text are given on the following pages. The following escape characters may be used with the text plotting routines:

<u>Escape Character</u>	<u>Action or Character Generated on Plot</u>
\CR	- carriage return
\LF	- line feed
\CL	- carriage return and line feed
\^	- superscript (no space required)
\-	- normal (no space required)
_	- subscript (no space required)
\CLO	- centered logo
\CSQ	- centered square
\CDI	- centered diamond
\CCS	- centered cross
\CX	- centered X
\CTR	- centered triangle
\CCI	- centered circle
\CDO	- centered dot
\DDLINE	- dot-dash line
\DLINE	- dotted line
\LDLINE	- long dash line
\LO	- logo
\MDLINE	- medium dash line
\SDLINE	- solid line
\SQ	- square
\DI	- diamond
\CS	- cross
\X	- X
\TR	- triangle
\CI	- circle
\DO	- dot
\PLUSMIN	- plus or minus
\GR	- start Greek font
\ENG	- return to normal font
\LEQ	- less than or equal to
\GEQ	- greater than or equal to
\NEQ	- not equal to
\PRIME	- prime
\NLEQ	- not less than or equal to
\NGEQ	- not greater than or equal to
\LL	- much less than
\GG	- much greater than
\SUM	- summation
\NLT	- not less than
\NGT	- not greater than
\APPROX	- approximation sign
\\	- single backslash

PLTTXTCEN
Subroutine

Name	PLTTXTCEN - Plot centered text.			
Description	PLTTXTCEN plots the specified text centered at a specified location. The text is centered in the x direction only. The text attributes apply.			
Syntax	CALL PLTTXTCEN (XD, YD, TEXT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD, YD	Input	real	The device x,y coordinates for the centered text.
	TEXT	Input	char	The text to be plotted.
See Also	PLTSETTXT for attributes			

PLTTEXTEND

Subroutine

Name	PLTTEXTEND - Return coordinates of the end of the last text output			
Description	PLTTEXTEND returns the coordinates of the end of the last text output.			
Syntax	CALL PLTTEXTEND (XD, YD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD, YD	Output	real	The device x,y coordinates of the end of the last text output.
See Also	PLTSETTXT			

PLTTXTLEN
Subroutine

Name	PLTTXTLEN - Return the length of a character string			
Description	PLTTXTLEN returns the actual length of a specified character string, using the current character size to determine the length.			
Syntax	CALL PLTTXTLEN (TEXT, LENGTH)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	TEXT	Input	char	The character string.
	LENGTH	Output	real	The length of the character string (in device units).
See Also	PLTSETTXT			

PLTTXTNXT

Subroutine

Name	PLTTXTNXT - Return the position of the beginning of the next line of text			
Description	PLTTXTNXT returns the coordinates of the beginning of the next line of text output.			
Syntax	CALL PLTTXTNXT (XD, YD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD, YD	Output	real	Device x,y coordinates of the beginning of the next line of text output.
See Also	PLTSETTXT			

PLTTXTSTR

Subroutine

Name	PLTTXTSTR - Plot text			
Description	PLTTXTSTR plots a specified character string. The text attributes apply.			
Syntax	CALL PLTTXTSTR (XD, YD, TEXT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD, YD	Input	real	Device x,y coordinates for beginning of text to be plotted.
	TEXT	Input	char	Text to be plotted (133-character maximum).
See Also	PLTSETTXT for attributes			

10.2.4 Two-Dimensional Graphing

Detailed descriptions of the routines used for two-dimensional graphing are given on the following pages.

PLTARROW
Logical Function

Name PLTARROW - Draw an arrow

Description PLTARROW draws an arrow on a set of existing axes. This routine should be called only after a call to PLTAXES or PLTSCALE. The basic graphics attributes apply. PLTARROW returns .TRUE. if and only if any part of the arrow is within the clipping window.

Syntax Logical = PLTARROW (XTAIL, YTAIL, XHEAD, YHEAD, ANGLE, ARRLEN)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XTAIL, YTAIL	Input	real	Graph x,y coordinate for the tail of the arrow.
	XHEAD, YHEAD	Input	real	Graph x,y coordinate for the head of the arrow.
	ANGLE	Input	real	Angle between the arrow head and body in degrees.
	ARRLEN	Input	real	Length of arrow head in device coordinates.

See Also PLTAXES, PLTSCALE
PLTSETDRW for attributes

PLTAXES
Subroutine

Name	PLTAXES - Draw a set of axes			
Description	PLTAXES draws a set of axes using the attributes set by PLTSETGPH.			
Syntax	CALL PLTAXES (XLABL, XUNIT, YLABL, YUNIT)			
Variables In Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XLABL	Input	char	Label for x-axis.
	XUNIT	Input	char	Units for x-axis.
	YLABL	Input	char	Label for y-axis.
	YUNIT	Input	char	Units for y-axis.
Note	If autoscale is selected for either axis (with X/Y_SCALING_TYPE of PLTSETGPH), PLTSCALE must be called to set the axis limits before PLTAXES is called.			
See Also	PLTSETGPH to set graph attributes PLTSCALE to set autoscale axis limits			

PLTCIRCLE
Logical Function

Name	PLTCIRCLE - Draw a circle			
Description	PLTCIRCLE draws a circle on a set of existing axes. This routine should be called only after a call to PLTAXES or PLTSCALE. The basic graphics attributes apply. PLTCIRCLE returns .TRUE. if and only if any part of the circle is within the clipping window.			
Syntax	logical = PLTCIRCLE (XG, YG, RAD, MODE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XG, YG	Input	real	Graph x,y coordinates of center of circle.
	RAD	Input	real	The radius of the circle in graph units.
	MODE	Input	char*1	A character that tells how to draw the circle (upper- or lowercase): O - draw only the outline of the circle S - shade the circle with the current color
See Also	PLTSETDRW for attributes PLTAXES, PLTSCALE			

PLTCLIP

Logical Function

Name	PLTCLIP - Convert and clip a two-dimensional vector from graph coordinates to device coordinates			
Description	PLTCLIP converts a two-dimensional vector, clipping the vector against the clipping window defined by PLTSETGPH. PLTCLIP returns .TRUE. if and only if any part of the vector is within the window.			
Syntax	logical = PLTCLIP (XG0, YG0, XG1, YG1, XD0, YD0, XD1, YD1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XG0, YG0	Input	real array	Graph x,y coordinate of start point for the vector.
	XG1, YG1	Input	real array	Graph x,y coordinate of end point for the vector.
	XD0, YD0	Output	real array	Device x,y coordinate of start point for the clipped vector.
	XD1, YD1	Output	real array	Device x,y coordinate of end point for the clipped vector.
See Also	PLTSETGPH			

PLTCURVE
Logical Function

Name	PLTCURVE - Draw a curve with optional graphics symbols			
Description	PLTCURVE draws a curve with optional graphics symbols on a set of existing axes. This routine should be called only after a call to PLTAXES or PLTSCALE. The basic graphics attributes apply to the curve. The symbol attributes apply to the symbols. PLTCURVE returns .TRUE. if and only if any part of the curve is within the clipping window.			
Syntax	logical = PLTCURVE (N, XG, YG, SYM, INCR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	The number of points to plot (if $N \leq 0$, no curve is plotted).
	XG, YG	Input	real array	Graph x,y coordinates of the curve points.
	SYM	Input	char	The symbol to be plotted. This is a single character. Note that this character can be an escape sequence such as \CSQ. If blank, no symbol is plotted.
	INCR	Input	integer	Plot every INCR th symbol starting with the first if a symbol is requested. If ≤ 0 , no symbol is plotted.
Note	See Section 10.2.3 for a list of escape characters that can be used with PLTCURVE.			
See Also	PLTAXES, PLTSCALE PLTSETDRW and PLTSETSYM for attributes			

PLTD2G
Logical Function

Name	PLTD2G - Convert from device to graph coordinates			
Description	PLTD2G converts device coordinates to graph coordinates.			
Syntax	logical = PLTD2G (XD, YD, XG, YG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD, YD	Input	real	Device x,y coordinates to be converted.
	XG, YG	Output	real	Graph x,y coordinates.
See Also	PLTG2D			

PLTG2D
Logical Function

Name	PLTG2D - Convert from graph to device coordinates			
Description	PLTG2D converts graph coordinates to device coordinates. No clipping is done.			
Syntax	logical = PLTG2D (XG, YG, XD, YD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XG, YG	Input	real	Graph x,y coordinates to be converted.
	XD, YD	Output	real	Device x,y coordinates.
See Also	PLTD2G			

PLTINI
Subroutine

Name	PLTINI - Return appropriate number for axis scaling (within range)			
Description	PLTINI returns appropriate numbers to use in axis scaling. These numbers are inside the XMIN-to-XMAX interval so that XMIN < RSTART and REND < XMAX. (PLTINO returns numbers that extend outside the XMIN-to-XMAX interval.)			
Syntax	CALL PLTINI (XMIN, XMAX, RSTART, REND, INTER, IEXP, NMIN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XMIN	Input	real	The minimum value for the interval.
	XMAX	Input	real	The maximum value for the interval.
	RSTART	Output	real	Starting value for scaled axis ($\times 10^{-IEXP}$).
	REND	Output	real	Ending value for scaled axis ($\times 10^{-IEXP}$).
	INTER	Output	real	Interval for scaled axis ($\times 10^{-IEXP}$).
	IEXP	Output	real	Exponent to be used in axis scaling.
	NMIN	Output	integer	Number of minor intervals for scaled axis.
See Also	PLTINO			

PLTINO
Subroutine

Name	PLTINO - Return appropriate number for axis scaling (extends outside range)			
Description	PLTINO returns appropriate numbers to use in axis scaling. These number extend outside the XMIN-to-XMAX interval so that RSTART < XMIN and XMAX < REND. (PLTINI returns numbers inside the XMIN-to-XMAX interval.)			
Syntax	CALL PLTINO (XMIN, XMAX, RSTART, REND, INTER, IEXP, NMIN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XMIN	Input	real	The minimum value for the interval.
	XMAX	Input	real	The maximum value for the interval.
	RSTART	Output	real	Starting value for scaled axis ($\times 10^{-IEXP}$).
	REND	Output	real	Ending value for scaled axis ($\times 10^{-IEXP}$).
	INTER	Output	real	Interval for scaled axis ($\times 10^{-IEXP}$).
	IEXP	Output	real	Exponent to be used in axis scaling.
	NMIN	Output	integer	Number of minor intervals for scaled axis.
See Also	PLTINI			

PLTPOLY
Logical Function

Name	PLTPOLY - Draw a polygon			
Description	PLTPOLY draws a polygon on a set of existing axes. This routine should be called only after a call to PLTAXES or PLTSCALE. The basic graphics attributes apply. PLTPOLY returns .TRUE. if and only if any part of the polygon is within the clipping window.			
Syntax	logical = PLTPOLY (N, XG, YG, MODE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vertices for the polygon (the maximum is 32).
	XG, YG	Input	real array	Graph x,y coordinates of the polygon vertices.
	MODE	Input	char*1	A character that tells how to draw the polygon (upper or lower case): 'O' means draw only the outline of the polygon with vectors. 'S' means to shade the polygon with the current color (only on raster devices).
See Also	PLTAXES, PLTSCALE PLTSETDRW for attributes			

PLTSKALE
Logical Function

Name	PLTSKALE - Draw the graph window to fit curve points			
Description	PLTSKALE is given a set of curve points. It defines the x- and/or y-axis scaling if the scaling type for the axis (set by PLTSETGPH) is autoscale. PLTSKALE returns .TRUE. if and only if the x and y axes can be scaled.			
Syntax	logical = PLTSKALE (N, XG, YG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	The number of curve points.
	XG, YG	Input	real array	Graph x,y coordinates of the curve points.
See Also	PLTSETGPH			

PLTSYMBOL
Logical Function

Name	PLTSYMBOL - Draw symbols			
Description	PLTSYMBOL draws symbols on a set of existing axes. This routine should be called only after a call to PLTAXES or PLTSCALE. The symbol attributes apply. PLTSYMBOL returns .TRUE. if and only if any symbol is within the clipping window.			
Syntax	logical = PLTSYMBOL (N, XG, YG, SYM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	XG, YG	Input	real array	Graph x,y coordinates of the points.
	SYM	Input	char	The symbol to be plotted. This is a single character. Note that this character can be an escape sequence such as \CSQ.
Note	See Section 10.2.3 for a list of escape characters that can be used with PLTSYMBOL.			
See Also	PLTSETSYM for attributes PLTAXES, PLTSCALE			

PLTVECTOR
Logical Function

Name	PLTVECTOR - Draw vectors			
Description	PLTVECTOR draws vectors on a set of existing axes. This routine should be called only after a call to PLTAXES or PLTSCALE. The basic graphics attributes apply. PLTVECTOR returns .TRUE. if and only if any part of any vector is within the clipping window.			
Syntax	logical = PLTVECTOR (N, XG0, YG0, XG1, YG1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vectors.
	XG0, YG0	Input	real array	Graph x,y coordinates of start points for the vectors.
	XG1, YG1	Input	real array	Graph x,y coordinates of end points for the vectors.
See Also	PLTAXES, PLTSCALE PLTSETDRW for attributes			

10.2.5 Device Coordinate Plotting Primitives

Detailed descriptions of the routines that provide device coordinate plotting primitives are given on the following pages.

PLTARR
Subroutine

Name	PLTARR - Draw an arrow			
Description	PLTARR draws an arrow with the specified characteristics. The basic graphics attributes apply.			
Syntax	CALL PLTARR (XTAIL, YTAIL, XHEAD, YHEAD, ANGLE, ARRLEN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XTAIL, YTAIL	Input	real	Device x,y coordinate for the tail of the arrow.
	XHEAD, YHEAD	Input	real	Device x,y coordinate for the head of the arrow.
	THETA	Input	real	Angle between the arrow head and body in radians.
	ARRLEN	Input	real	Length of arrow head in device coordinates.
See Also	PLTSETDRW for attributes			

PLTAXS
Subroutine

Name	PLTAXS - Draw a linear axis			
Description	PLTAXS draws a linear axis (either x or y, depending on TYPE). The axis attributes are set by PLTSETGPH.			
Syntax	CALL PLTAXS (X, Y, XLENG, YLENG, TYPE, XMIN, XMAX, XSTART, NDEC, INTER, MININT, LABEL, UNITS, EXP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X,Y	Input	real	Origin of the axis in device coordinates.
	XLENG	Input	real	Length of x-axis in device coordinates.
	YLENG	Input	real	Length of y-axis in device coordinates (needed if frame around plot is desired).
	TYPE	Input	char	Type of axis; either 'x' or 'y'.
	XMIN	Input	real	Minimum number on axis.
	XMAX	Input	real	Maximum number on axis.
	XSTART	Input	real	Suitable number between XMIN and XMAX that tells where to start the first major interval.
	NDEC	Input	integer	Number of decimal places.
	INTER	Input	integer	The suitable interval between major ticks.
	MININT	Input	integer	Suitable number of minor intervals between minor ticks.
	LABEL	Input	char	Label for axis.
	UNITS	Input	char	Units on axis.
	EXP	Input	real	Exponent for axis.
See Also	PLTSETGPH to set graph attributes			

PLTDRW
Subroutine

Name	PLTDRW - Draw a vector			
Description	PLTDRW draws a vector from the current pen position to the specified position. The basic graphics attributes apply.			
Syntax	CALL PLTDRW (XD, YD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD, YD	Input	real	Device x,y coordinate of point to be drawn to.
See Also	PLTSETDRW for attributes			

PLTMOV
Subroutine

Name PLTMOV - Move the pen

Description PLTMOV moves the pen to specified device coordinates.

Syntax CALL PLTMOV (XD, YD)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD, YD	Input	real	Device x,y coordinate to move the pen to.

PLTPLY
Subroutine

Name	PLTPLY - Draw a filled polygon			
Description	PLTPLY draws a filled polygon (on supported devices). The basic graphics attributes apply.			
Syntax	CALL PLTPLY (N, XD, YD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vertices in the polygon.
	XD, YD	Input	real array	Device x,y coordinates of ordered polygon vertices.
See Also	PLTSETDRW for attributes			

PLTPNT
Subroutine

Name	PLTPNT - Plot points			
Description	PLTPNT plots points from an array of device coordinates. The basic graphics attributes apply.			
Syntax	CALL PLTPNT (N, XD, YD)			
Variables In Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points to plot.
	XD, YD	Input	real array	Device x,y coordinates at which to plot points.
See Also	PLTSETDRW for attributes			

PLTPTM
Subroutine

Name	PLTPTM - Plot points with masking			
Description	PLTPTM plots points with masking. The basic graphics attributes apply.			
Syntax	CALL PLTPTM (N, MASK, XD, YD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	MASK	Input	integer	Bitmask. If bit 0 is on (1), the first point is a candidate for clipping; if off (0), it is not to be clipped, etc.
	XD, YD	Input	real array	Device x,y coordinates at which to draw the points.
See Also	PLTCP2 PLTSETDRW for attributes			

PLTRXY
Subroutine

Name	PLTRXY - Return the current position of the pen			
Description	PLTRXY returns the current position of the pen.			
Syntax	CALL PLTRXY (XD, YD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD, YD	Output	real	Device x,y coordinate of the current pen position.

PLTSYMCEN
Subroutine

Name	PLTSYMCEN - Plot a character centered at specified locations			
Description	PLTSYMCEN plots a specified character centered at the specified locations. The symbol attributes apply.			
Syntax	CALL PLTSYMCEN (N, XD, YD, SYM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	XD, YD	Input	real	Device x,y coordinates for the centers at which the character is to be plotted.
	SYM	Input	char	The symbol to be plotted. This is a single character. Note that this character can be an escape sequence such as \CSQ.
Note	See Section 10.2.3 for a list of escape characters that can be used with PLTSYMCEN.			
See Also	PLTSETSYM for attributes			

PLTSYMMSK

Subroutine

Name	PLTSYMMSK - Plot symbols with masking			
Description	PLTSYMMSK plots a symbol at each of the specified points with masking. The symbol attributes apply.			
Syntax	CALL PLTSYMMSK (N, MASK, XD, YD, SYM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	MASK	Input/ Output	integer	Bitmask. On entering the routine, if bit 0 is on (1), point 1 is a candidate for clipping; if off (0), point 1 is not to be clipped, etc. On exiting the routine, if bit 0 is off (0), point 1 was clipped, assuming bit 0 was on when the routine was entered.
	XD, YD	Input	real array	Device x,y coordinates of points.
	SYM	Input	char	The symbol to be plotted. This is a single character. Note that this character may be an escape sequence such as \CSQ.
Note	See Section 10.2.3 for a list of escape characters that can be used with PLTSYMMSK.			
See Also	PLTSETSYM for attributes			

PLTVCM
Subroutine

Name	PLTVCM - Draw vectors with masking			
Description	PLTVCM draws vectors with masking. The basic graphics attributes apply.			
Syntax	CALL PLTVCM (N, MASK, XD0, YD0, XD1, YD1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vectors to draw.
	MASK	Input	integer	Bitmask. If bit 0 is on (1), the first vector is drawn, if off (0) it is not, etc.
	XD0, YD0	Input	real array	Device x,y coordinates of start points for the vectors.
	XD1, YD1	Input	real array	Device x,y coordinates of end points for the vectors.
See Also	PLTSETDRW for attributes			

PLTVCT
Subroutine

Name	PLTVCT - Draw vectors			
Description	PLTVCT draws a set of vectors. The basic graphics attributes apply.			
Syntax	CALL PLTVCT (N, XD0, YD0, XD1, YD1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vectors to draw.
	XD0, YD0	Input	real array	Device x,y coordinates of start points for the vectors.
	XD1, YD1	Input	real array	Device x,y coordinates of end points for the vectors.
See Also	PLTSETDRW for attributes			

10.2.6 Two- and Three-Dimensional Mapping Routines

Detailed descriptions of the routines that provide two- and three-dimensional mapping are given on the following pages.

MP2PG
Subroutine

Name	MP2PG - Map a two-dimensional polygon			
Description	MP2PG maps a two-dimensional polygon.			
Syntax	CALL MP2PG (N, XG, YG, NM, XD, YD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vertices for the polygon (the maximum is 32).
	XG, YG	Input	real array	Graph x,y coordinates of the polygon vertices.
	NM	Input/ Output	integer	On entering the routine, the maximum number of output vertices that you have allocated space for, i.e., the dimension of XD and YD. On exiting the routine, the number of resulting vertices (the maximum is 32).
	XD, YD	Output	real array	Device x,y coordinates of mapped polygon vertices.
Comments	MP2PG uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines. Note that no call to the viewing routines is necessary in two dimensions.			
See Also	MPD2PG: MP2PG is the same as MPD2PG except that it doesn't draw the polygon, but returns the polygon vertices to the user.			

MP2PT
Subroutine

Name	MP2PT - Map two-dimensional points			
Description	MP2PT maps two-dimensional points.			
Syntax	CALL MP2PT (N, XG, YG, XD, YD, MASK)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	XG, YG	Input	real array	Graph x,y coordinates of points.
	XD, YD	Output	real array	Device x,y coordinates of mapped points.
	MASK	Output	integer array	Bitmask. If bit 0 is off (0), point 1 was clipped, if on (1), it was not, etc. This array must be dimensioned to the next higher integer after N/32.
Comments	MP2PT uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines. Note that no call to the viewing routines is necessary in two dimensions.			
See Also	<p>PLTPTM: You can use PLTPTM to plot these points.</p> <p>MPD2PT: MP2PT is the same as MPD2PT except that it doesn't draw the mapped points; it returns them to the user.</p>			

MP2VC
Subroutine

Name	MP2VC - Map two-dimensional vectors			
Description	MP2VC maps two-dimensional vectors.			
Syntax	CALL MP2VC (N, XG0, YG0, XG1, YG1, XD0, YD0, XD1, YD1, MASK)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vectors.
	XG0, YG0	Input	real array	Graph x,y coordinates of start points for the vectors.
	XG1, YG1	Input	real array	Graph x,y coordinates of end points for the vectors.
	XD0, YD0	Output	real array	Device x,y coordinates of start points for the mapped vectors.
	XD1, YD1	Output	real array	Device x,y coordinates of end points for the mapped vectors.
	MASK	Output	integer array	If bit 0 is off (0), point 1 was clipped, if on (1), it was not clipped, etc. This array must be dimensioned to the next higher integer after N/32.
Comments	MP2VC uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines. Note that no call to the viewing routines is necessary in two dimensions.			
See Also	PLTVCM: You can use PLTVCM to plot these vectors. MPD2VC: MP2VC is the same as MPD2VC except that it doesn't draw the mapped vectors; it returns them to the user.			

MP3PG
Subroutine

Name	MP3PG - Map a three-dimensional polygon			
Description	MP3PG maps a three-dimensional polygon.			
Syntax	CALL MP3PG (N, XG, YG, ZG, NM, XD, YD, ZD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vertices in the polygon (the maximum is 32).
	XG, YG, ZG	Input	real array	Graph x,y,z coordinates of vertices for the polygon.
	NM	Input	integer	The number of vertices in the output polygon (maximum is 32). Upon calling MP3PG, NM should be the dimension of XD, YD, and ZD. If NM = 0 on return, then the polygon was clipped so that the eye cannot see it.
	XD, YD, ZD	Output	real array	Device x,y,z coordinates of mapped vertices. The mapped z-coordinate is returned for use in hidden line or surface calculations. It can be ignored for other applications.
Note	MP3PG uses a rudimentary clipping technique on three-dimensional polygons: if any of the vertices are clipped, then the entire polygon is considered clipped.			
Comments	MP3PG uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines.			

MP3PT
Subroutine

Name	MP3PT - Map three-dimensional points			
Description	MP3PT maps three-dimensional points			
Syntax	CALL MP3PT (N, XG, YG, ZG, XD, YD, ZD, MASK)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	XG, YG, ZG	Input	real array	Graph x,y,z coordinates of points.
	XD, YD, ZD	Output	real array	Device x,y,z coordinates of mapped points. The mapped z-coordinate is returned for use in hidden line or surface calculations. It can be ignored for other applications.
	MASK	Output	integer array	Bitmask. If bit 0 is off (0), point 1 was clipped, if on (1), it was not, etc. This array must be dimensioned to the next higher integer after N/32.
Comments	MP3PT uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines.			
See Also	<p>PLTPTM: You can use PLTPTM to plot these points.</p> <p>MPD3PT: MP3PT is the same as MPD3PT except that it doesn't draw the mapped points; it returns them to the user.</p>			

MP3VC
Subroutine

Name	MP3VC - Map three-dimensional vectors			
Description	MP3VC maps three-dimensional vectors.			
Syntax	CALL MP3VC (N, XG0, YG0, ZG0, XG1, YG1, ZG1, XD0, YD0, ZD0, XD1, YD1, ZD1 MASK)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vectors.
	XG0, YG0, ZG0	Input	real array	Graph x,y,z coordinates of start points for the vectors.
	XG1, YG1, ZG1	Input	real array	Graph x,y,z coordinates of end points for the vectors.
	XD0, YD0, ZD0	Output	real array	Device x,y,z coordinates of start points for the mapped vectors.
	XD1, YD1, ZD1	Output	real array	Device x,y,z coordinates of end points for the mapped vectors.
	MASK	Output	integer array	If bit 0 is off (0), point 1 was clipped, if on (1), it was not clipped, etc. This array must be dimensioned to the next higher integer after N/32.
Comments	MP3VC uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines.			
See Also	<p>PLTVCM: You can use PLTVCM to plot these vectors.</p> <p>MPD3VC: MP3VC is the same as MPD3VC except that it doesn't draw the mapped vectors; it returns them to the user.</p>			

MPCLP2
Logical Function

Name	MPCLP2 - Specify lines for clipping vectors, points, and polygons			
Description	MPCLP2 allows the user to specify up to 10 clipping lines against which vectors, points, and polygons will be clipped before they are drawn by the drawing routines. These clipping lines are specified in the world coordinate system.			
Syntax	logical = MPCLP2 (N, CUT1X, CUT1Y, CUT2X, CUT2Y)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	The number of clipping lines.
	CUT1X	Input	real array	X-coordinates of the beginning points of clipping lines.
	CUT1Y	Input	real array	Y-coordinates of the beginning points of clipping lines.
	CUT2X	Input	real array	X-coordinates of the end points of clipping lines.
	CUT2Y	Input	real array	Y-coordinates of the end points of clipping lines.
Comments	If you are standing on CUT1 and looking at CUT2, then points to your right will be clipped and points to your left will not. If N = 0, there are no clipping lines.			

MPCLP3
Logical Function

Name	MPCLP3 - Specify planes for clipping vectors, points, and polygons			
Description	MPCLP3 allows the user to specify up to 10 clipping planes against which vectors, points, and polygons will be clipped before they are drawn by the drawing routines. These clipping lines are specified in the world coordinate system.			
Syntax	logical = MPCLP3 (N, XA, YA, ZA, VX, VY, VZ)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	The number of clipping planes in the arrays.
	XA, YA, ZA	Input	real array	Arrays containing the x, y, and z coordinates of points on the clipping planes.
	VX, VY, VZ	Input	real array	Arrays containing the normal vectors to the clipping planes.
Comments	The VX, VY, and VZ vectors point to the side of the planes where points are <i>not</i> clipped.			

MPD2PG
Subroutine

Name	MPD2PG - Map and draw a two-dimensional polygon			
Description	MPD2PG maps and draws a two-dimensional polygon. The basic graphics attributes apply.			
Syntax	CALL MPD2PG (N, XG, YG, MODE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vertices for the polygon (the maximum is 32).
	XG, YG	Input	real array	Graph x,y coordinates of the polygon vertices.
	MODE	Input	char*1	A character that tells how to draw the polygon (upper or lower case): 'O' means draw only the outline of the polygon with vectors. 'S' means to shade the polygon with the current color (only on raster devices).
Comments	MPD2PG uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines. Note that no call to the viewing routines is necessary in two dimensions.			
See Also	MP2PG: MP2PG is the same as MPD2PG except that it doesn't draw the polygon, but returns the polygon vertices to the user. PLTSETDRW for attributes.			

MPD2PT
Subroutine

Name	MPD2PT - Map and draw two-dimensional points			
Description	MPD2PT maps and draws two-dimensional points. The basic graphics attributes apply.			
Syntax	CALL MPD2PT (N, XG, YG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	XG YG	Input	real array	Graph x,y coordinates of the points.
Comments	MPD2PT uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines. Note that no call to the viewing routines is necessary in two dimensions.			
See Also	<p>MP2PT: MP2PT is the same as MPD2PT except that it doesn't draw the mapped points; it returns them to the user.</p> <p>PLTSETDRW for attributes.</p>			

MPD2SY
Subroutine

Name	MPD2SY - Map and draw two-dimensional symbols			
Description	MPD2SY maps and draws two-dimensional symbols. The symbol attributes apply.			
Syntax	CALL MPD2SY (N, XG, YG, SYM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	XG, YG	Input	real array	Graph x,y coordinates of the points.
	SYM	Input	char	The symbol to be plotted. This is a single character. Note that this character can be an escape sequence such as \CSQ.
Comments	MPD2SY uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines. Note that no call to the viewing routines is necessary in two dimensions.			
Note	See Section 10.2.3 for a list of escape characters that can be used with MPD2SY.			
See Also	PLTSETSYM for attributes			

MPD2VC
Subroutine

Name	MPD2VC - Map and draw two-dimensional vectors			
Description	MPD2VC maps and draws two-dimensional vectors. The basic graphics attributes apply.			
Syntax	CALL MPD2VC (N, XG0, YG0, XG1, YG1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vectors.
	XG0, YG0	Input	real array	Graph x,y coordinates of start points for the vectors.
	XG1, YG1	Input	real array	Graph x,y coordinates of end points for the vectors.
Comments	MP2VC uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines. Note that no call to the viewing routines is necessary in two dimensions.			
See Also	<p>MP2VC: MP2VC is the same as MPD2VC except that it doesn't draw the mapped vectors; it returns them to the user.</p> <p>PLTSETDRW for attributes.</p>			

MPD3PG
Subroutine

Name	MPD3PG - Map and draw a three-dimensional polygon			
Description	MPD3PG maps and draws a three-dimensional polygon. The basic graphics attributes apply.			
Syntax	CALL MPD3PG (N, XG, YG, ZG, MODE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vertices in the polygon (the maximum is 32).
	XG, YG, ZG	Input	real array	Graph x,y,z coordinates of vertices for the polygon.
	MODE	Input	char*1	A character that tells how to draw the polygon (upper or lower case): 'O' means to draw only the outline of the polygon with vectors. 'S' means to shade the polygon with the current color (only on raster devices).
Comments	MPD3PG uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines.			
See Also	PLTSETDRW for attributes.			

MPD3PT
Subroutine

Name	MPD3PT - Map and draw three-dimensional points			
Description	MPD3PT maps and draws three-dimensional points. The basic graphics attributes apply.			
Syntax	CALL MPD3PT (N, XG, YG, ZG)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	XG, YG, ZG	Input	real array	Graph x,y,z coordinates of points.
Comments	MPD3PT uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines.			
See Also	MP3PT: MP3PT is the same as MPD3PT except that it doesn't draw the mapped points, but returns them to the user.			
	PLTSETDRW for attributes.			

MPD3VC
Subroutine

Name	MPD3VC - Map and draw three-dimensional vectors			
Description	MPD3VC maps and draws three-dimensional vectors. The basic graphics attributes apply.			
Syntax	CALL MPD3VC (N, XG0, YG0, ZG0, XG1, YG1, ZG1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vectors.
	XG0, YG0, ZG0	Input	real array	Graph x,y,z coordinates of start points for the vectors.
	XG1, YG1, ZG1	Input	real array	Graph x,y,z coordinates of end points for the vectors.
Comments	MPD3VC uses whatever modelling and viewport information the user has set up with calls to the modelling, projection, and viewport routines.			
See Also	MP3VC: MP3VC is the same as MPD3VC except that it doesn't draw the mapped vectors; it returns them to the user. PLTSETDRW for attributes.			

MPGETM
Subroutine

Name MPGETM - Get the modelling, viewing, and projection matrices, and the viewport

Description MPGETM returns the current modelling, viewing, and projection 4×4 matrices, as well as the current viewport.

Syntax CALL MPGETM (TMODEL, TVIEW, TPROJ, TVWPT)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	TMODEL	Output	real array	Modelling transformation (4×4 array).
	TVIEW	Output	real array	Viewing transformation (4×4 array).
	TPROJ	Output	real array	Projection transformation (4×4 array).
	TVWPT	Output	real array	The current viewport in a 4-element array defined as left, right, bottom, top.

MPINIT
Subroutine

Name	MPINIT - Initialize data structures
Description	MPINIT initializes some data structures. Call it to reset transformations only. MPINIT sets the modelling, viewing, and projection matrices to identity and sets the viewport to full screen. It also zeroes out the user-specified clip lines and planes.
Syntax	CALL MPINIT

MPLOOK
Subroutine

Name	MPLOOK - Define the viewing position using coordinates			
Description	MPLOOK defines the viewing position, setting up the viewing matrix.			
Syntax	CALL MPLOOK (VX, VY, VZ, X, Y, Z, TWIST)			
Variables In Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	VX, VY, VZ	Input	real	Coordinates for the location of the eye (view-point).
	X, Y, Z	Input	real	Coordinates for the point the eye is looking at (reference point).
	TWIST	Input	real	The angle of rotation in degrees about the eye system's z-axis (this axis is along a line from the viewpoint to the reference point).
Comments	<p>This transformation is defined as follows:</p> $\text{TRANS } (-VX, -VY, -VZ) \times \text{ROTY } (\text{THETA}) \times \text{ROTX } (\text{PIII}) \times \text{ROTZ } (-\text{TWIST})$ <p>See the Silicon Graphics Graphics Library Programming Guide (McLendon, 1991), Appendix C.4, "Viewing Transformations," for more information.</p>			

MPORT2

Logical Function

Name	MPORT2 - Define a two-dimensional orthographic projection transformation			
Description	MPORT2 defines an orthographic projection transformation, setting up the projection matrix. The function defines a two-dimensional clipping rectangle, and the projection matrix is a two-dimensional map. The z values are unchanged.			
Syntax	logical = MPORT2 (LEFT, RIGHT, BOTTOM, TOP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	LEFT	Input	real	The x-coordinate of the left edge of the rectangle.
	RIGHT	Input	real	The x-coordinate of the right edge of the rectangle.
	BOTTOM	Input	real	The y-coordinate of the bottom edge of the rectangle.
	TOP	Input	real	The y-coordinate of the top edge of the rectangle.
Comments	The four values in the calling sequence are essentially the minimum and maximum world coordinates that you wish to see. See the Silicon Graphics Graphics Library Programming Guide (McLendon, 1991), Appendix C.6, "Orthographic Transformations," for more information.			

MPORT3

Logical Function

Name	MPORT3 - Define a three-dimensional orthographic projection transformation			
Description	MPORT3 defines an orthographic projection transformation, setting up the projection matrix. The function defines a parallelepiped in the eye coordinate system.			
Syntax	logical = MPORT3 (LEFT, RIGHT, BOTTOM, TOP, NEAR, FAR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	LEFT	Input	real	The x-coordinate of the left edge of the rectangle.
	RIGHT	Input	real	The x-coordinate of the right edge of the rectangle.
	BOTTOM	Input	real	The y-coordinate of the bottom edge of the rectangle.
	TOP	Input	real	The y-coordinate of the top edge of the rectangle.
	NEAR	Input	real	The location (distance from the eye) of the near clipping plane.
	FAR	Input	real	The location (distance from the eye) of the far clipping plane.
Comments	LEFT, RIGHT, TOP, and BOTTOM define the x and y clipping planes; NEAR and FAR define the near and far clipping planes. See the Silicon Graphics Graphics Library Programming Guide (McLendon, 1991), Appendix C.6, "Orthographic Transformations," for more information.			

MPPERS
Logical Function

Name	MPPERS - Define a perspective projection transformation in angles			
Description	MPPERS defines a perspective projection transformation, setting up the projection matrix.			
Syntax	logical = MPPERS (FOVY, ASPECT, NEAR, FAR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FOVY	Input	real	The field of view angle in degrees, in the y-direction of the eye coordinate system.
	ASPECT	Input	real	The aspect ratio that determines the field of view in the x-direction.
	NEAR	Input	real	The location (distance from the eye) of the near clipping plane.
	FAR	Input	real	The location (distance from the eye) of the far clipping plane.
Comments	The aspect ratio is the ratio of x to y. This should match the aspect ratio for the viewport. See the Silicon Graphics Graphics Library Programming Guide (McLendon, 1991), Appendix C.5, "Perspective Transformations," for more information.			

MPPOLA
Subroutine

Name	MPPOLA - Define the viewing position using angles			
Description	MPPOLA defines the viewing position, setting up the viewing matrix.			
Syntax	CALL MPPOLA (DIST, AZIM, INC, TWIST)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	DIST	Input	real	The distance from the eye to the world space origin.
	AZIM	Input	real	The azimuthal angle in degrees in the x-z plane measured from the z-axis. This is a rotation about the y-axis. (Keep the right-hand rule in mind when you determine the sign of the angle.)
	INC	Input	real	The incidence angle in degrees in the y-z plane measured from the z-axis. This is a rotation about the x-axis. (Keep the right-hand rule in mind when you determine the sign of the angle.)
	TWIST	Input	real	The angle of rotation in degrees about the line of sight (right-hand rule applies).
Comments	<p>The line of sight is defined as the line between the eye and the world space origin. See the Silicon Graphics Graphics Library Programming Guide (McLendon, 1991), Appendix C.4, "Viewing Transformations," for more information. This transformation is defined as follows:</p> $\text{ROTY} (-\text{AZIM}) \times \text{ROTX} (-\text{INC}) \times \text{ROTZ} (-\text{TWIST}) \times \text{TRANS} (0, 0, -\text{DIST})$			

MPPOPM
Subroutine

Name	MPPOPM- Pop mapping parameters from the stack
Description	MPPOPM pops mapping parameters from the stack.
Syntax	CALL MPPOPM
See Also	.MPPSHM, MPPUTM

MPPSHM
Logical Function

Name	MPPSHM - Push the mapping parameters onto a stack
Description	MPPSHM pushes the mapping parameters onto a stack. The stack is ten deep. The function returns as <i>.FALSE.</i> if you push too deep.
Syntax	logical = MPPSHM
See Also	MPPOPM, MPPUTM

MPPUTM
Subroutine

Name	MPPUTM - Set modelling, viewing, and projection matrices and viewport			
Description	MPPUTM sets the current modelling, viewing, and projection 4×4 matrices, as well as the current viewport to the user-specified arrays.			
Syntax	CALL MPPUTM (TMODEL, TVIEW, TPROJ, TVWPT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	TMODEL	Input	real array	The modelling transformation (4×4 array).
	TVIEW	Input	real array	The viewing transformation (4×4 array).
	TPROJ	Input	real array	The projection transformation (4×4 array).
	TVWPT	Input	real array	The viewport (4×4 array), defined as left, right, bottom, top.
See Also	MPPSHM, MPPOPM			

MPRESE
Subroutine

Name	MPRESE - Reset the modelling transformation to identity.
Description	MPRESE resets the modelling transformation to identity.
Syntax	CALL MPRESE

MPRLOC
Subroutine

Name	MPRLOC - Locate the eye, the point the eye is looking at, and the twist angle			
Description	MPRLOC returns the position of the eye, the point the eye is looking at, and the twist angle of the eye about its line of sight.			
Syntax	CALL MPRLOC (EYE, LOOKAT, TWIST)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	EYE	Output	real array	The x, y, z position of the eye.
	LOOKAT	Output	real array	The x, y, z position of the point the eye is looking at.
	TWIST	Output	real	The rotation angle in degrees of the eye about its line of sight.

MPROTA
Logical Function

Name	MPROTA - Rotate about an axis			
Description	MPROTA rotates about an axis. This function modifies the modelling matrix.			
Syntax	logical = MPROTA (ANGLE, AXIS)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ANGLE	Input	real	The amount to rotate in degrees.
	AXIS	Input	char*1	The axis to rotate about: "X" or "Y" or "Z".
Note	The rotations are about the origin. See the Silicon Graphics Graphics Library Programming Guide (McLendon, 1991), Appendix C.3, "Rotation," for more information.			

MPSCAL
Subroutine

Name	MPSCAL - Scale in the x, y, and z directions			
Description	MPSCAL scales by X, Y, and Z. This subroutine modifies the modelling matrix.			
Syntax	CALL MPSCAL (X, Y, Z)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X, Y, Z	Input	real	The amount to scale in each direction. X, Y, or Z > 1 to expand in that direction, < 1 to shrink, and < 0 to mirror.
Comment	See the Silicon Graphics Graphics Library Programming Guide (McLendon, 1991), Appendix C.2, "Scaling and Mirroring," for more information.			

MPTRAN
Subroutine

Name	MPTRAN - Translate by the specified amount in each direction			
Description	MPTRAN translates by X, Y, and Z. This subroutine modifies the modelling matrix.			
Syntax	CALL MPTRAN (X, Y, Z)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X, Y, Z	Input	real	The amount to translate in each direction (in graph coordinates).
Note	This subroutine places the object space origin at (X, Y, Z). See the Silicon Graphics Graphics Library Programming Guide (McLendon, 1991), Appendix C.1, "Translation," for more information.			

MPVIEW
Logical Function

Name	MPVIEW - Define the viewport			
Description	MPVIEW defines the viewport, i.e., the area of the screen where the image is displayed, setting up the viewing matrix.			
Syntax	logical = MPVIEW (LEFT, RIGHT, BOTTOM, TOP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	LEFT, RIGHT, BOTTOM, TOP	Input	real	The four coordinates of the viewport.

MPWIND
Logical Function

Name	MPWIND - Define a perspective projection transformation in coordinates			
Description	MPWIND defines a perspective projection transformation, setting up the projection matrix.			
Syntax	logical = MPWIND (LEFT, RIGHT, BOTTOM, TOP, NEAR, FAR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	LEFT	Input	real	The x-coordinate of the left edge of the viewing frustum.
	RIGHT	Input	real	The x-coordinate of the right edge of the viewing frustum.
	BOTTOM	Input	real	The y-coordinate of the bottom edge of the viewing frustum.
	TOP	Input	real	The y-coordinate of the top edge of the viewing frustum.
	NEAR	Input	real	The location (distance from the eye) of the near clipping plane.
	FAR	Input	real	The location (distance from the eye) of the far clipping plane.
Comments	The viewing frustum is in the near clipping plane. See the Silicon Graphics Graphics Library Programming Guide (McLendon, 1991), Appendix C.5, "Perspective Transformations," for more information.			

10.2.7 Clipping of Two- and Three-Dimensional Points, Lines, and Polygons

Detailed descriptions of the routines that provide clipping of two- and three-dimensional points, lines, and polygons are given on the following pages.

PLTCG2
Subroutine

Name	PLTCG2 - Clip a two-dimensional polygon against a line			
Description	PLTCG2 clips a two-dimensional polygon against a clipping line. Both are specified in the routine call.			
Syntax	CALL PLTCG2 (N, XV, YV, NO, XVO, YVO, CUT0, CUT1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vertices for the polygon (before clipping).
	XV	Input	real array	X-coordinates for the polygon (before clipping).
	YV	Input	real array	Y-coordinates for the polygon (before clipping).
	NO	Input/ Output	integer	On entering the routine, the maximum number of output vertices that you have allocated space for, i.e., the dimension of XVO and YVO. On exiting the routine, the number of resulting vertices.
	XVO	Output	real array	X-coordinates of polygon vertices after clipping.
	YVO	Output	real array	Y-coordinates of polygon vertices after clipping.
	CUT0	Input	real array	The x,y coordinates for the beginning point of clipping line.
	CUT1	Input	real array	The x,y coordinates for the end point of clipping line.
Comments	Picture yourself at CUT0 looking at CUT1. Points on your right will be clipped. Points on your left will not be clipped. Points on the line will not be clipped.			

PLTCP2
Subroutine

Name	PLTCP2 - Clip two-dimensional points against a line			
Description	PLTCP2 clips two-dimensional points against a clipping line. Both the points and the clipping line are specified in the routine call.			
Syntax	CALL PLTCP2 (N, MASK, XA, YA, CUT0, CUT1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	MASK	Input	integer array	Bitmask. On entering the routine, if bit 0 is on (1), point 1 [XA(1),YA(1)] is a candidate for clipping; if off (0), point 1 is not to be clipped, etc. On exiting the routine, if bit 0 is off (0), point 1 was clipped, assuming bit 0 was on when the routine was entered.
	XA	Input	real array	X-coordinates of points.
	YA	Input	real array	Y-coordinates of points.
	CUT0	Input	real array	The x,y coordinates for beginning point of clipping line.
	CUT1	Input	real array	The x,y coordinates for end point of clipping line.
Comments	Picture yourself at CUT0 looking at CUT1. Points on your right will be clipped. Points on your left will not be clipped. Points on the line will not be clipped.			

PLTCP3
Subroutine

Name	PLTCP3 - Clip three-dimensional points against a plane			
Description	PLTCP3 clips three-dimensional points against a plane. Both the points and the plane are specified in the routine call.			
Syntax	CALL PLTCP3 (N, MASK, XA, YA, ZA, PTIN, VECORT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of points.
	MASK	Input/ Output	integer array or variable	Bitmask. On entering the routine, if bit 0 is on (1), point 1 [XA(1),YA(1),ZA(1)] is a candidate for clipping; if off (0), point 1 is not to be clipped, etc. On exiting the routine, if bit 0 is off (0), point 1 was clipped, assuming bit 0 was on when the routine was entered.
	XA	Input/ Output	real array	X-coordinates of points; returned clipped.
	YA	Input/ Output	real array	Y-coordinates of points; returned clipped.
	ZA	Input/ Output	real array	Z-coordinates of points; returned clipped.
	PTIN	Input	real array	The x,y,z coordinates of a point in the clipping plane.
	VECORT	Input	real array	The x,y,z coordinates of a vector orthogonal to the clipping plane.
Comments	VECORT and PTIN define the clipping plane. VECORT points into the side of the plane where points are <i>not</i> to be clipped.			

PLTCV2
Subroutine

Name	PLTCV2 - Clip two-dimensional vectors against a line			
Description	PLTCV2 clips two-dimensional vectors against a clipping line. Both the vectors and the clipping line are specified in the routine call.			
Syntax	CALL PLTCV2 (N, MASK, XIN0, YIN0, XIN1, YIN1, XOUT0, YOUT0, XOUT1, YOUT1, CUT0, CUT1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vectors.
	MASK	Input/ Output	integer array	Bitmask. On entering the routine, if bit 0 is on (1), vector 1 is a candidate for clipping; if off (0), vector 1 is not to be clipped, etc. On exiting the routine, if bit 0 is off (0), vector 1 was clipped, assuming bit 0 was on when the routine was entered.
	XIN0, YIN0	Input	real array	Coordinates of start points for input vectors.
	XIN1, YIN1	Input	real array	Coordinates of end points for input vectors.
	XOUT0, YOUT0	Output	real array	Coordinates of start points for resulting (clipped) vectors.
	XOUT1, YOUT1	Output	real array	Coordinates of end points for resulting (clipped) vectors.
	CUT0	Input	real array	The x,y coordinates for the beginning point of the clipping line.
	CUT1	Input	real array	The x,y coordinates for the end point of the clipping line.
Comments	Picture yourself at CUT0 looking at CUT1. Points on your right will be clipped. Points on your left will not be clipped. Points on the line will not be clipped.			

PLTCV3
Subroutine

Name	PLTCV3 - Clip three-dimensional vectors against a plane			
Description	PLTCV3 clips three-dimensional vectors against a plane. Both the vectors and the plane are specified in the routine call.			
Syntax	CALL PLTCV3 (N, MASK, XIN0, YIN0, ZIN0, XIN1, YIN1, ZIN1, XOUT0, YOUT0, ZOUT0, XOUT1, YOUT1, ZOUT1, PTIN, VECORT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	N	Input	integer	Number of vectors.
	MASK	Input/ Output	integer array or literal	Bitmask. On entering the routine, if bit 0 is on (1), vector 1 is a candidate for clipping; if off (0), vector 1 is not to be clipped, etc. On exiting the routine, if bit 0 is off (0), vector 1 was clipped, assuming bit 0 was on when the routine was entered.
	XIN0, YIN0, ZIN0	Input	real array	Coordinates of start points for input vectors.
	XIN1, YIN1, ZIN1	Input	real array	Coordinates of end points for input vectors.
	XOUT0, YOUT0, ZOUT0	Output	real array	Coordinates of start points for resulting (clipped) vectors.
	XOUT1, YOUT1, ZOUT1	Output	real array	Coordinates of end points for resulting (clipped) vectors.
	PTIN	Input	real array	The x, y, and z coordinates of a point in the clipping plane.
	VECORT	Input	real array	The x, y, and z coordinates of a vector orthogonal to the clipping plane.
Comments	VECORT and PTIN define the clipping plane. VECORT points into the side of the plane where points are <i>not</i> to be clipped.			

PLTVWG
Subroutine

Name	PLTVWG - Clip a polygon against a veiwport			
Description	PLTVWG clips a polygon against a viewport. The viewport is a rectangle defined by PLL (lower left) and PUR (upper right) in the routine call.			
Syntax	CALL PLTVWG (PLL, PUR, N, XV, YV, ZV, NO, XVO, YVO, ZVO)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	PLL	Input	real array	The x,y coordinates of the lower-left corner of the viewport rectangle.
	PUR	Input	real array	The x,y coordinates of the upper-right corner of the viewport rectangle.
	N	Input	Integer	Number of vertices for the polygon.
	XV, YV, ZV	Input	real array	Coordinates of the input vertices for the polygon.
	NO	Input/ Output	integer	On input this is the dimension of XVO, YVO, and ZVO. On output this is the number of resulting vertices (maximum is 50).
	XVO, YVO, ZVO	Output	real array	Coordinates of the resulting (clipped) vertices.

PLTVWP
Subroutine

Name	PLTVWP - Clip points against a veiwport			
Description	PLTVWP clips points against a viewport. The viewport is a rectangle defined by PLL (lower left) and PUR (upper right) in the routine call.			
Syntax	CALL PLTVWP (PLL, PUR, N, MASK, X, Y)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	PLL	Input	real array	The x,y coordinates of the lower-left corner of the viewport rectangle.
	PUR	Input	real array	The x,y coordinates of the upper-right corner of the viewport rectangle.
	N	Input	integer	Number of points.
	MASK	Input/ Output	integer array	On entering the routine, if bit 0 is on (1), point 1 is a candidate for clipping; if off (0), point 1 is not to be clipped, etc. On exiting the routine, if bit 0 is off (0), point 1 was clipped, assuming bit 0 was on when the routine was entered.
	X, Y	Input/ Output	real array	Coordinates of the points. These are returned clipped.

PLTVWV
Subroutine

Name	PLTVWV - Clip vectors against a veiwport			
Description	PLTVWV clips vectors against a viewport. The viewport is a rectangle defined by PLL (lower left) and PUR (upper right) in the routine call.			
Syntax	CALL PLTVWV (PLL, PUR, N, MASK, XV0, YV0, XV1, YV1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	PLL	Input	real array	The x,y coordinates of the lower-left corner of the viewport rectangle.
	PUR	Input	real array	The x,y coordinates of the upper-right corner of the viewport rectangle.
	N	Input	integer	Number of vectors.
	MASK	Input/ Output	integer array	Bitmask. On entering the routine, if bit 0 is on (1), vector 1 is a candidate for clipping; if off (0), vector 1 is not to be clipped, etc. On exiting the routine, if bit 0 is off (0), vector 1 was clipped, assuming bit 0 was on when the routine was entered.
	XV0, YV0	Input/ Output	real array	Coordinates of the start points for the vectors. These are returned clipped.
	XV1, YV1	Input/ Output	real array	Coordinates of the end points for the vectors. These are returned clipped.

PLTZCP
Subroutine

Name	PLTZCP - Clip points against two clipping planes			
Description	PLTZCP clips points against two clipping planes. Both the points and the planes are specified in the routine call. Both planes are perpendicular to the z direction and their distances from the origin are ZNEAR and ZFAR.			
Syntax	CALL PLTZCP (ZNEAR, ZFAR, N, MASK, ZA)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ZNEAR	Input	real	Distance of the nearer plane from the origin.
	ZFAR	Input	real	Distance of the further plane from the origin.
	N	Input	integer	Number of points
	MASK	Input/ Output	integer array or literal	Bitmask. On entering the routine, if bit 0 is on (1), point 1 is a candidate for clipping; if off (0), point 1 is not to be clipped, etc. On exiting the routine, if bit 0 is off (0), point 1 was clipped, assuming bit 0 was on when the routine was entered.
	ZA	Input/ Output	real array	Z-coordinates of the points. Only the z-coordinates are needed because the clipping planes are perpendicular to the z axis. Clipped coordinates are returned in this argument.

PLTZCV
Subroutine

Name	PLTZCV - Clip vectors against two clipping planes			
Description	PLTZCV clips vectors against two clipping planes. Both the vectors and the planes are specified in the routine call. Both planes are perpendicular to the z direction and their distances from the origin are ZNEAR and ZFAR.			
Syntax	CALL PLTZCV (ZNEAR, ZFAR, N, MASK, XV0, YV0, ZV0, XV1, YV1, ZV1)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ZNEAR	Input	real	Distance of the nearer plane from the origin.
	ZFAR	Input	real	Distance of the further plane from the origin.
	N	Input	integer	The number of vectors.
	MASK	Input/ Output	integer array	Bitmask. On entering the routine, if bit 0 is on (1), vector 1 is a candidate for clipping; if off (0), vector 1 is not to be clipped, etc. On exiting the routine, if bit 0 is off (0), vector 1 was clipped, assuming bit 0 was on when the routine was entered.
	XV0, YV0, ZV0	Input/ Output	real array	Coordinates of the start points of the vectors. These are returned clipped.
	XV1, YV1, ZV1	Input/ Output	real array	Coordinates of the end points of the vectors. These are returned clipped.

10.2.8 Color Palette Routines

Detailed descriptions of the routines that set the color palette and provide color information are given on the following pages.

PLTCNM

Logical Function

Name	PLTCNM - Return the color name for a color index			
Description	PLTCNM returns the color name for a specified color index. The function returns <code>.TRUE.</code> if successful.			
Syntax	logical = PLTCNM (XCOLOR, COLOR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XCOLOR	Input	real	The color index of the desired color.
	COLOR	Output	char	The name of the desired color. The color names are: BLACK, RED, GREEN, YELLOW, BLUE, MAGENTA, WHITE, P1, P2, P3, P4, P5, P6, P7, P8, GRAY, DKGRAY, LTGRAY, LIME, ORANGE, VIOLET, LTBLUE P1...P8 are the variable portions of the palette and are set by PLTPAL.
See Also	PLTICL, PLTPAL			

PLTICL
Logical Function

Name	PLTICL - Return the color index for a color name			
Description	PLTICL returns the color index for a specified color name. The function returns .TRUE. if successful.			
Syntax	logical = PLTICL (COLOR, XCOLOR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	COLOR	Input	char	The name of the desired color. The color names are: BLACK, RED, GREEN, YELLOW, BLUE, MAGENTA, WHITE, P1, P2, P3, P4, P5, P6, P7, P8, GRAY, DKGRAY, LTGRAY, LIME, ORANGE, VIOLET, LTBLUE P1...P8 are the variable portions of the palette and are set by PLTPAL.
	XCOLOR	Output	real	The color index of the specified color.
See Also	PLTCNM, PLTPAL			

PLTIQC
Subroutine

Name PLTIQC - Return the red, green, and blue intensity for a color

Description PLTIQC returns the red, green, and blue intensity for a specified color.

Syntax CALL PLTIQC (ICOLOR, RED, GREEN, BLUE)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ICOLOR	Input	integer	Index of the desired color.
	RED	Output	real	Red intensity for the color.
	GREEN	Output	real	Green intensity for the color.
	BLUE	Output	real	Blue intensity for the color.

PLTISP
Subroutine

Name	PLTISP - Map a number into the spectrum			
Description	PLTISP maps a number between 0 and 1 into the spectrum. If there is not a spectrum (i.e., the number of colors ≤ 16), then it returns the maximum allowed color.			
Syntax	CALL PLTISP (SPEC, XCOLOR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	SPEC	Input	real	The number to be mapped. The range is 0.0 through 1.0.
	XCOLOR	Output	real	The color index corresponding to SPEC.

PLTPAL
Subroutine

Name	PLTPAL - Set a palette color			
Description	PLTPAL sets a palette color in the variable portion of the palette (values 8-15 of the color table).			
Syntax	CALL PLTPAL (XCOLOR, RED, GREEN, BLUE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XCOLOR	Input	real	The color index of the color to be set (range 8-15).
	RED	Input	real	The red intensity to be set (range 0.0-1.0).
	GREEN	Input	real	The green intensity to be set (range 0.0-1.0).
	BLUE	Input	real	The blue intensity to be set (range 0.0-1.0).
Comments	Defines colors P1, P2, ..., P8			
See Also	PLTCNM, PLTICL			

PLTCOL
Subroutine

Name PLTCOL - Set a color to red, green, and blue values

Description PLTCOL sets a color to the specified red, green, and blue values.

Syntax CALL PLTCOL (ICOLOR, RED, GREEN, BLUE)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ICOLOR	Input	integer	The color index of the color to be set (range 0-255).
	RED	Input	real	The red intensity to be set (range 0.0-1.0).
	GREEN	Input	real	The green intensity to be set (range 0.0-1.0).
	BLUE	Input	real	The blue intensity to be set (range 0.0-1.0).

PLTSPC
Subroutine

Name	PLTSPC - Set up colors in the spectrum			
Description	PLTSPC sets up colors in a specified interval of the spectrum. S1 and S2 are normalized numbers between 0 and 1 that map to an index in the spectrum.			
Syntax	CALL PLTSPC (S1, RED1, GREEN1, BLUE1, S2, RED2, GREEN2, BLUE2)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	S1	Input	real	The starting value for the spectrum (range 0.0-1.0).
	RED1	Input	real	The red intensity at the starting value.
	GREEN1	Input	real	The green intensity at the starting value.
	BLUE1	Input	real	The blue intensity at the starting value.
	S2	Input	real	The ending value for the spectrum (range 0.0-1.0).
	RED2	Input	real	The red intensity at the end of the spectrum interval.
	GREEN2	Input	real	The green intensity at the end of the spectrum interval.
	BLUE2	Input	real	The blue intensity at the end of the spectrum interval.

10.2.9 Obsolete Routines

The routines described in this section are still available but have been made obsolete by new routines.

PLTSTC
Logical Function

Name	PLTSTC - Set color parameters (obsolete)			
Description	PLTSTC is replaced by PLTSETCOL.			
Syntax	logical = PLTSTC (INDEX, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INDEX	Input	integer	Index for color parameter to be set.
	BUFFER	Input	real	Values for color parameters (dependent on INDEX).
Parameter Values	Index	Action		
	0	Reset color parameters to default		
	1	Set the color spectrum to BUFFER(1) as follows:		
		-1.0 =rainbow reversed order		
		0.0 =rainbow order (default)		
		1.0-15.0 =linearly vary the color spectrum from 0.0, 0.0, 0.0 to this color (except BLACK, i.e., 0)		

PLTSTD
Logical Function

Name PLTSTD - Set device parameters (obsolete)

Description PLTSTD is replaced by PLTSETDRW

Syntax CALL PLTSTD (INDEX, BUFFER)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INDEX	Input	integer	Index for device parameters to be set.
	BUFFER	Input	real array	Values for device parameters (dependent on INDEX).

Parameter values	Index	Action
	0	Reset device parameters to default
	1	Set foreground color to BUFFER(1) (range 0.0 - 255.0)
	2	Set background color to BUFFER(1) (range 0.0 - 255.0)
	3	Set intensity to BUFFER(1) (range 0.0 - 100.0), where 0.0 is invisible

See Also PLTGETDRW

PLTSTG
Logical Function

Name	PLTSTG - Set graph parameters (obsolete)			
Description	PLTSTG is replaced by PLTSETGPH.			
Syntax	CALL PLTSTG (INDEX, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INDEX	Input	integer	Index for graph parameter to set.
	BUFFER	Input	real array	Values for graph parameters (dependent on INDEX).
Parameter Values	Index	Action		
	0	Reset graph parameters to default		
	1	Set x-origin of graph to BUFFER(1)		
	2	Set y-origin of graph to BUFFER(1)		
	3	Set length of x-axis to BUFFER(1)		
	4	Set length of y-axis to BUFFER(1)		
	5	Set style of line used to draw curve to BUFFER(1) as follows: 0.0=no line 1.0=solid 2.0=dotted 3.0=dot dash 4.0=short dash 5.0=long dash 6.0=medium dash		
	6	Set color of line used to draw curve to BUFFER(1) (range 0.0-255.0)		
	7	Set symbol to be used at data points based on BUFFER(1) as follows: 0.0=no symbol 1.0=square 2.0=diamond 3.0=cross 4.0=X 5.0=triangle 6.0=circle 7.0=dot		

Parameter Values (continued)	8	Set symbol increment to BUFFER(1); if symbol plotting is turned on, plot only every n^{th} symbol starting with the first.
	9	Set axis type based on BUFFER(1): 1.0=normal x, normal y 2.0=log x, normal y 3.0=log y, normal x 4.0=log x, log y
	10	Set axis color to BUFFER(1) (range 0.0-255.0)
	11	Set scaling type based on BUFFER(1) as follows: BUFFER(1) = 1.0 - different x and y scaling possible = 2.0 - same x and y scaling forced = 3.0 - user defines scaling as follows: BUFFER(2) - minimum x BUFFER(3) - maximum x BUFFER(4) - number of major x intervals BUFFER(5) - number of minor intervals on x axis BUFFER(6) - minimum y BUFFER(7) - maximum y BUFFER(8) - number of major y intervals BUFFER(9) - number of minor intervals on y axis BUFFER(1) = 4.0 - user defines exact scaling as follows: BUFFER(2) - minimum x BUFFER(3) - first nice x BUFFER(4) - maximum x BUFFER(5) - x interval BUFFER(6) - number of minor x intervals BUFFER(7) - minimum y BUFFER(8) - first nice y BUFFER(9) - maximum y BUFFER(10) - y interval BUFFER(11) - number of minor y intervals
	12	Turn on graph framing if BUFFER(1) is 1; turn off if BUFFER(1) is 0
	13	Set x exponent to BUFFER(1); this exponent is the exponent labelled in scientific notation on the linear axis (ignored if scientific notation is not set); -999999.0 to let the code determine the exponent

PLTSTG

Logical Function

Parameter Values (continued)	14	Set y exponent to BUFFER(1); this exponent is the exponent labelled in scientific notation on the linear exponent axis (ignored if scientific notation exponent value is not set); -999999.0 to let the code determine the exponent
	15	Set line style for major grid to BUFFER(1) (see INDEX = 5 for valid types); 0 to turn off grid drawing
	16	Set color for major grid to BUFFER(1)
	17	Set color for axis labels to BUFFER(1)
	18	Set type of notation on axes based on BUFFER(1): 1.0 = scientific x, normal y 2.0 = scientific y, normal x 3.0 = scientific x, scientific y 4.0 = normal x, normal y
	19	Set number of decimal places in x-axis numbers to BUFFER(1) (range 0-9)
	20	Set number of decimal places in y-axis numbers to BUFFER(1) (range 0-9)
	21	Set y number vertical or horizontal based on BUFFER(1) (1=vertical; otherwise horizontal)
	22	*Set scaling for x-axis number to BUFFER(1); 0 turns off drawing the numbers
	23	*Set scaling for x-axis labels to BUFFER(1); 0 turns off drawing the label
	24	*Set scaling for graph symbols to BUFFER(1)
	25	Label minor x log ticks to BUFFER(1)
	26	Label minor y log ticks to BUFFER(1)
	27	Set map array for graph to BUFFER(1) - BUFFER(14)
	28	Set pen width of axes to BUFFER(1)
	29	Set pen width of curves to BUFFER(1)
	30	Set pen width of axis number to BUFFER(1)
	31	Set pen width of axis labels to BUFFER(1)
	32	Set pen width of symbols to BUFFER(1)
	33	Set pen width of ticks to BUFFER(1)
	34	Set pen width of major grid to BUFFER(1)
	35	Set pen width of minor grid to BUFFER(1)
	36	Set pen width of line at zero to BUFFER(1)
	37	Set line style of line at zero to BUFFER(1)
	38	Set color of line at zero to BUFFER(1)
	39	Set line style of minor grid to BUFFER(1) (see INDEX = 5 for valid types); 0 to turn off grid drawing
	43	Set color of minor grid to BUFFER(1)
	44	Set color of symbols to BUFFER(1)
	45	Set color of axes number to BUFFER(1)
	46	Set color of ticks to BUFFER(1)
	47	*Set scaling for y-axis numbers to BUFFER(1); 0 turns off drawing numbers
	48	*Set scaling for y-axis labels to BUFFER(1); 0 turns off drawing the label

See Also PLTGETGPH

Comment *INDEX = 22, 23, 24, 47, 48:
Axis labels, numbers, and symbols are scaled to some fraction of the average axis length L ($L = 1/2$ (x-axis length + y-axis length)). BUFFER(1), for these indices, allows the user to adjust labels, numbers, and symbols relative to this nominal size where

$$\left\{ \begin{array}{ll} 1 & \text{is } 0.5 \\ 2 & \text{is } 1.0 \\ 10 & \text{is } 1.5 \end{array} \right\} \times \text{the nominal size}$$

For axis numbers, the nominal size is L/50.
For axis labels, the nominal size is L/40.
For symbols, the nominal size is L/120.

PLTSTM
Logical Function

Name	PLTSTM - Set global mapping parameters (obsolete)			
Description	<p>PLTSTM is replaced by PLTSETMAP. This routine sets global mapping parameters, allowing you to perform the following two-dimensional transformations:</p> <ul style="list-style-type: none">• Set a scale factor for the x and y directions.• Set a translation amount for the x and y directions.• Set a rotation angle to rotate the plot.• Set a viewport in which to draw the plot. A viewport is specified by giving the right, left, top, and bottom coordinates in the device space of a rectangle in which to draw vectors, polygons, etc. <p>The parameters are set according to the specified index and buffer values. The buffer is flushed so the changes are up-to-date.</p>			
Syntax	CALL PLTSTM (INDEX, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INDEX	Input	integer	Index for setting global mapping parameters.
	BUFFER	Input	real array	Values for global mapping parameters.
Parameter Values	Index	Action		
	0	Reset global mapping parameters to default		
	1	Set global x-scaling factor to BUFFER(1)		
	2	Set global y-scaling factor to BUFFER(1)		
	3	Set global x-translation amount to BUFFER(1)		
	4	Set global y-translation amount to BUFFER(1)		
	5	Set global rotation angle in degrees to BUFFER(1)		
	6	Set global viewport to BUFFER(1) - BUFFER(4), where BUFFER is an array indicating left, right, bottom, and top, of the viewport in device coordinates.		
See Also	PLTGETMAP			

PLTSTT
Logical Function

Name	PLTSTT - Set text parameters (obsolete)			
Description	PLTSTT is replaced by PLTSETTXT.			
Syntax	logical = PLTSTT (INDEX, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INDEX	Input	integer	Index for text parameter to set.
	BUFFER	Input	real array	Values for text parameters (dependent on INDEX).
Parameter Values	Index	Action		
	0	Reset text parameters to default		
	1	Set hardware character size to BUFFER(1)		
	2	Set software character size to BUFFER(1)		
	3	Set angle for software text to be written; BUFFER(1) is the angle in degrees		
	4	Set angle for software characters to be written; BUFFER(1) is the angle in degrees		
	5	Set text window to BUFFER(1) - BUFFER(8); the buffer denotes the four points of the window in CCW Order		
	6	Set space between lines of software text; BUFFER(1) contains a factor by which to multiply the y character size to obtain the linefeed size		
	7	Set spacing between characters; BUFFER(1) contains a factor by which to multiply the normal character spacing (included as part of the font) to obtain the actual character spacing		
	8	Set reduction in y character size for sub- and superscripts. BUFFER(1) contains a factor by which to multiply the current y character size to obtain the size of the sub- and superscripts		
	9	Set the amount by which to raise the superscripts; BUFFER(1) contains a number which, when multiplied by the current character size, will give the amount to raise the superscript		

PLTSTT
Logical Function

Parameter Values (continued)	10	Set the amount by which to lower the subscripts; BUFFER(1) contains a number which, when multiplied by the current character size, will give the amount to lower the subscript
	11	Set the pen width for text to BUFFER(1)
	12	Set the font for text based on BUFFER(1) as follows: 1.0 = Roman 2.0 = stick 3.0 = sans serif

The buffer is flushed so the changes are up-to-date.

See Also PLTGETTXT

PLTSTV
Logical Function

Name	PLTSTV - Set vector parameters			
Description	PLTSTV sets the vector parameters according to the specified index and buffer values. The buffer is flushed so the changes are up-to-date.			
Syntax	logical = PLTSTV (INDEX, BUFFER)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INDEX	Input	integer	Index for vector parameters.
	BUFFER	Input	real array	Values for vector parameters.
Parameter	Index	Action		
	0	Reset vector parameters to default		
	1	Set the vector style based on BUFFER(1) as follows: 0.0 = no line 1.0 = solid 2.0 = dotted 3.0 = dot dash 4.0 = short dash 5.0 = long dash 6.0 = medium dash		
	2	Set vector line width to BUFFER(1) (range is 0.0-1000.0, where 1000 is 0.01 in VDI space)		
See Also	PLTGTV			

10.3 General Guidelines on the Use of HJIPLLOT_LIB Routines

10.3.1 Sponsorship and Version

Author/Sponsor: H. J. Iuzzolino
Version/Date: C-2.00VV/December 1992
Language: FORTRAN 77

10.3.2 Overview of HJIPLLOT_LIB

HJIPLLOT_LIB provides numerous mid-level and high-level plot routines to FORTRAN and C programs. C routines should use call-by-address for INT and FLOAT variables. Text should be passed from C routines to FORTRAN as a two-word INT array: the string length and the string address.

HJIPLLOT_LIB routines are called by a user-written program and cannot be executed without a user-written main program.

10.3.3 Linking

The HJIPLLOT_LIB routines are in an object library in file

CAMCON\$ROOT:[CAMCON.LIBRARIES.HJIPLLOT_LIB]HJIPLLOT_LIB.OLB.

CAMCON defines the symbol HJIPLLOT_LIB to point to this file. The link command has the following form:

```
$SELECT NULL
$LINK code_name, HJIPLLOT_LIB/LIB, SHRPLT/LIB, CDRLIB/LIB/INCL = CDRABC
```

10.3.4 Limitations

- The library must be linked with the Sandia VDI plot primitives.
- Procedure SELECT must be invoked to select the terminal and hardcopy devices.
- Character rotation is unavailable at this time.

10.3.5 Error Messages

Error messages are written to file PLOTERROR.MSG or to file FOR101.DAT. The error messages occur when illegal values are sent to the scaling routines. The illegal values are changed to legal values and processing continues. The error messages are as follows (the lowercase names represent numeric values):

```
HPLQQQQ01: ERROR: VMIN=VMAX=vmin, SETTING VMAX=vmax
HPLQQQQ001: ERROR: VMIN=VMAX=vmin, SETTING VMAX=vmax
HPLQQQQ002: ERROR: VMIN=VMAX=vmin, SETTING VMAX=vmax
```

HPLQQQ003:	ERROR: VMIN=0,	SETTING VMIN=1.E-6*VMAX=vmin
HPLQQQ003:	ERROR: VMAX=0,	SETTING VMAX=1.E6*VMIN=vmax
HPLQQQ003:	ERROR: VMIN=VMAX=vmin,	SETTING VMAX=vmax

10.3.6 Summary of Routines

The HJIPLLOT_LIB routines are described in detail in the next section. The following is a brief description of the HJIPLLOT_LIB routines.

- HPLAHSAX - plots an arc-hyperbolic sine axis
- HPLAXIMODE - unpacks the axis mode value
- HPLAXIS - plots a linear axis at any angle
- HPLBOX - draws a rectangular box
- HPLDCLIMIT - returns plot frame limits in device coordinates
- HPLFIELDWD - returns the field width generated by a format
- HPLFNAHSIN - arc hyperbolic sine function
- HPLFNHSIN - hyperbolic sine function
- HPLGENFMT - generates a format suitable to print/plot each item in an array
- HPLINITPLOT - initializes the plotting with device aspect ratio and justification
- HPLINITPLT - initializes the plotting with device aspect ratio, justification, page mode, and font number
- HPLINTRP1 - performs linear interpolation
- HPLLENTXT - returns the length of a string to the last nonblank, non-null character
- HPLLINE - draws a piecewise continuous line through points in world coordinates
- HPLLINED - draws a piecewise continuous line through points in device coordinates
- HPLLINEW - draws a piecewise continuous line through points in world coordinates
- HPLLOGAX - draws a logarithmic axis at any angle
- HPLMARKER - draws a centered marker
- HPLMGDEVS - initialize multiple graphics devices
- HPLMULPLOT - draws one or more curves on a frame using solid and dashed line patterns
- HPLMULPTRN - specify MULPLOT line pattern number
- HPLNIDFD - returns the number of integer digits, fraction digits, and significant digits
- HPLNUMBER - plots a number using a specified format
- HPLPLOT - draws or moves to a point with specified world coordinates
- HPLPLOTD - draws or moves to a point with specified device coordinates
- HPLPLOTW - draws or moves to a point with specified world coordinates
- HPLPOPVEC - restores the previous vector of plot attributes
- HPLPUSHVEC - saves the current vector of plot attributes
- HPLQQQQ01 - returns appropriate end points and tic spacing for an axis range
- HPLQQQ001 - returns appropriate end points and tic spacing for an axis range
- HPLQQQ002 - finds decade end points that bound minimum and maximum values
- HPLQQQ003 - finds round numbers that bound minimum and maximum values
- HPLSCREEN - defines the bounds of the plot
- HPLSYMBOL - plots characters in a text string at a given angle
- HPLWAITCR - holds the plot until the RETURN key is pressed
- HPLWAITOFF - turns off the WAITCR behavior of waiting for the RETURN key
- HPLWAITON - turns on the WAITCR behavior of waiting for the RETURN key
- HPLXMAPDC - maps world x-coordinates to device x-coordinates
- HPLYMAPDC - maps world y-coordinates to device y-coordinates
- HPLXWTODC - returns the device x-coordinate for a specified world x-coordinate
- HPLYWTODC - returns the device y-coordinate for a specified world y-coordinate

10.4 Description of Routine Calls

Detailed descriptions of the HJIPILOT_LIB routines are given on the following pages.

HPLAHSAX
Subroutine

Name	HPLAHSAX - Plot an arc-hyperbolic sine axis			
Description	HPLAHSAX plots an arc-hyperbolic sine axis. This axis resembles a log axis but can include zero and negative numbers.			
Syntax	CALL HPLAHSAX (XDC, YDC, VI, VF, DCLLEN, VLBL, U, MODE, ANGAX, ANGNM, LBL)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XDC	Input	real	Device x-coordinate for the start of the axis.
	YDC	Input	real	Device y-coordinate for the start of the axis.
	VI	Input	real	World coordinate value for the start of the axis.
	VF	Input	real	World coordinate value for the end of the axis.
	DCLLEN	Input	real	Axis length in device coordinate units.
	VLBL	Input	real	Value of the smallest numbered tic mark.
	U	Input	real	Scale factor. Recommended value is 0.2 times the world coordinate value of the smallest tic spacing.
	MODE	Input	integer	Mode of axis numbering and tic style. The following are the values for MODE MOD 4 and the resulting tic modes: 0 tics are on both sides of the axis 1 tics are on the numbered side of the axis 2 tics are on the unnumbered side of the axis 3 only the tics are drawn ≥4 the numbering is suppressed
	ANGAX	Input	real	Axis angle (degrees) counterclockwise from the right horizontal.
	ANGNM	Input	real	Angle (degrees) of the axis numbering.
	LBL	Input	real	Axis label (FORTRAN character variable or constant).

HPLAXIMODE

Subroutine

Name	HPLAXIMODE - Unpack the axis mode value			
Description	HPLAXIMODE unpacks the axis mode parameter and generates logical variables that control the appearance of the axis.			
Syntax	CALL HPLAXIMODE (MODE, ANGAX, CCS, PTO)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	MODE	Input	integer	Axis tic and numbering mode. The following are the values for MODE MOD 4 and the resulting tic modes: 0 tics are on both sides of the axis 1 tics are on the numbered side of the axis 2 tics are on the unnumbered side of the axis 3 only the tics are drawn ≥4 the numbering is suppressed
	ANGAX	Input	real	Axis angle (degrees) clockwise from the right horizontal.
	CS	Output	logical	.TRUE. if tics should be drawn on the clockwise side of the axis, .FALSE. if not.
	CCS	Output	logical	.TRUE. if tics should be drawn on the counter-clockwise side of the axis, .FALSE. if not.
	PTO	Output	logical	.TRUE. if tics should be drawn but not the axis, .FALSE. otherwise.
Note	Although available for general use, HPLAXIMODE is intended for internal use within axis routines.			

HPLAXIS
Subroutine

Name	HPLAXIS - Plot a linear axis at any angle			
Description	HPLAXIS plots a linear axis at any angle.			
Syntax	CALL HPLAXIS (XDC, YDC, VI, VF, VSC, VTIC, VLBL, MODE, FMT, ANGAX, ANGNUM, LBL)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XDC	Input	real	Device x-coordinate for the start of the axis.
	YDC	Input	real	Device y-coordinate for the start of the axis.
	VI	Input	real	World coordinate value for the start of the axis.
	VF	Input	real	World coordinate value for the end of the axis.
	VSC	Input	real	Scale factor: device coordinates per world coordinate
	VTIC	Input	real	Tic spacing in world coordinates.
	VLBL	Input	real	Spacing between numbered tic marks in world coordinates.
	MODE	Input	integer	Axis tic and numbering mode. The following are the values for MODE MOD 4 and the resulting tic and numbering modes: 0 tics are on both sides of the axis 1 tics are on the numbered side of the axis 2 tics are on the unnumbered side of the axis 3 only the tics are drawn ≥4 the numbering is suppressed
	FMT	Input	real	Format for the axis numbering, bounded by parentheses.
	ANGAX	Input	real	Axis angle (degrees) counterclockwise from the right horizontal.
	ANGNUM	Input	real	Numbering angle (degrees) counterclockwise from the right horizontal.
	LBL	Input	real	Axis label (FORTRAN character variable or constant).

HPLBOX
Subroutine

Name HPLBOX - Draw a box

Description HPLBOX draws a rectangular box, given the coordinates of two opposite corners.

Syntax CALL HPLBOX (X1, Y1, X2, Y2)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X1	Input	real	Device x-coordinate for one corner of the rectangle.
	Y1	Input	real	Device y-coordinate for one corner of the rectangle.
	X2	Input	real	Device x-coordinate for the opposite corner.
	Y2	Input	real	Device y-coordinate for the opposite corner.

HPLDCLIMIT
Subroutine

Name	HPLDCLIMIT - Return plot frame limits			
Description	HPLDCLIMIT returns plot frame limits in device coordinates.			
Syntax	CALL HPLDCLIMIT (XDMN, XDMX, YDMN, YDMX)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XDMN	Output	real	Minimum device x-coordinate.
	XDMX	Output	real	Maximum device x-coordinate of the smallest device.
	XDLIM	Output	real	Maximum device x-coordinate of the largest device.
	YDMN	Output	real	Minimum device y-coordinate.
	YDMX	Output	real	Maximum device y-coordinate of the smallest device.
	YDLIM	Output	real	Maximum device y-coordinate of the largest device.

HPLFIELDWD

Function

Name	HPLFIELDWD - Return the field width generated by a format			
Description	HPLFIELDWD returns the field width (number of characters) generated by a format.			
Syntax	integer = HPLFIELDWD (FORMAT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FORMAT	Input	char	String containing a format for a number or text string.
Return Value	HPLFIELDWD	Output	integer	Number of characters generated by the format.

HPLFNAHSIN

Function

Name	HPLFNAHSIN - Arc hyperbolic sine function			
Description	HPLFNAHSIN returns the arc hyperbolic sine of the scaled argument.			
Syntax	real = HPLFNAHSIN (X,U)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real	Independent variable.
	U	Input	real	Scale factor.
Return Value	HPLFNAHSIN Output	real	sign(log(abs(X/U) + sqrt(X/U)**2+1)),X)	

HPLFNHSIN

Function

Name	HPLFNHSIN - Hyperbolic sine function			
Description	HPLFNHSIN returns the scaled hyperbolic sine of the argument.			
Syntax	real = HPLFNHSIN (X,U)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real	Independent variable.
	U	Input	real	Scale factor.
Return Value	HPLFNHSIN	Output	real	$0.5*U*(\exp(X) - \exp(-X))$

HPLGENFMT
Subroutine

Name	HPLGENFMT - Generate a format for printing items in an array			
Description	HPLGENFMT generates a format suitable to print/plot each item in an array.			
Syntax	CALL HPLGENFMT (FMT, ARRAY, NN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FMT	Output	char	Suitable format for printing each item in ARRAY. The format is enclosed in parentheses.
	ARRAY	Input	real array	Array of FORTRAN real numbers.
	NN	Input	integer	Number of numbers in ARRAY.

HPLINITPLOT

Subroutine

Name	HPLINITPLOT - Initialize the plotting			
Description	HPLINITPLOT initializes the plotting. It must be called only once.			
Syntax	CALL HPLINITPLOT (ASPECT, JUSTIF)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ASPECT	Input	real	Aspect ratio of device: maximum device x to maximum device y
	JUSTIF	Input	integer	Justification (where the plot is put if it does not fill the frame): 7=left top 8=center top 9=right top 4=left center 5=center 6=rightcenter 0 or 1 = left 2=center 3=right bottom bottom bottom

HPLINITPLT

Subroutine

Name	HPLINITPLT - Initialize the plotting																															
Description	HPLINITPLT initializes the plotting. It must be called only once																															
Syntax	CALL HPLINITPLT (ASPECT, JUSTIF, PGMODE, NFONT)																															
Variables in Call	Name	I/O	Type	Description																												
	ASPECT	Input	real	Aspect ratio of device: maximum x to device maximum y.																												
	JUSTIF	Input	integer	Justification (where the plot is put if it does not fill the frame): 7=left top 8=center top 9=right top 4=left center 5=center 6=right center 0 or 1 = left 2=center 3=right bottom bottom bottom																												
	PGMODE	Input	real	Page mode: 0 for landscape mode 1 for portrait mode																												
	NFONT	Input	integer	Font number = 10×typeface value+style value. The tens digit selects the typeface, and the units digit selects the style: <table><tr><td>Typeface</td><td>Value</td><td>Style</td><td>Value</td></tr><tr><td>Courier</td><td>10</td><td>Normal (Roman)</td><td>0</td></tr><tr><td>Helvetica</td><td>20</td><td>Bold</td><td>1</td></tr><tr><td>Times</td><td>30</td><td>Italic</td><td>2</td></tr><tr><td>Symbol</td><td>40</td><td>Bold Italic</td><td>3</td></tr><tr><td></td><td></td><td>Extended</td><td>4</td></tr><tr><td></td><td></td><td>Condensed</td><td>5</td></tr></table> If an unsupported value is specified, the font is set to the default (Helvetica). Font selection is supported by PostScript devices but not by most other devices.	Typeface	Value	Style	Value	Courier	10	Normal (Roman)	0	Helvetica	20	Bold	1	Times	30	Italic	2	Symbol	40	Bold Italic	3			Extended	4			Condensed	5
Typeface	Value	Style	Value																													
Courier	10	Normal (Roman)	0																													
Helvetica	20	Bold	1																													
Times	30	Italic	2																													
Symbol	40	Bold Italic	3																													
		Extended	4																													
		Condensed	5																													
Note	Font selection (NFONT) is not yet implemented.																															

HPLINTRP1

Real Function

Name	HPLINTRP1 - Perform linear interpolation			
Description	HPLINTRP1 finds F(XX) by linear interpolation given N data points in arrays X and F.			
Syntax	<i>real</i> = HPLINTRP1 (X, F, N, XX, IXTYPE, IFTYPE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real array	Array of x values (independent variable).
	F	Input	real array	Array of y values (dependent variable).
	N	Input	integer	Number of points in the X,F arrays.
	XX	Input	real	Value at which the interpolation is performed.
	IXTYPE	Input	integer	Type of x scale: 0 if x is on a linear scale 1 if x is on a logarithmic scale
	IFTYPE	Input	integer	Type of F scale: 0 if F is on a linear scale 1 if F is on a logarithmic scale
Return Value	HPLINTRP1	Output	real	Value of F at XX.

HPLLENTXT
Integer Function

Name	HPLLENTXT - return the length of a string			
Description	HPLLENTXT returns the length of a string to the first null or else to the last nonblank character.			
Syntax	<i>integer</i> = HPLLENTXT (TEXT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	TEXT	Input	character	A FORTRAN character variable or constant.
Return Value	HPLLENTXT	Output	integer	String length (to first null or last non-blank character).

HPLLINE
Subroutine

Name	HPLLINE - Draw a piecewise continuous line (world coordinates)			
Description	HPLLINE draws a piecewise continuous line through the NP points whose world coordinates are in arrays X and Y.			
Syntax	CALL HPLLINE(X, Y, NP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real array	Array of world x-coordinates.
	Y	Input	real array	Array of world y-coordinates.
	NP	Input	integer	Number of points.
Note	HPLLINE is an entry point in subroutine HPLLINEW and is included for compatibility with other plotting packages.			

HPLINED
Subroutine

Name	HPLINED - Draw a piecewise continuous line (device coordinates)			
Description	HPLINED draws a piecewise continuous line through the NP points whose device coordinates are in arrays X and Y.			
Syntax	CALL HPLINED (X, Y, NP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real array	Array of device x-coordinates.
	Y	Input	real array	Array of device y-coordinates.
	NP	Input	integer	Number of points.

HPLLINEW
Subroutine

Name	HPLLINEW - Draw a piecewise continuous line (world coordinates)			
Description	HPLLINEW draws a piecewise continuous line through the NP points whose world coordinates are in arrays X and Y.			
Syntax	CALL HPLLINEW (X, Y, NP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real array	Array of world x-coordinates.
	Y	Input	real array	Array of world y-coordinates.
	NP	Input	integer	Number of points.

HPLLOGAX
Subroutine

Name	HPLLOGAX - Draw a logarithmic axis			
Description	HPLLOGAX draws a logarithmic axis at any angle.			
Syntax	CALL HPLLOGAX (XDC, YDC, VI, VF, FDCCY, MODE, ANGAX, ANGNM, LBL)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XDC	Input	real	Device x-coordinate at the start of the axis.
	YDC	Input	real	Device y-coordinate at the start of the axis.
	VI	Input	real	World coordinate value of the start of the axis.
	VF	Input	real	World coordinate value of the end of the axis.
	FDCCY	Input	real	Scale factor: device coordinates per decade.
	MODE	Input	integer	Axis tic and numbering mode. The following are the values for MODE MOD 4 and the resulting tic and numbering modes: 0 tics are on both sides of the axis 1 tics are on the numbered side of the axis 2 tics are on the unnumbered side of the axis 3 only the tics are drawn ≥ 4 the numbering is suppressed
	ANGAX	Input	real	Axis angle (degrees) counterclockwise from the right horizontal.
	ANGNM	Input	real	Numbering angle (degrees) counterclockwise from the right horizontal.
	LBL	Input	char	Axis label (FORTRAN character variable or constant).

HPLMARKER
Subroutine

Name	HPLMARKER - Draw a centered marker			
Description	HPLMARKER draws a centered marker.			
Syntax	CALL HPLMARKER (X, Y, DIAM, MARK, ANGLE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real	Device x-coordinate for the center of the marker.
	Y	Input	real	Device y-coordinates for the center of the marker.
	DIAM	Input	real	Diameter (or width) of the marker in device coordinates.
	MARK	Input	integer	Index number of the symbol: $1 \leq \text{MARK} \leq 24$. Markers 1 - 13 and 21 - 24 are outlines only, while markers 14 through 20 are filled.
	ANGLE	Input	real	Counterclockwise rotation angle (degrees) for the marker.

HPLMGDEVS

Subroutine

Name	HPLMGDEVS - Set up multiple graphics devices			
Description	HPLMGDEVS initializes multiple graphics devices. If HJIPLOT_LIB is used with the 1981 version of the Sandia VDI library (SVDI), one terminal device and one file device may be used. A multiple virtual device package (MVDI) currently under development allows one terminal device and up to 9 file devices. HPLMGDEVS is called by HPLINITPLT or HPLINITPLOT and need not be called by the user.			
Syntax	CALL HPLMGDEVS (KDEV, CODES, UNITNOS, MSGUNIT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	KDEV	Input	integer	Count of device codes. If KDEV=0, the device codes will be taken from the VMS global symbols VDI_TERM, VDI_FILE, and VDI_DEVn, where n = 1,2,...,9.
	CODES	Input	char*5 array	Array of device codes.
	UNITNOS	Input	integer array	Array of file numbers, one for each output device.
	MSGUNIT	Input	integer	Number of the file used for error messages. If MSGUNIT=0, then 101 will be used.
See Also	HPLINITPLOT, HPLINITPLT			

May 1993

HPLMULPLOT

Subroutine

Variables in Call (continued)

			linear y-axis	32	logarithmic y-axis
				64	arc sinh x-axis
				128	arc sinh y-axis
			half frame	256	full frame
			line plot	512	point plot
			X array given	1024	X0, DX given
			Y array given	2048	Y0, DY given
			advance frame after call	4096	hold frame for another call
SCALES	Input	real array	Axis scaling parameters: SC(1) = x-axis length in device coordinates SC(2) = x-axis initial value SC(3) = x-axis final value SC(4) = y-axis length in device coordinates SC(5) = y-axis initial value SC(6) = y-axis final value SC(7) = minimum fraction of frame filled by SC(3) - SC(2) SC(8) = minimum fraction of frame filled by SC(6) - SC(5) SC(9) = scaling parameter for arc hyperbolic sine x-axis SC(10) = scaling parameter for arc hyper- bolic sine y-axis		
ORGS	Input	real array	Origin locations for various parts of the frame. ORGS(1), (2) = X,Y of bottom left corner of rectangle defined by axes ORGS(3), (4) = X,Y of bottom left corner of main heading ORGS(5), (6) = X,Y of top left corner of leg- ends for graphs ORGS(7), (8) = X,Y of bottom left corner of next frame		
TITLES	Input	char*80 array	Three lines of the main heading.		
AXLBLS	Input	char*80 array	Labels for the x and y axes.		
LEGEND	Input	char	Legend for the current graph.		

See Also

HPLMULPTRN

HPLMULPTRN***Subroutine***

Name	HPLMULPTRN - specify HPLMULPLOT line pattern number			
Description	HPLMULPTRN is an entry point to HPLMULPLOT which allows the user to specify line patterns in an order other than the default.			
Syntax	CALL HPLMULPTRN (NPATRN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NPATRN	Input	integer	Line pattern number. Pattern 1 is a solid line. Patterns 2 through 20 are different combinations of long, medium, and short dashes. If NPATRN > 20, pattern 20 is used.
See Also	HPLMULPLOT			

HPLNIDFD
Subroutine

Name	HPLNIDFD - Get the number of integer digits, fraction digits, and significant digits			
Description	HPLNIDFD returns the number of integer digits, fraction digits, and significant digits in FNUM.			
Syntax	CALL HPLNIDFD (FNUM, NID, NFD, NSD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	FNUM	Input	real	Real number.
	NID	Output	integer	Number of integer digits. If FNUM=0., NID=1. If FNUM is negative, NID is increased by 1 to accommodate the minus sign.
	NFD	Output	integer	Number of digits after the decimal point.
	NSD	Output	integer	Number of significant digits. If FNUM=0., NSD=1.

HPLNUMBER

Subroutine

Name	HPLNUMBER - Plot a number			
Description	HPLNUMBER plots a number using format FMT.			
Syntax	CALL HPLNUMBER (X, Y, HGT, VALUE, ANGLE, FMT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X,Y	Input	real	Device x and y coordinates of the front bottom corner of the rectangular area occupied by the number.
	HGT	Input	real	Height of the number. The actual height depends on the device and the aspect ratio. Typically, HGT = 0.01 produces fine print (about 0.05 inch high) and HGT = 0.08 produces digits about 0.5 inch high.
	VALUE	Input	real or integer	The value to be plotted. The value may be a FORTRAN real or integer variable or constant, but FMT must indicate the correct type.
	ANGLE	Input	real	The rotation angle (degrees) measured counterclockwise from the right horizontal direction. The nearest angle supported by the graphics device will be used.
	FMT	Input	char	A character variable or constant holding the format for the number, bounded by parentheses, e.g., FMT = '(F10.3)' for a real value or FMT = '(I6)' for an integer value.

HPLPLOT
Subroutine

Name	HPLPLOT - Draw or move to a point			
Description	HPLPLOT draws or moves to a point with world coordinates XW, YW.			
Syntax	CALL HPLPLOT (XW, YW, IPEN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XW	Input	real	World x-coordinate to be drawn or moved to.
	YW	Input	real	World y-coordinate to be drawn or moved to.
	IPEN	Input	integer	Pen state: 1 - use the previous value of IPEN 2 - draw to XW, YW 3 - move to XW, YW without drawing

HPLPLOTD
Subroutine

Name HPLPLOTD - Draw or move to a point

Description HPLPLOTD draws or moves to a point with device coordinates XD, YD.

Syntax CALL HPLPLOTD (XD, YD, IPEN)

Variables In Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD	Input	real	Device x-coordinate to be drawn or moved to.
	YD	Input	real	Device y-coordinate to be drawn or moved to.
	IPEN	Input	integer	Pen state: 1 - use the previous value of IPEN 2 - draw to XD, YD 3 - move to XD, YD without drawing

HPLPLOTW

Subroutine

Name	HPLPLOTW - Draw or move to a point with specified world coordinates			
Description	HPLPLOTW draws or moves to a point with world coordinates XW, YW. PLOTW is an entry point to subroutine PLOT and is included to allow a more obvious distinction between calls using world coordinates and those using device coordinates.			
Syntax	CALL HPLPLOTW (XW, YW, IPEN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XW	Input	real	World x-coordinate to be drawn or moved to.
	YW	Input	real	World y-coordinate to be drawn or moved to.
	IPEN	Input	integer	Pen state: 1 - use the previous value of IPEN 2 - draw to XW, YW 3 - move to XW, YW without drawing
See Also	HPLPLOT			

HPLPOPVEC

Subroutine

Name	HPLPOPVEC - Restore the previous vector of plot attributes
Description	<p>HPLPOPVEC restores the previous graphics attribute vector from a push-down stack. If HPLPOPVEC is called more times than HPLPUSHVEC, the initial graphics attribute vector will be restored. The graphics attribute vector contains the following data for each active graphics device:</p> <ul style="list-style-type: none">VECTOR (1) = FOREGROUND COLOR(2) = BACKGROUND COLOR(3) = INTENSITY(4) = LINE STYLE(5) = LINE WIDTH(6) = CHARACTER BOX Y(7) = CHARACTER BOX X
Syntax	CALL HPLPOPVEC
See Also	HPLPUSHVEC

HPLPUSHVEC
Subroutine

Name	HPLPUSHVEC - Save the current vector of plot attributes
Description	<p>HPLPUSHVEC saves the current graphics attribute vector on a push-down stack. The stack can hold the initial graphics attribute vector and up to nine changes. If the current attribute vector is the same as the previous vector, a counter is increased rather than adding to the stack. No additions can be made to the stack when it contains 10 vectors.</p> <p>The graphics attribute vector contains the following data for each active graphics device:</p> <ul style="list-style-type: none">VECTOR (1) = FOREGROUND COLOR(2) = BACKGROUND COLOR(3) = INTENSITY(4) = LINE STYLE(5) = LINE WIDTH(6) = CHARACTER BOX Y(7) = CHARACTER BOX X
Syntax	CALL HPLPUSHVEC
See Also	HPLPOPVEC

HPLQQQQ01

Subroutine

Name	HPLQQQQ01 - Return suitable endpoints and tic spacing for a linear axis			
Description	HPLQQQQ01 returns suitable endpoints and tic spacing for a linear axis given the bounds VMIN and VMAX and the fraction of the range to be covered.			
Syntax	CALL HPLQQQQ01(VMIN, VMAX, TIC, VSTART, VSTOP, FRMIN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	VMIN	Input	real	Minimum value.
	VMAX	Input	real	Maximum value.
	TIC	Output	real	A suitable value for tic mark spacing.
	VSTART	Output	real	The starting value bounding VMIN-to-VMAX.
	VSTOP	Output	real	The ending value bounding VMIN-to-VMAX.
	FRMIN	Input	real	The minimum fraction of VSTART-to-VSTOP to be covered by VMIN-to-VMAX. If FRMIN < .5, .5 is used. If FRMIN > .9, .9 is used.
See Also	HPLQQQ001			

HPLQQQ001
Subroutine

Name	HPLQQQ001 - Return suitable endpoints and tic spacing for a linear axis			
Description	HPLQQQ001 returns suitable endpoints and tic spacing for a linear axis given the bounds VMIN and VMAX.			
Syntax	CALL HPLQQQ001(VMIN, VMAX, TIC, VSTART, VSTOP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	VMIN	Input	real	Minimum value.
	VMAX	Input	real	Maximum value.
	TIC	Output	real	A suitable value for tic mark spacing
	VSTART	Output	real	The starting value bounding VMIN-to-VMAX.
	VSTOP	Output	real	The ending value bounding VMIN-to-VMAX.
See Also	HPLQQQ001			

HPLQQQ002

Subroutine

Name	HPLQQQ002 - Find decade endpoints that bound the range			
Description	HPLQQQ002 returns the decade endpoints, VSTART and VSTOP, that bound VMIN-to-VMAX.			
Syntax	CALL HPLQQQ002(VMIN, VMAX, FCYC, VSTART, VSTOP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	VMIN	Input	real	Minimum value.
	VMAX	Input	real	Maximum value.
	FCYC	Output	real	The number of logarithmic cycles covered by VSTART-to-VSTOP
	VSTART	Output	real	The starting value bounding VMIN-to-VMAX.
	VSTOP	Output	real	The ending value bounding VMIN-to-VMAX.
See Also	HPLQQQ003			

HPLQQQ003

Subroutine

Name	HPLQQQ003 - Find round numbers that bound the range			
Description	HPLQQQ003 returns round numbers (one nonzero digit) for the endpoints VSTART and VSTOP that bound VMIN-to-VMAX. VSTART and VSTOP are not necessarily the endpoints of a decade.			
Syntax	CALL HPLQQQ003(VMIN, VMAX, FCYC, VSTART, VSTOP)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	VMIN	Input	real	Minimum value.
	VMAX	Input	real	Maximum value.
	FCYC	Output	real	The number of logarithmic cycles covered by VSTART-to-VSTOP
	VSTART	Output	real	The starting value bounding VMIN-to-VMAX.
	VSTOP	Output	real	The ending value bounding VMIN-to-VMAX.
See Also	HPLQQQ002			

HPLSCREEN

Subroutine

Name	HPLSCREEN - Define the bounds of the plot			
Description	HPLSCREEN defines the bounds of the plot. Margins are set to about 10% of the x and y extents.			
Syntax	CALL HPLSCREEN (XMIN, XMAX, YMIN, YMAX, XTYPE, YTYPE, XPRAM, YPRAM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XMIN	Input	real	Minimum world x-coordinate to be displayed.
	XMAX	Input	real	Maximum world x-coordinate to be displayed.
	YMIN	Input	real	Minimum world y-coordinate to be displayed.
	YMAX	Input	real	Maximum world y-coordinate to be displayed.
	XTYPE	Input	integer	X-coordinate type: 0 - linear 1 - logarithmic 2 - arc hyperbolic sine
	YTYPE	Input	integer	Y-coordinate type: 0 - linear 1 - logarithmic 2 - arc hyperbolic sine
	XPRAM	Input	real	Scaling parameter for arc hyperbolic sine mapping of the x-axis.
	YPRAM	Input	real	Scaling parameter for arc hyperbolic sine mapping of the y-axis.
See Also	HPLXDCMAP, HPLYDCMAP			

HPLSYMBOL
Subroutine

Name	HPLSYMBOL - Plot characters			
Description	HPLSYMBOL plots NC characters in text string TEXT at angle ANGLE. (ANGLE is not implemented yet. The letters remain horizontal.)			
Syntax	CALL HPLSYMBOL (X, Y, HGT, TEXT, ANGLE, NC)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real	Device x-coordinate of the front bottom corner of the rectangular area occupied by the string.
	Y	Input	real	Device y-coordinate of the front bottom corner of the rectangular area occupied by the string.
	HGT	Input	real	Height of the text. The actual height depends on the device and aspect ratio. Typically, HGT = 0.01 produces fine print (about 0.05 inches high) and HGT = 0.08 produces letters about 0.5 inches high.
	TEXT	Input	text	The text string, either a FORTRAN character variable or a string surrounded by apostrophes.
	ANGLE	Input	real	Rotation angle (degrees) measured counter-clockwise from the right horizontal direction. The nearest angle supported by the device will be used.
	NC	Input	integer	The number of characters (including blanks) in the string.

HPLWAITCR

Subroutine

Name	HPLWAITCR - Wait for Return key
Description	HPLWAITCR holds the plot until the Return key is pressed. The message "Press RETURN to continue" is displayed on the terminal screen. No message appears on hard copy.
Syntax	CALL HPLWAITCR
See Also	HPLWAITOFF, HPLWAITON

HPLWAITOFF

Subroutine

Name	HPLWAITOFF - Turn off HPLWAITCR
Description	HPLWAITOFF turns off the HPLWAITCR behavior of waiting for the Return key before going on to the next plot. (Calling HPLWAITON restores the wait option.)
Syntax	CALL HPLWAITOFF
See Also	HPLWAITCR, HPLWAITON

HPLWAITON

Subroutine

Name	HPLWAITON - Turn on HPLWAITCR
Description	HPLWAITON turns on the HPLWAITCR behavior of waiting for the Return key before going on to the next plot. (Calling HPLWAITOFF turns off the wait option.)
Syntax	CALL HPLWAITON
See Also	HPLWAITCR, HPLWAITOFF

HPLXMAPDC

Subroutine

Name	HPLXMAPDC - Map world x-coordinates to device x-coordinates			
Description	HPLXMAPDC maps world x-coordinates XW1, XW2 to device x-coordinates XD1, XD2. The mapping is linear, logarithmic, or arc hyperbolic sine, depending on the value of XTYP.			
Syntax	CALL HPLXMAPDC (XD1, XW1, XD2, XW2, XTYP, XPRAM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XD1	Input	real	Minimum device x-coordinate.
	XW1	Input	real	Minimum world x-coordinate (corresponding to XD1).
	XD2	Input	real	Maximum device x-coordinate.
	XW2	Input	real	Maximum world x-coordinate (corresponding to XD2).
	XTYP	Input	integer	Type of coordinate mapping: 0 - linear mapping 1 - logarithmic mapping 2 - arc hyperbolic sine mapping
	XPRAM	Input	real	Scaling parameter for the arc hyperbolic sine mapping.
See Also	HPLYMAPDC			

HPLYMAPDC

Subroutine

Name	HPLYMAPDC - Map world y-coordinates to device y-coordinates			
Description	HPLYMAPDC maps world y-coordinates YW1, YW2 to device y-coordinates YD1, YD2. The mapping is linear, logarithmic, or arc hyperbolic sine, depending on the value of YTYP.			
Syntax	CALL HPLYMAPDC (YD1, YW1, YD2, YW2, YTYP, YPRAM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	YD1	Input	real	Minimum device y-coordinate.
	YW1	Input	real	Minimum world y-coordinate (corresponding to YD1).
	YD2	Input	real	Maximum device y-coordinate.
	YW2	Input	real	Maximum world y-coordinate (corresponding to YD2)
	YTYP	Input	integer	Type of coordinate mapping: 0 - linear mapping 1 - logarithmic mapping 2 - arc hyperbolic sine mapping
	YPRAM	Input	real	Scaling parameter for the arc hyperbolic sine mapping
See Also	HPLXMAPDC			

HPLXWTODC

Real Function

Name HPLXWTODC - Return the device x-coordinate for a world x-coordinate

Description HPLXWTODC returns the device x-coordinate for world x-coordinate XW.

Syntax *real* = HPLXWTODC (XW)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XW	Input	real	World x-coordinate.
Return Value	HPLXWTODC Output		real	Device x-coordinate.

HPLYWTODC

Real Function

Name	HPLYWTODC - Return the device y-coordinate for a world y-coordinate			
Description	HPLYWTODC returns the device y-coordinate for world y-coordinate YW.			
Syntax	<i>real</i> = HPLYWTODC (YW)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	YW	Input	real	World y-coordinate.
Return Value	HPLYWTODC	Output	real	Device y-coordinate.

11. Graphic Device Interfaces: SVDI and DVDI

Major CAMCON system plot packages use the Sandia Virtual Device Interface (SVDI) and Dual Virtual Device Interface (DVDI) for communicating with a graphics device. The SVDI is a library of basic graphic commands designed to support higher level graphic packages such as PLT_LIB (see Chapter 10). The DVDI is an extension of the SVDI and permits communication with one or two graphics devices (either a terminal device and/or a hardcopy device) in one plotting session. The routines within SVDI are described in the following three sections. The use of DVDI is described in Section 11.4.

11.1 Sandia Virtual Device Interface Library

11.1.1 Sponsorship and Version

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<i>Sponsor:</i>	H. J. Iuzzolino
<i>Version / Date:</i>	C-1.00VV/February 1991
<i>Language:</i>	FORTRAN 77

11.1.2 Overview of SVDI

The SVDI (Erikson and Simons, 1982) is a library of graphics primitives designed to support graphics packages at Sandia National Laboratories. SVDI consists of a library file of 30 routines for each of 9 terminal devices and 7 file devices. Library files are selected at run time for a terminal device or for a hardcopy device based on global DCL symbols VDI_TERM and VDI_FILE. (Both a terminal device and a hardcopy device can be selected using DVDI_LIB, as described in Section 11.4.)

SVDI provides the base graphics library for the PLT_LIB and HJIPILOT_LIB libraries. The PLT_LIB library provides substitute calls for all SVDI routines, and PLT_LIB users are encouraged to use the PLT_LIB versions instead of the SVDI routines. HJIPILOT_LIB users may use the SVDI routines directly, except VDINIT, since there are no substitutes in HJIPILOT_LIB. If any HJIPILOT_LIB routines are used, the user must call HPLINITPLOT or HPLINITPLT to initialize the plotting. If only SVDI routines are used, the SVDI subroutine, VDINIT, may be used to initialize the plotting.

11.1.3 Summary of Routines

The SVDI routines are described in detail in Section 11.3. The following is a summary of the SVDI routines.

- VBERRH - error handling
- VDAABU - awaits any button
- VDABGL - awaits a button, then gets the keyboard locator
- VDAKGL - awaits a keyboard key, then gets the keyboard locator
- VDALOC - returns the keyboard locator
- VDBELL - rings the bell
- VDBUFL - flushes the buffer
- VDESCP - sets the escape code
- VDFRAM - draws header or trailer frame
- VDINIT - initializes SVDI
- VDIQCO - makes color table inquiry
- VDIQCP - makes current position inquiry
- VDIQDC - makes device capabilities inquiry
- VDIQES - makes escape inquiry
- VDIQND - makes NDC limits inquiry
- VDIQOS - makes output status inquiry
- VDLINA - draws a line
- VDLOGE - logs an error
- VDMOVA - moves the cursor
- VDNWPG - goes to new page
- VDPNTA - draws a point
- VDPOLY - draws a filled polygon
- VDSTBC - sets the background color
- VDSTCO - sets the color table
- VDSTCS - sets the character size
- VDSTFC - sets the foreground color
- VDSTFN - sets the hardware character font
- VDSTIN - sets the intensity
- VDSTLA - sets the initial locator position
- VDSTLS - sets the line style
- VDSTLW - sets the line width
- VDSTOS - sets the output status
- VDSTSA - sets the character string angle
- VDTERM - terminates SVDI
- VDTEXT - draws text
- VDWAIT - waits for the user

11.2 Escape Codes for SVDI-Supported Devices

An escape code provides access to device-dependent functions not directly supported by SVDI. Escape codes are accessed from within a FORTRAN routine by CALL VDESCP (ICODE, N, ARGS), where ICODE is an integer escape code, N is the number of arguments in ARGS ($N \geq 0$), and ARGS is a real array containing the arguments. The devices currently supported are shown in Table 11-1. Contact the SVDI sponsor to add or delete devices. Table 11-2 shows the escape codes for CAMCON SVDI-supported devices. Additional escape codes for DVDI are listed in Section 11.4.

Table 11-1. Currently Supported Devices in SVDI

3 Digit Code	Description
Terminal Device Codes:	
T05	Tektronix 4105
T07	Tektronix 4107
V34	Digital VT340
V41	Digital VT241
Hardcopy Device Codes:	
H75	HP 7580
PST	Postscript Level II

Table 11-2. Escape Codes for CAMCON SVDI-Supported Devices
Syntax: CALL VDESCP (ICODE, N, ARGS)

ICODE	N	ARGS	Meaning
Device code = H75:			
1400	2	XINCH, YINCH	Size of paper in inches. Must be called before VDINIT. X = side moved by roller drum, Y = side moved by pen.
1401	3	XNDC, YNDC,	Draw an arc of specified degrees and tolerance centered at XNDC, YNDC, using the current pen status.
	4	ANGLE TOLER	
1402	1	IRAD	Circle instruction. IRAD = radius in plotter units if scaling is not in effect; otherwise use user units. TOLER = chord tolerance in degrees or deviation distance.
	2	TOLER	
1403	1	IFONT	Designate alternate character set. IFONT=0 through 5 for fixed-font set and 10 through 15 for variable-font set. Default = 0.
1404	1	ANGLE	Character chord angle instruction. ANGLE = angle in degrees, values > 45 are set to 45.

Table 11-2. Escape Codes for CAMCON SVDI-Supported Devices
Syntax: CALL VDESCP (ICODE, N, AR6S) (Continued)

ICODE	N	ARGS	Meaning
Device code = H75 (continued):			
1405	1	IFONT	Designate standard character set. IFONT = 0 through 5 for fixed-font set and 10 through 15 for variable-font set. Default = 0.
1406	1 2	WIDTH HEIGHT	Extra space instruction. WIDTH = spaces (positive or negative) between characters. HEIGHT = spaces (positive or negative) between lines.
1407	0		Select alternate character set.
1408	1	TANANG	Character slant instruction. TANANG = tangent of the angle with the vertical.
1409	0		Select standard character set.
1410	1 2	IPENAC IPEN	Acceleration select instruction. IPENAC = pen acceleration, 1 to 4. IPEN = pen 1 through 8 to which acceleration applies. Default = all pens.
1411	1 2	IPENFC IPEN	Force select instruction. IPENFC = pen force, 1 to 8, where force = $10 + 8 \times (\text{IPENFC} - 1)$ grams. IPEN = pen 1 through 8 to which force applies. Default = all pens.
1412	1 2	IVELOC IPEN	Velocity select instruction. IVELOC = pen velocity, 1 to 60 cm/sec. IPEN = pen 1 through 8 to which velocity applies. Default = all pens.
1413	1 2	TP TN	Tic length instruction. TP = percentage of p2y-p1y above the x-axis or percentage of p2x-p1x to the right of the y-axis. TN = percentage of p2y-p1y below the x-axis or percentage of p2x-p1x to the left of the y-axis
1414	0		X tic instruction.
1415	0		Y tic instruction.

Table 11-2. Escape Codes for CAMCON SVDI-Supported Devices
Syntax: CALL VDESCP (ICODE, N, AR6S) (Concluded)

ICODE	N	ARGS	Meaning
Device code = H75 (continued):			
1416	1	N	Automatic pen pickup instruction. $N \leq 32768$. Only the 3 least significant bits are used. Bit 0 = 1: pen lift after 65 seconds Bit 1 = 1: pen storage after 65 seconds Bit 2 = 1: delay retrieval Default = 7 (all three bits set)
1417	1	N	Chord tolerance units instruction. Determines how to interpret chord tolerance for circle and arc commands. $N = 0$ for degree units, $N = 1$ for deviation units.
1418	0		Reset instruction. Sets plotter to defaults.
1419	0 2 4	P1X, P1Y P2X, P2Y	Input P1 and P2 instruction. Set scaling points. Omitting all sets P2X and P2Y 15 mm inside hard clip limits. Omitting last two causes P2 to move the same distance as P1.
1420	4	X1, X2, X3, X4	Input window instruction. Specifies X and Y coordinates of opposite corners of the window. Values are in NDC units.
1421	1	IROTAT	Rotate coordinate system. IROTAT = 0 turns off rotation. IROTAT = 90 rotates coordinate system 90 degrees about the plotter origin.
1422	4	XMIN, XMAX, YMIN, YMAX	Scale instruction. Scales plotting areas to user units.

Device code = T05:

100	0		Produce hardcopy of what is now on the screen and wait until complete.
-----	---	--	--

Also uses T14 codes 1020-1025, 1030-1032, and 1505.

11.3 Description of Routine Calls

Detailed descriptions of the SVDI routines are given on the following pages.

VBERRH
Subroutine

Name	VBERRH - Error handling					
Description	VBERRH logs an error and continues or quits according to the severity of the error. VBERRH calls VDLOGE to report the error before deciding whether or not to terminate.					
Syntax	CALL VBERRH (ERRNUM, ERRSEV)					
Variables in Call	Name	I/O	Type	Description		
	ERRNUM	Input	integer	Error number:		
				Value	Severity	Meaning
				208	5	text contains an undefined character
				211	6	text string out of bounds
				212	5	text string length < 1
				213	5	text string length > 132
				401	5	invalid attribute value
				720	5	invalid justification sent to VDINIT
				721	5	invalid aspect sent to VDINIT
				723	5	invalid number of color table indexes
				724	5	invalid color table index
				725	5	invalid color model
				726	5	invalid device capability index
				727	5	invalid color table entry
				802	5	incorrect parameter count
				901	13	job security level code is undefined
				957	13	attempt to run a classified job using unclassified SVDI
	ERRSEV	Input	integer	Error severity value:		
				5		invalid parameter value
				6		invalid SVDI state
				10		operating system detected error
				11		security error - program may continue
				12		security error - may be fatal
				13		security error - fatal

VDAABU
Subroutine

Name	VDAABU - Wait for a graphics device button			
Description	VDAABU awaits any graphics device button and returns the number of the button. The button number is in the range 1 to a device-dependent maximum which is at least 8. VDAABU flushes the output buffer before doing input.			
Syntax	CALL VDAABU (BTNNUM)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	BTNNUM	Output	integer	Number of the button pressed.

VDABGL
Subroutine

Name	VDABGL - Wait for a graphics device button and get the keyboard locator			
Description	VDABGL waits until a graphics device button is pressed, then returns the button number and the coordinates of the keyboard locator (cross hairs, cursor, etc.). The locator should be positioned (e.g., by using the arrow keys), then the button should be pressed. VDABGL flushes the output buffer before doing input.			
Syntax	CALL VDABGL (BTNNUM, X, Y)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	BTNNUM	Output	integer	Number of the button pressed.
	X	Output	real	X-coordinate (NDC) of the locator.
	Y	Output	real	Y-coordinate (NDC) of the locator.

VDAKGL
Subroutine

Name	VDAKGL - Wait for a keyboard key, then return the keyboard locator			
Description	VDAKGL waits until a keyboard key is pressed, then returns the character and the coordinates of the keyboard locator (cross hairs, cursor, etc.). The locator should be positioned (e.g., by using arrow keys), then a key should be pressed. If the ASCII value of the key is outside the range 32-126, a blank (32) is returned. VDAKGL flushes the output buffer before doing input.			
Syntax	CALL VDAKGL (CHAR, X, Y)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	CHAR	Output	integer	ASCII value of the key pressed, right-justified and zero-filled.
	X	Output	real	X-coordinate (NDC) of the locator.
	Y	Output	real	Y-coordinate (NDC) of the locator.

VDALOC
Subroutine

Name	VDALOC - Return the coordinates of the keyboard locator			
Description	VDALOC returns the coordinates of the keyboard locator (cross hairs, cursor, etc.). The locator should be positioned (e.g., by using arrow keys), then any key other than the return key should be pressed. VDALOC flushes the output buffer before doing input.			
Syntax	CALL VDALOC (X, Y)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Output	real	X-coordinate (NDC) of the locator.
	Y	Output	real	Y-coordinate (NDC) of the locator.

VDBELL
Subroutine

Name	VDBELL - Rings the bell
Description	VDBELL rings the device bell to get the user's attention. This function is ignored by batch devices.
Syntax	CALL VDBELL

VDBUFL
Subroutine

Name	VDBUFL - Flush buffers
Description	VDBUFL assures that the picture is up-to-date by flushing buffers if necessary. It also prepares the device to operate in alphanumeric (as opposed to graphics) mode. This is necessary on some devices so that alphanumeric data from FORTRAN I/O will not be misinterpreted as graphic data.
Syntax	CALL VDBUFL

VDESCP
Subroutine

Name	VDESCP - Set the escape code			
Description	VDESCP invokes the nonstandard, device-dependent function ESCPCD. The input variable N is the number of arguments used by this function and ARGS is the real array containing these arguments. ARGS may also be text strings when necessary. Unsupported values of ESCPCD are ignored, not causing an error.			
Syntax	CALL VDESCP (ESPCD, N, ARGS)			
Variables in Call	<i>Name</i>	<i>I / O</i>	<i>Type</i>	<i>Description</i>
	ESPCD	Input	integer	Escape function code.
	N	Input	integer	Number of arguments in ARGS. Range: $N \geq 0$.
	ARGS	Input	real array	Arguments for this escape function.
Note	See Table 10.1 for a description of escape codes.			

VDFRAM
Subroutine

Name	VDFRAM - Draw a header or trailer frame			
Description	VDFRAM draws either a header or trailer frame. It gets job information from the operating system from the computer-dependent routine CDRJOB and writes it on an identification frame.			
Syntax	CALL VDFRAM (ITYPE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ITYPE	Input	integer	Code for either header or trailer frame. ITYPE = 0 for header frame ITYPE = 1 for trailer frame

VDINIT
Subroutine

Name	VDINIT - Initialize SVDI			
Description	VDINIT initializes SVDI. If only SVDI routines are used, this must be the first SVDI call (except for calls to VDESCP). The color table, all attribute values, and the current position are set to the appropriate defaults for the device. All necessary input device initialization is done. The screen is cleared or paper advanced if necessary to guarantee a blank view surface for drawing.			
Syntax	CALL VDINIT (ASPECT, JUSTIF)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ASPECT	Input	real	Specifies the ratio of the x-dimension to the y-dimension. Range: ASPECT > 0.0 Default: 0.0 (device dependent)
	JUSTIF	Input	integer	Justification of NDC space on the device. Range: 0 ≤ JUSTIF ≤ 9 Default: 0 (device dependent)
Comments	<p>The input variable ASPECT specifies the ratio of the x-dimension to the y-dimension. Maximum NDC values (at least one of which will be 1.0) are computed to give the ASPECT specified. The default ASPECT (0.0) is device-dependent and is equal to the aspect ratio of the physical device, except for variable aspect devices (such as drum plotters) which are assigned a default aspect of 1.0. The NDC rectangle is scaled until one dimension fills the corresponding dimension of the device.</p> <p>The input variable JUSTIF determines where the rectangle is located on the device as shown below:</p> <div style="text-align: center;"> <p>7 8 9 4 5 6 1 2 3</p> </div> <p>For example, JUSTIF = 7 indicates that the NDC space will be upper-left justified on the device.</p>			

VDIQCO
Subroutine

Name	VDIQCO - Color table inquiry			
Description	VDIQCO returns one or more of the color table entries. The input variables NUM and INDEX specify how many and which indexes are being requested. The input variable CLRMOD specifies which color model (0=RGB, 1=HLS) should be used in constructing values to return in the output array CLRARY. A device that does not support a specified color table index will return -1.0 in the first element of the CLRARY value for that index.			
Syntax	CALL VDIQCO (NUM, INDEX, CLRARY, CLRMOD)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NUM	Input	integer	Number of color indexes to be set. Range: 1-256
	INDEX	Input	integer array	Array of indexes to be set. Range: 0-255
	CLRARY	Output	real array	Array of 3 by NUM elements specifying the values of the components of the index to be set. Range for RGB: red 0.0-1.0 green 0.0-1.0 blue 0.0-1.0 Range for HLS: hue 0.0-360.0 lightness 0.0-1.0 saturation 0.0-1.0
	CLRMOD	Input	integer	Color model being used: 0 for RGB, 1 for HLS.

VDIQCP
Subroutine

Name VDIQCP - Inquire about current position

Description VDIQCP asks where the current position is.

Syntax CALL VDIQCP (X, Y)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Output	real	X-coordinate (NDC) of current position.
	Y	Output	real	Y-coordinate (NDC) of current position.

VDIQDC
Subroutine

Name	VDIQDC - Inquire about device capabilities			
Description	VDIQDC returns values indicating various device capabilities.			
Syntax	CALL VDIQDC (INDEX, VALUE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INDEX	Input	integer	Index of device capability.
	VALUE	Output	real	Capability value.
Parameter Values	Index	Capability	Value	Description
	1	Erasability	0. 1. 2. 3. 4. 5.	None (hard copy) Screen (Tektronix 4010) Point or line SLOW (plasma) Point or line MEDIUM (Refresh Serial connected) Point or line FAST (Refresh Direct connected) Screen and some point or line MEDIUM (Tektronix 4014 with write-through mode)
	2	Scan Type	0. 1. 2.	Vector Raster Matrix (plasma)
	3	# Intensities	1-N	The number of colors that can be displayed at one time and may be less than the total number of colors the device can produce.
	4	# Colors	1-N	
	5	# Line Widths	1-N	A bit pattern indicating which of the 5 nonsolid line styles are supported in the device. Bits 4,3,2,1, and 0 correspond to line styles medium dash, long dash, short dash, dot dash, and dot. (0 - device has no hardware line styles - simulate.)
	6	Line Styles	0-N	
	7	Character Size	0-N	(0 - device has no hardware - simulate.)

Parameter Values (continued)	Index	Capability	Value	Description
	8	# Locator Devices		
	9	# Valuator Devices		
	10	# Button Devices		
	11	# Keyboard Devices		
	12	# Stroke Devices		
	13	Input	0.	None
			1.	Synchronous only - program requests input, then the user supplies it
			2.	Synchronous and asynchronous; synchronous is the same as above; asynchronous means the user can provide input at any time; this input is then saved by the system in an event queue until the program calls for it
	14	Input timing	0.	No timeout supported
			1.	Unreliable timing
			2.	Timeout with reliable timing
	15	X-dimension of view surface in device coordinates		
	16	Y-dimension of view surface in device coordinates		
	17	X-dimension of view surface in physical units (mm) (0 if undefined); if this dimension is variable (as for drum plotters), it should be set equal to the y-dimension to guarantee a device aspect ratio of 1.0		
	18	Y-dimension of view surface in physical units (mm) (0 if undefined)		
	19	Smallest line width in device coordinates at default intensity		
	20	Smallest point in device coordinates at default intensity		
	21	Smallest character size in device coordinates		
	22	Header and trailer frames required (0=no, 1=yes)		
	23	Device identifier	1.0	TK4 - Tektronix 4014
			1.1	TK6 - Tektronix 4016
			1.2	TEK - Tektronix 4010, 4012
			1.3	TP2 - Tektronix 4662
			1.4	TP8 - Tektronix 4662 with 8 pen option
			1.5	T14 - Tektronix 4114
			1.6	T13 - Tektronix 4113
			1.7	T05 - Tektronix 4105
			1.8	T07 - Tektronix 4107
			1.9	T15 - Tektronix 4115
			4.0	T27 - Tektronix 4027
			4.1	T25 - Tektronix 4025
			5.0	ALP - Alphanumeric Terminal

VDIQDC
Subroutine

Parameter Values (continued)	Index	Capability	Value	Description
	23	Device identifier (continued)		
			8.0	TST - Test Driver, Print VDI calls made
			9.0	V25 - Digital VT125
			9.1	V40 - Digital VT240
			9.2	V41 - Digital VT241
			9.3	V34 - Digital VT340
			11.0	MET - SVDI Metafile
			12.1	H75 - HP 7580
			12.3	H74 - HP 7475A
			12.4	H50 - HP 7550
			21.0	QMS - QMS LASER PRINTER
			21.1	QMS - QMS LASERGRAFIX - raster version
			25.	T45 - Tektronix 4510 Rasterizer
			27.	I10 - Imagen I10 laser printer
			27.1	I30 - Imagen I30 laser printer
			27.2	I30 - Imagen I30 - RASTER version
			28.	BTK - Batch Tektronix Driver
			29.	LN3 - DEC LN03 PLUS Laser printer
	24	Polygon support level		
			0.	no support
			1.	fills convex polygons
			2.	fills simple polygons (may be concave but not self-crossing)
			3.	full complex polygon fill support
	25	Maximum number of points in a polygon (99999. if infinite)		
	26	Setable color table		
			0.	no
			1.	yes
	27	Device color palette size (1-N) - the number of different colors a device can produce (may be more than the device can display simultaneously)		
	28	Direct color space size (0-N) - the number of colors available via direct RGB color specification (displayable simultaneously)		
	29	Vector versus raster VDI		
			0.	SVDI
			1.	SVDI + Raster
	30	Maximum character height (DC)		
	31	Maximum line width (DC)		
	32	Color versus monochrome (grayscale) device		
			0.	monochrome
			1.	color
	33	Device pixel aspect - the ratio of the spacing of device pixels in x divided by the spacing in y (1 for square pixels)		
	34	Device x-margin in device coordinates		
	35	Device y-margin in device coordinates		

VDIQES
Subroutine

Name	VDIQES -Escape inquiry			
Description	VDIQES returns an integer value indicating the level of support for an escape sequence.			
Syntax	CALL VDIQES (ESCPCD, SUPPRT)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ESCPCD	Input	integer	Escape function code.
	SUPPRT	Output	integer	Level of support for the escape sequence specified
				Range: 0, 1, 2 2 = hardware supported 1 = software supported 0 = unsupported

VDIQND
Subroutine

Name	VDIQND - Inquire about NDC limits			
Description	VDIQND returns the maximum NDC values as set to realize the aspect defined by VDINIT.			
Syntax	CALL VDIQCP (XNDC, YNDC)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XNDC	Output	real	Maximum valid NDC value.
	YNDC	Output	real	Maximum valid NDC value.

VDIQOS
Subroutine

Name	VDIQOS - Output status inquiry			
Description	VDIQOS gets the graphics attributes status vector.			
Syntax	CALL VDIQOS (VECTOR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	VECTOR	Output	real array	<p>Array of graphics attributes.</p> <p>VECTOR (1) = foreground color number</p> <p>VECTOR (2) = background color number</p> <p>VECTOR (3) = line intensity</p> <p>VECTOR (4) = line style</p> <p>VECTOR (5) = line width</p> <p>VECTOR (6) = character box y</p> <p>The following attribute array values are implemented only for some applications:</p> <p>VECTOR (7) = character box x</p> <p>VECTOR (8) = foreground color R value</p> <p>VECTOR (9) = foreground color G value</p> <p>VECTOR (10) = foreground color B value</p> <p>VECTOR (11) = background color R value</p> <p>VECTOR (12) = background color G value</p> <p>VECTOR (13) = background color B value</p>

VDLINA
Subroutine

Name	VDLINA - Draw a line			
Description	VDLINA draws a line from the current cursor position to the specified normalized device coordinates.			
Syntax	CALL VDLINA (X, Y)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real	X-coordinate (NDC).
	Y	Input	real	Y-coordinate (NDC).

VDLOGE
Subroutine

Name VDLOGE - Log an error

Description VDLOGE logs an error and continues or quits according to severity.

Syntax CALL VDLOGE (ERRNUM, ERRSEV)

Variables in Call

<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
ERRNUM	Input	integer	Error number.
ERRSEV	input	integer	Error severity value.

Parameter Values

ERRNUM	Value	Severity	Meaning
	208	5	The text contains an undefined character
	211	6	Text string out of bounds
	212	5	Text string length less than 1
	213	5	Text string length exceeds 132
	401	5	Invalid attribute value
	720	5	Invalid justification sent to VDINIT
	721	5	Invalid aspect sent to VDINIT
	723	5	Invalid number of color table indexes
	724	5	Invalid color table index
	725	5	Invalid color model
	726	5	Invalid device capability index
	727	5	Invalid color table entry
	802	5	Incorrect parameter count
	901	13	Job security level code is undefined
	957	13	Attempt to run a classified job using unclassified SVDI

ERRSEV	Value	Meaning
	5	Invalid parameter value
	6	Invalid SVDI state
	10	Operating system detected error
	11	Security error - program may continue
	12	Security error - may be fatal
	13	Security error - fatal

VDMOVA
Subroutine

Name	VDMOVA -Move the cursor			
Description	VDMOVA moves the current position to the specified normalized device coordinates. Nothing is drawn.			
Syntax	CALL VDMOVA (X, Y)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real	X-coordinate (NDC).
	Y	Input	real	Y-coordinate (NDC).

VDNWPG
Subroutine

Name	VDNWPG - Advance to a new page
Description	VDNWPG physically advances the medium or clears the screen, whichever is appropriate. It also floods the screen with the background color on devices that support this function. The current position is not changed.
Syntax	CALL VDNWPG

VDPNTA
Subroutine

Name VDPNTA - Draw a point

Description VDPNTA draws a point at the specified normalized device coordinates.

Syntax CALL VDPNTA (X, Y)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	X	Input	real	X-coordinate (NDC).
	Y	Input	real	Y-coordinate (NDC).

VDPOLY
Subroutine

Name	VDPOLY - Draw a filled polygon			
Description	VDPOLY draws a polygon. On devices that support polygon fill, the polygon will be filled with the current foreground color. VDI will close the polygon if the first and last points are not the same. NPTS may not exceed 508.			
Syntax	CALL VDPOLY (XARRAY, YARRAY, NPTS)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XARRAY	Input	real array	X-coordinate (NDC) array.
	YARRAY	Input	real array	Y-coordinate (NDC) array.
	NPTS	Input	integer	Number of points in (XARRAY, YARRAY)

VDSTBC *Subroutine*

Name	VDSTBC - Set the background color			
Description	VDSTBC sets the background color index. The range of allowable values is 0-255, but most devices support fewer colors. The default background color index is device-dependent. All devices support at least a single device-dependent value in the range 0-7. If an unsupported value is specified, it is set to the default for the device.			
Syntax	CALL VDSTBC (INDEX)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INDEX	Input	integer	Background color index.

VDSTCO
Subroutine

Name VDSTCO - Set color table

Description VDSTCO sets one or more color table entries. This is a dynamic setting if the device will support it, meaning that primitives that have already been drawn will change their appearance when the setting is changed. The input variable INDEX is the position (or array of positions) in the table. The input variable CLRARY is a three-element vector (or 3-by-NUM array) with the fractions of RGB or values of HLS. (The GSPC79 translator for HLS to RGB is used.) The input variable CLRMOD specifies the color model (0=RGB, 1=HLS). All devices support at least a single device-dependent value for each of red, green, and blue, and the corresponding values for hue, lightness, and saturation. If unsupported values are specified, they are set to the closest supported values. All devices support at least a single device-dependent INDEX value in the range 0-7. If an unsupported value is specified, it is ignored.

Syntax CALL VDSTCO (NUM, INDEX, CLRARY, CLRMOD)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NUM	Input	integer	Number of color indexes to be set. Range: 1-256
	INDEX	Input	integer array	Array of indexes to be set. Range: 0-255
	CLRARY	Output	real array	Array of 3-by-NUM elements specifying the values of the index components to be set. Range for RGB: red 0.0-1.0 green 0.0-1.0 blue 0.0-1.0 Range for HLS: hue 0.0-360.0 lightness 0.0-1.0 saturation 0.0-1.0 Default: INDEX Color RGB Values 0 Black 0.,0.,0. 1 Red 1.,0.,0. 2 Green 0.,1.,0. 3 Yellow 1.,1.,0. 4 Blue 0.,0.,1. 5 Magenta 1.,0.,1. 6 Cyan 0.,1.,1. 7 White 1.,1.,1.
	CLRMOD	Input	integer	Color model being used: 0 for RGB, 1 for HLS. Default: 0 (RGB)

VDSTCS
Subroutine

Name	VDSTCS - Set character size			
Description	VDSTCS sets the y-dimension (in NDC) of the character box. Values are in the range 0. to 1. The default is usually the smallest hardware character size. The x-dimension is assigned based on the font for the device. All devices support at least a single device-dependent value. If an unsupported value is specified, it is set to the largest supported value that does not exceed the specified size.			
Syntax	CALL VDSTCS (YSIZE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	YSIZE	Input	real	Character box y-value.

VDSTFC
Subroutine

Name	VDSTFC - Set foreground color			
Description	VDSTFC sets the foreground color index. The range of allowable values is 0-255, but most devices support fewer colors. All devices support at least a single device-dependent value in the range 0-7. If an unsupported value is specified, it is set to the default for the device. The default foreground color index is device-dependent.			
Syntax	CALL VDSTFC (INDEX)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INDEX	Input	integer	Foreground color index.

VDSTFN
Subroutine

Name VDSTFN - Set hardware character font

Description VDSTFN selects a hardware font for plotting text strings. Most devices do not offer a choice of hardware character fonts. If an unsupported value is specified, Helvetica will be used if available; otherwise the default font for the graphics device will be used. This routine is a recent (1993) addition to the original (1981) SVDI package and is available only with the CAMCON library version.

Syntax CALL VDSTFN (NFONT)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	NFONT	Input	integer	Two-digit integer that designates the desired font and style. The tens digit selects the typeface and the units digit selects the style:
	Typeface	Value	Style	Value
	Courier	10	Normal (Roman)	0
	Helvetica	20	Bold	1
	Times	30	Italic	2
	Symbol	40	Bold italic	3
			Extended	4
			Condensed	5

VDSTIN
Subroutine

Name	VDSTIN - Set intensity			
Description	VDSTIN sets the intensity value for future primitives. Intensity is a real value between 0 (not visible) and 1 (maximum). Intensities are monotonically increasing within this range. All devices support at least a single value: 1.0. If an unsupported value is specified, it is set to the closest supported value.			
Syntax	CALL VDSTIN (INTEN)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	INTEN	Input	real	Intensity value.

VDSTLA
Subroutine

Name	VDSTLA - Set initial locator position			
Description	VDSTLA sets the position of the keyboard locator (cross hairs, cursor, etc.).			
Syntax	CALL VDSTLA (XLOC, YLOC)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	XLOC	Input	real	X-coordinate (NDC) of the locator.
	YLOC	Input	real	Y-coordinate (NDC) of the locator.

VDSTLS
Subroutine

Name	VDSTLS - Set line style			
Description	VDSTLS sets the line style value for future line drawing primitives. All devices support at least the values 0 and 5. If an unsupported value is specified, it is set to 5.			
Syntax	CALL VDSTLS (LINSTY)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	LINSTY	Input	integer	Line style value: 0 = solid 1 = dotted 2 = dot dash 3 = short dash 4 = long dash 5 = medium dash

VDSTLW
Subroutine

Name	VDSTLW - Set line width			
Description	VDSTLW sets the line width value for future line-drawing primitives. Values are in the range 0. to 1., with 1. being 0.01 NDC. All devices support at least a single device-dependent value. The default line width is device-dependent. If an unsupported value is specified, it is set to the closest supported value.			
Syntax	CALL VDSTLW (LINWID)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	LINWID	Input	real	Line width value (in 0.01 NDC).

VDSTOS
Subroutine

Name	VDSTOS - Set output status			
Description	VDSTOS sets graphics attributes.			
Syntax	CALL VDSTOS (ATTARR)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ATTARR	Input	real array	<p>Array of graphics attributes: ATTARR (1) = foreground color ATTARR (2) = background color ATTARR (3) = line intensity ATTARR (4) = line style ATTARR (5) = line width ATTARR (6) = character box y</p> <p>The following attribute array values may be implemented for some applications: ATTARR (7) = character box x ATTARR (8) = foreground color R value ATTARR (9) = foreground color G value ATTARR (10) = foreground color B value ATTARR (11) = background color R value ATTARR (12) = background color G value ATTARR (13) = background color B value</p>

VDSTSA
Subroutine

Name	VDSTSA - Set character string angle			
Description	VDSTSA sets the angle for plotting text strings using hardware characters. This routine is a recent (1993) addition to the original (1981) SVDI package and is available only with the CAMCON library version.			
Syntax	CALL VDSTSA (ANGLE)			
Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	ANGLE	Input	real	String angle measured in degrees counter-clockwise from the right horizontal.

C-1.00VV/February 1991

VDTEXT
Subroutine

Name VDTEXT - Draw text

Description VDTEXT draws text from an array of characters.

Syntax CALL VDTEXT (LENGTH, CHARS)

Variables in Call	<i>Name</i>	<i>I/O</i>	<i>Type</i>	<i>Description</i>
	LENGTH	Input	integer	Number of characters in array CHARS.
	CHARS	Input	integer array	Array of integer values of ASCII characters, right justified, one character per word.

VDWAIT
Subroutine

Name	VDWAIT - Wait for user
Description	VDWAIT waits for the user to view the screen. The wait is ended by a signal from the user, such as pressing any key. This function flushes the output buffers before doing input.
Syntax	CALL VDWAIT

11.4 Dual Device Interface Extension

11.4.1 Sponsorship and Version

Author: D. P. Flanagan
Sponsor: A. P. Gilkey
Version / Date: C-1.00VV/February 1991
Language: DCL

11.4.2 Overview of DVI

Major plot codes in the CAMCON system use the DVI extension to SVDI. The primary purpose of the DVI extension (although it is not limited to this purpose) is to allow a program to plot to an interactive terminal device and store all or selected plots in a graphics file for later printing on the appropriate hardcopy device. The graphics file created is not an exact copy of the terminal screen but rather a device-dependent copy that permits the plot image to be reproduced to the full capabilities of the hardcopy device; furthermore, the "device" may be either a specific piece of hardware (e.g., a brand name printer) or a graphics format (such as PostScript) that is used by a piece of hardware.

To accomplish its primary purpose, DVI groups all devices into two categories: terminal devices and file devices (or "hardcopy"). The application program can choose one device from each category. A *terminal device* can be (but need not be) interactive; i.e., it can generate input as well as output and is usually tended by a user. A *hardcopy device* uses an intermediate graphics file and is never used interactively. Note that the category of a device depends upon the capabilities implemented in the available subroutine device driver, not the full advertised capabilities of the device (Figure 11-1).

Both device categories contain a *null device*, which is simply a set of dummy routines that satisfy calls from DVI, but performs no functions. Hence, DVI can run in a single device mode.

11.4.3 Application Programming Guidelines

DVI Extensions. The extensions provided by the DVI are programmed in three existing SVDI routines: VDESCP, VDIQES, and VDINIT (see Section 11.1, "Sandia Virtual Device Interface Library"). (Additional integer codes for the arguments have been provided to pass back required information, as described below.) This method of implementation means that DVI is transparent to single-device graphics applications. Furthermore, programs that make use of dual devices should function (in single device mode) on systems where DVI has not been installed.

It is important, however, for the application programmer to remember that the two devices do not communicate with each other. Consequently, if a device is made inactive, its state (cursor position, line style, color, etc.) may not be current with the active device. Therefore, when a device is reactivated, the application program must bring the reactivated device "up to date."

TRI-6342-2160-0

Figure 11-1. Communication with graphic devices is accomplished through the Dual Virtual Device Interface (DVDI).

Initialization by VDINIT. The modified SVDI routine, VDINIT, will determine whether either device is null, in which case that device is set to inactive (Off) for the duration of the program's execution, regardless of any calls to VDESCP. The VDINIT will initialize a currently active device only. Therefore, it is possible to initialize each device independently.

Communication Codes for VDESCP. An application program controls the status of the terminal and hardcopy devices by calling VDESCP with the codes shown below (Table 11-3): Note that each call to VDESCP sets the status of both devices. Each device is initially active (On).

Table 11-3. Communication Codes for the SVDI Routine, VDESCP
Syntax: CALL VDESCP (ICODE, 0, 0)

ICODE	Terminal	Hardcopy
10000	Off	Off
10001	On	Off
10002	Off	On
10003	On	On

Communication Codes for VDIQES. The application program can inquire as to the availability of DVID, the terminal device, and the hardcopy device through VDIQES (Table 11-4). The routine returns the appropriate status in the argument ISTAT; a value of 1 indicates *available* while a value of 0 indicates *not available*. The meaning of the status returned by VDIQES for each DVID escape code is given in Table 11-4. Note that these values reflect whether a device is available (i.e., not null) rather than the device's current state (i.e., On or Off).

Table 11-4. Communication Codes for the SVDI Routine, VDIQES
Syntax: CALL VDIQES (ICODE, ISTAT)

ICODE	Returns ISTAT = 1 if and only if
10000	DVID implemented
10001	Terminal device available
10002	Hardcopy device available
10003	Terminal <i>and</i> hardcopy device available

Input and Output. Duplex output through DVID is straightforward: a call is made to the terminal device, if it is active, then a duplicate call is made to the hardcopy device, if it is active.

Input through DVID is more subtle. DVID merges input, including responses from inquiry functions, by calling the terminal device *first*. In other words, the terminal device has priority on input and is often called the "primary" device. It is possible to read or inquire from the hardcopy device only while the terminal device is inactive. Thus, the second device is often called the "secondary" device.

11.4.4 Linking

Most plot applications should be linked to shareable graphics libraries like PLT_LIB. These shareable images are already linked to the switchable dual device sets. Therefore, it should be rare that a programmer would need to link directly to the dual device drivers.

When linking to DVDI, it is critical that both devices be selected to be null. Once this is done, an application is linked to the shareable DVDI graphics system simply by referencing the shareable graphics library. The following example links to the shareable PLT graphics library:

```
$ SELECT NULL
$ LINK code_name, ..., SHRPLT/LIB, CDRLIB/LIB/INCL=CDRABC
```

11.4.5 Device Selection and Execution

The dual graphics devices are selected at image activation, i.e., just prior to each execution. The DCL procedure, `SELECT`, controls device selection. It presents the user with a list or lists of appropriate devices, displays the default device selection(s), and prompts the user to make a selection. If the user simply hits the RETURN key, the default device selection will be retained. If the user enters "" (two double quotes), the null device will be selected (see also Rechard, 1992, Appendix D).

The default devices are those devices specified in the last graphics program executed. The experienced user who typically plots to only one terminal type or hardcopy device may define the default for the devices by setting global symbols `VDI_TERM` (for the terminal) and/or `VDI_FILE` (for the hardcopy device) in his or her login file. For example:

```
$ VDI_TERM == "V34"      !Set default graphics terminal
$ VDI_FILE == "PST"      !Set default hardcopy device
```

If the procedure executes successfully, it will set the logical name switches `SHRVDT` and `SHRVDF` to point to the appropriate terminal and hardcopy device images, respectively. Furthermore, the symbols `VDI_TERM` and `VDI_FILE` will contain the device IDs of the selections made.

When the user requests a plot to the graphics terminal, the plot appears immediately on the terminal. Requesting a plot to the hardcopy device, on the other hand, results in the creation of a file containing the commands necessary for the hardcopy device to produce the plot. The device-dependent graphics file can be sent to the hardcopy device by using a `PRINT` command after the program has finished executing.

The default name of the graphics file is `FOR077.DAT`. It is suggested that the applications program or DCL file running the program rename the file to a more meaningful name. Most programs should use *code_name.device_code* (e.g., `BLOT.PST`).

Since device selection takes place before the application program is run, the program is conveniently run from a DCL file. The example of a DCL file shown below calls `SELECT` to select the devices, runs the given executable code, and renames the hardcopy file, if any. Note that it also assigns the codes of the selected devices to special symbols so they can be retrieved within the application program with the

CAMSUPES_LIB routine EXNAME (see Chapter 9). The application program would retrieve these symbols as follows:

```

:
CALL EXNAME (-1, TRM COD, IDUM)
CALL EXNAME (-2, HRDCOD, IDUM)
:

```

The following DCL fragment (with some added features) for running a generic application program is available in CAMCON\$ROOT:[CAMCON.LIBRARIES.DVDI_LIB]DVDI_DRIVER.COM.

```

$!      *** Command file to run Generic Graphics Code ***
$!
$! Parameters:
$!   P1 = the name of the code executable
$!   P2 = the device code of the primary graphics device
$!   P3 = the device code of the secondary graphics device
$!   P4...P8 = the program command line parameters
$!
$! P2 and P3 are used by the SELECT procedure, which handles the defaults
$! and requests for user input. Assignments are made as described in the
$! table below. The program named by P1 is then run.
$!
$! Assignments:
$!   EXT01      Graphics terminal      'P2' or ""
$!   EXT02      Graphics hardcopy device  'P3' or ""
$!   FOR077     Hardcopy file           'P3' or program.dev
$!   SYS$INPUT  Unused                 SYS$COMMAND
$!
$! Assign the parameters to symbols.
$!
$ PROGEXE = P1      !Code executable
$ DEVTERM = P2      !Terminal device code
$ DEVHARD = P3      !Hardcopy device code
$!
$! Check that the code executable exists.
$!
$ IF F$PARSE (PROGEXE, , , "TYPE", "SYNTAX_ONLY") .EQS. "." THEN -
    PROGEXE = F$PARSE (".EXE", PROGEXE, , , "SYNTAX_ONLY")
$!

```

```

$ IF F$SEARCH (PROGEXE) .NES. "" THEN GOTO ENDIF_PROG_OK
$   WRITE SYS$OUTPUT $Code ""'PROGEXE'"" does not exist"
$   GOTO END
$ ENDIF_PROG_OK:
$!
$! Extract the code name from the executable.
$ PROGNAME = F$PARSE (PROGEXE, , , "NAME", "SYNTAX_ONLY"
$!
$! Call SELECT procedure to select the graphics devices.
$!
$ IF (DEVTERM) .EQS. "" .AND. (DEVHARD .EQS. "") THEN WRITE SYS$OUTPUT ""
$ SELECT 'DEVTERM' 'DEVHARD'
$!
$! Assign the device codes to special symbols that the application code can read
$! using the CAMSUPES_LIB routine EXNAME.
$!
$ EXT01 = VDI_TERM
$ EXT02 = VDI_FILE
$!
$! Save the full file name of the existing FOR077.DAT hardcopy file, if any.
$! Assign the file name of the new (renamed) hardcopy file.
$!
$ IF VDI_FILE .EQS. "" THEN GOTO ENDIF_NAME_FILE
$   FUNIT = "FOR077"
$   OLDHARD = F$SEARCH ("'"FUNIT'.DAT")
$   OUTHARD = PROGNAME + "." + VDI_FILE
$ ENDIF_NAME_FILE:
$!
$! Run the graphics code with the command line parameters.
$!
$ RUNIT = "$ '"PROGEXE'"
$ ASSIGN/USER SYS$COMMAND SYS$INPUT
$ RUNIT ""'P4" ""'P5'" ""'P6'" ""'P7'" ""'P8'"
$!
$! Rename the hardcopy file. Delete it if it is empty. Do nothing if no
$! file was created.
$! NOTE: Some drivers cannot assign device FOR077, so rename is done instead.
$!
$ IF VDI_FILE .EQS. "" THEN GOTO ENDIF_RENAME_HARDCOPY
$   NEWHARD = F$SEARCH ("'"FUNIT'.DAT")

```

```

$ IF NEWHARD .EQS. "" THEN GOTO ENDIF_RENAME_HARDCOPY
$! Check that the hardcopy file was not an old hardcopy file.
$ IF NEWHARD .EQS. OLDHARD THEN GOTO ENDIF_RENAME_HARDCOPY
$! Rename the hardcopy file.
$ RENAME 'NEWHARD' 'OUTHARD'
$! A very small file is empty - delete it.
$ IF F$FILE ATTRIBUTES (OUTHARD, "EOF") .GT. 3 THEN -
    GOTO ENDIF_RENAME_HARDCOPY
$ DELETE 'OUTHARD';0
$ ENDIF_RENAME_HARDCOPY:
$!
$ END:

```

11.4.6 Adding a Device Driver

A device driver can be added at any time. The new device driver will automatically be available to *all* graphics applications using the shareable DVDI graphics system.

Normally, the CAMCONexec sponsor adds the device driver at the request of a user. All users have write privileges in the DVDI directory (SNL\$SHARE) so that an experienced user may add device drivers. The CAMCONexec sponsor needs to be notified when a driver is added. No other operations should be performed in this directory without the prior approval of the CAMCONexec sponsor.

The procedure for adding a device driver is straightforward, but the user should proceed carefully since all graphics applications will be affected. The user must first assign the device code of the desired device. A list of currently assigned device codes can be found by typing at the system prompt **\$SHELP VDI DEVICES**. Next, place the relocatable object library needed to add the driver in SYS\$VDI:VDIdev.OLB.

Next, ensure that your default directory is SNL\$SHARE. Finally, to add a terminal device driver for device *trm*, enter **\$@SHRVDT *trm***.

To add a hardcopy device driver for device *hrd*, enter **\$@SHRVDF *hrd***.

If the addition is successful, SHRVDT, SHRVDT*trm*.EXE, and SHRVDT*trm*.OLB are created. Also, the device code *trm* should appear in the SELECT prompt as an available terminal device. SHRVDF operates similarly.

12. Software Development Utilities

Twelve utility codes or procedural files are available to aid the software developer in meeting general coding guidelines or software QA requirements:

ABSGEN	A code that produces a software abstract from an ASCII text file structured as a VAX/VMS help file.
CHANGES	A code to allow users to report errors and propose enhancements to codes within the CAMCON system.
CREATE_PROGRAM	A code to compile and link a program.
FLINT	A commercial code that can identify many subtle FORTRAN errors in both compiled and noncompiled codes. For example, it checks compatibility of calling sequence in routines and common blocks, variables used but not assigned or assigned but not used. FLINT can find an embarrassing number of dormant bugs in codes that have been running for months.
FORMRENUM	A code to format and renumber FORTRAN programs and identify subtle errors such as mismatched IF and DO block endings.
HLPCHK	A code that checks the contents of the ASCII help file for a program.
LISTDCL	A code to print listings for DCL code subroutines including both individual subroutine line members and total accumulated code line members. LISTDCL can be used for both programs consolidated into one large file or when subroutines and INCLUDE files are stored as separate files.
LISTFORTRAN	A code to print listings for FORTRAN code subroutines including both individual subroutine line members and total accumulated code line members. LISTFORTRAN can be used for both programs consolidated into one large file or when subroutines and INCLUDE files are stored as separate files.
QA_PREP	A code that copies *.FOR and *.INC files from a directory and prepares them for input into QA_PRINT.
QA_PRINT	A DCL procedural file that runs FLINT, LISTFORTRAN, and LISTDCL with a set of standard options and parameters to produce uniform output for the software notebooks (see Section 4.6, "On-Line Documentation").
UPDATE_PROGRAM	A code to compile a routine and link a program compiled by CREATE_PROGRAM.
VAX/VMS DEBUG	A VAX/VMS debugging utility.

Details on the use of these codes are presented in the following sections, as well as a brief introduction to common commands used with the VAX/VMS DEBUG utility.

12.1 Chapter Conventions

Throughout this chapter, the following organizational and typographic conventions are used:

- Descriptions of codes, and groups of keywords, commands, parameters, variables, and values are organized alphabetically.
- Data entered by the user (e.g., at the VAX/VMS system prompt, "\$") are shown in **boldface** type (e.g., **QA_PRINT**).
- Unless otherwise indicated, data entered by the user must be followed by a <RETURN>. For brevity, this is not shown in the text.
- All default values are enclosed within angle brackets, <> (e.g., <ROUTINES.TXT>).
- The essential portion of keywords and commands (i.e., the minimum number of characters required for the function to be recognized) appears in upper case (e.g., **UPDATE_Program**).
- The CAMCON system codes are case-insensitive and so the essential portion of a keyword does not have to be entered in upper case.
- Alphanumeric data for keywords and commands are shown in *italics*.

12.2 ABSGEN, Software Abstract Generation

12.2.1 Sponsorship and Version

Name: ABSGEN, a code to extract data from software help files
Authors: J. S. Sandha, D. W. Osborn, and H. J. Iuzzolino
Sponsor: K. A. Byle
Version / Date: C-3.00VV/September 1992

12.2.2 Function

ABSGEN extracts QA information for software abstracts from CAMCON software help files and reformats it into a software abstract form acceptable for viewing, printing, or reading into a relational data base. The code searches for specific identifiers followed by a colon (:) and then extracts the text following the identifier. The program calls several plotting routines to draw the abstract form along with the appropriate text. The output of this program is a screen dump, plot file, or ASCII file.

ABSGEN is actually a DCL shell that calls two routines: HLP2ABS and ABS2RPT. HLP2ABS reads the help file specified and produces a temporary data file, *codename.dat*. ABS2RPT then reads this file and produces output at the specified destination. Any temporary files created by ABS2GEN are automatically deleted prior to exiting the routine.

12.2.3 Execution

First, extract the CAMCON help file from CHELP by typing

LIBRARY/EXTRACT - *code_name*/help/output = *code_name.hlp* CAMCON\$HELP

where CAMCON\$HELP is a CAMCON system-defined symbol pointing to CAMCON\$ROOT:[LIBRARIES.HELP_LIB]CAMCON_HELP.HLP.

Second, at the system prompt type the following:

ABSGEN *code_name.hlp* *destination*

where *code_name.hlp* is the name of the CAMCON help file providing QA information for the software abstract and *destination* is a printing option. The destination options are

- F** - File; this option creates a file named *codename.rpt* in the current directory
- S** - Screen; this option scrolls output directly to the terminal

P - Printer; this option sends output to a printer defined by the CAMCONexec sponsor using the symbol ABSPRNTR.

Note: ABSGEN prompts the user for any arguments not provided on the command line.

12.2.4 Required Identifiers and Headings

ABSGEN expects the following identifiers and headings (see also Section 4.6, "On-Line Documentation"):

- 1 CODE_NAME
 - Title:
 - Purpose:
 - Authors:
 - Sponsor:
 - Consultant:
- 2 UPDATE_HISTORY
 - Version:
 - Language:
 - Date:
- 2 QA_INFO
 - QA_Level: see UPDATE_HISTORY
 - Limitations:
 - Keywords:
 - Origin:
 - Parent Program:
 - Classification:
 - Description:
 - Type:
 - CAMCON Module:
 - Verification:
 - Hand Calculation
 - In-Use Test
 - Comparison with Analytic Solutions
 - Comparison with Other Verified Programs
 - Parametric Sensitivity Analysis
 - Documentation:
 - User's Reference
 - Theoretical Reference
 - Verification/Sample Problems Reference
 - Other Reference
 - Primary Reference

The general instructions given to software sponsors for constructing help files are given in Section 4.6, "On-Line Documentation."

12.3 CHANGES, Error and Enhancement Reporting

12.3.1 Sponsorship and Version

Name: CHANGES, CAMCON error and enhancement reporting system
Author / Sponsor: A.P. Gilkey
Version / Date: C-1.03VV/July 1992

12.3.2 Function

CHANGES allows users to report errors and propose changes to CAMCON software. An error/enhancement report to a sponsor contains:

- A report number
- The name of the person who sent the report and when it was sent
- The software name and its sponsor
- The subject of the message (40 characters)
- A text message (up to 20 lines)
- An optional reply from the sponsor (up to 20 lines)

CHANGES also allows sponsors to broadcast reports to all users. These reports contain the same information as error reports, but they allow multiple replies from any user. This is useful for querying users about proposed changes.

Each report is assigned a report number that is printed with the report. This number is used to identify the report. A temporary (negative) number is assigned when a report is added. The permanent number is assigned upon exit. Since reports can be deleted, there may be gaps in the numbers.

The reports are maintained on a file that is not updated until the program is exited. If the program aborted or interrupted, all changes are *lost*.

12.3.3 Execution

At the CAMCONexec main menu or the system prompt, type **CHANGES**. A listing file, CHANGES.TXT, may be created by the user.

12.3.4 Special Mode, SCANCHANGES

SCANCHANGES displays “new” reports and replies that have been sent to the user. The user may reply to a new report or write the report to a file, but no command input is allowed. SCANCHANGES

is a special mode of the CHANGES program. It can be run stand-alone to scan new reports. It is also run as a part of CHANGES before command input begins.

SCANCHANGES is run when setting up the CAMCON system environment using CAMCON_SYMS, a command that is usually part of the user's login file. Each user will have a file called SETUP.CHANGES created in the login directory. This file keeps track of when CHANGES was last run. When SCANCHANGES is run, each report and reply addressed to the last user (including broadcast reports) is checked against the time stamp of the last run. If it is a new report or reply, it is displayed to the user.

12.3.5 Commands for CHANGES

CHANGES recognizes the following user commands:

ADD	EDIT	QUIT
BROADCAST	EXIT	REPLY
DELETE	HELP	SPONSORS
DIRECTORY	PROGRAMS	VIEW

These commands are described below.

After a command is issued, all input is prompted for with the default (if any) shown in angle brackets (<>). Input may be in either lower or upper case. Most input can be abbreviated (i.e., the user need only enter enough characters to uniquely identify the item, but all characters given must be correct). Replying QUIT to most prompts will return to the CHANGES prompt, >. The sponsor name can be entered by the full name or the VAX system user name (either may be abbreviated).

Add

ADD sends a report to the appropriate software sponsor. The routine prompts for the name of the software (or the sponsor name for more general comments), the subject of the report, and the text file that contains the report text. The text may be entered interactively by omitting the name of a text file. The report will be displayed to the software sponsor the next time SCANCHANGES is run.

Broadcast

BROADCAST sends a report to all users. This is intended to help sponsors notify users of changes in software. The user (normally the software sponsor) is prompted for the name of the software, the subject of the report, and the text file that contains the report text. The text may be entered interactively by omitting the name of a text file. The report will be displayed to a user the next time SCANCHANGES is run.

DElete

DELETĒ deletes a report. Only the user who sent the report or the sponsor the report is addressed to can delete the report. The routine prompts for a report identifier to select the report(s) to delete. The identifier may be

- The report number to select a specific report
- The software name to select all reports about that software
- Your user name to select all reports that you may delete

The user can optionally delete each selected report.

Directory

DIRECTORY displays a summary of the reports. The routine prompts for a report identifier to select the reports to view. The identifier may be

- The report number to select a specific report
- ALL to select all reports
- The software name to select all reports about that software
- The sponsor name to select all reports addressed to that sponsor
- BROADCAST to select all broadcast reports

The routine also prompts for a report number or date of the first report to display.

EDit

EDIT allows the user to edit a report or a reply. Only the user who entered a report or reply can edit it. The routine prompts for a report number of the report to edit.

EXit

EXIT updates the report file and exits the program.

Help

HELP lists a short description of each command.

Programs

PROGRAMS displays the names and sponsors for CAMCON software. The routine prompts for a sponsor name. If a sponsor name is entered, only the software with the selected sponsor is listed; otherwise all software is listed.

Quit

QUIT exits the program without updating the report file (no changes are recorded).

Reply

REPLY enters a reply to a report. Anyone can reply to a broadcast report. Only the sponsor the

report is addressed to can reply to a non-broadcast report. The routine prompts for a report identifier to select the report(s). The identifier may be

- The report number to select a specific report
- The software name to select all reports about that software
- BROADCAST to select all broadcast reports
- Your user name to select all reports addressed to you (but not sent by you)

The user may optionally reply to each selected report. The routine prompts for the text for the reply. The reply is displayed to the author of the report the next time SCANCHANGES is run.

Sponsors

SPONSORS displays the sponsor names and system user names for all sponsors of CAMCON software.

View

VIEW displays the reports. The routine prompts for a report identifier to select the report(s) to view. The identifier may be

- A report number to select a specific report
- ALL to select all reports
- A software name to select all reports about that software
- BROADCAST to select all broadcast reports

The routine also prompts for a report number or date of the first report to display. Each selected report is displayed and the user may optionally reply to it (if possible) or send it to a listing file.

12.4 CREATE_PROGRAM, Compile and Link a Program

12.4.1 Sponsorship and Version

Name: CREATE_PROGRAM, a code to compile and link a program
Author/Sponsor: A.P. Gilkey
Version/Date: X-1.01VV/June 1992

12.4.2 Function

CREATE_PROGRAM compiles all *.FOR files in a directory, creates an object library, and links a program. A debug version may also be created in the sponsor's directory.

12.4.3 Execution

At the system prompt type the following (this code is not available through CAMCONexec [Rechard, 1992]):

CREATE_Program

If present in the directory, two optional files, ROUTINES.TXT and COMPILE_SYMBOLS.COM (explained below) are read.

12.4.4 Preparation

CREATE_PROGRAM works on a code that resides in its own directory. By default, the name of the directory is the name of the program (*code_name* in the following description). Although all source code for the program must reside in the directory, object libraries need not be in this directory.

ROUTINES.TXT File Contents. An optional file, called ROUTINES.TXT, may reside in the directory that lists the names of all INCLUDE files and all FORTRAN files used by the program (one file name per record). Each *.FOR file whose name is listed in ROUTINES.TXT is compiled. If ROUTINES.TXT does not exist, all *.FOR files in the directory are compiled. (See QA_PREP or QA_PRINT for information about preparing the ROUTINES.TXT file.)

COMPILE_SYMBOLS.COM Input Commands. An optional file, named COMPILE_SYMBOLS.COM, may reside in the directory that defines the symbols listed in the following paragraphs to customize the CREATE_PROGRAM and UPDATE_PROGRAM procedures. COMPILE_SYMBOLS is a standard DCL command file that will be executed in both procedures (with @COMPILE_SYMS). The symbols must be defined as DCL global (not local) symbols (either with == and quotes around the parameter, or alternately, with := and no quotes around the parameter). Only symbols that differ from the default need to be assigned in the file.

PROGNAME == "*code_name*" <*directory_name*>

PROGNAME specifies the file name of the executable file (i.e., *code_name*) without the extension. This defaults to the directory name (the lowest level name only).

MAINPROG == "*code_name*" <*directory_name*>

MAINPROG specifies the name of the program (in the FORTRAN program statement). MAINPROG should be set to double quotes, "", for a non-executable (library) directory.

LIBRARIES == "*library*" <"CAMCON_LIB">

LIBRARIES specifies the libraries needed to link the program (not including *code_name*_LIB.OLB). Separate the library names by commas. Do not include the "/LIB" or the ".OLB" extension, but include any directory specifier.

BLOCK_DATA == "*routine*" <"">

BLOCK_DATA specifies the names of any BLOCK DATA routines that contain DATA statements. The BLOCK DATA routine must be named.

COMPILE_OPTIONS == "*option₁*/*option₂*/..." <"/LIST/NODEBUG/OPTIMIZE">

COMPILE_OPTIONS specifies the compile options for the standard version.

DEBUG_COMPILE_OPTIONS == "*option₁*/*option₂*/..." <"/LIST/DEBUG/NOOPTIMIZE">

DEBUG_COMPILE_OPTIONS specifies the compile options for the debug version.

Example

```
$! COMPILE_SYMBOLS.COM is executed by CREATE_PROGRAM and
$! UPDATE_PROGRAM. It defines symbols used for compiling
$! and linking.
$!
$! Include the CAMDAT_LIB data base reader/writer library.
$ LIBRARIES == "CAMDAT_LIB, CAMCON_LIB, CAMSUPES_LIB"
$!
$! Compile with special double precision option.
$ COMPILE_OPTIONS == "/LIST/NODEBUG/OPTIMIZE/G_FLOAT"
$ DEBUG_COMPILE_OPTIONS == "/LIST/DEBUG/NOOPTIMIZE/G_FLOAT"
```

12.4.5 Output

As each file is compiled, a listing file is created and is then deleted if the compilation is successful. Thus, when CREATE_PROGRAM is completed, the only *.LIS files in the directory are for files with compilation errors. Also, an object library, *code_name_LIB.OLB*, consisting of all *.OBJ files in the directory, is created. The individual *.OBJ files are deleted.

If there were no compile errors, the program is then linked to create an executable file, *code_name.EXE*. The options for linking are /TRACE/MAP. Use UPDATE_PROGRAM to recompile and relink individual routines.

If the symbol *DEBUG_code_name* is defined, a debug version of the code is created in the user's directory. All files are recompiled with debug options, an object library (*code_name_LIB_DEBUG.OLB*) is created, and an executable file (*code_name_DEBUG.EXE*) is linked with the options /DEBUG /TRACE. The symbol *DEBUG_code_name* is defined similarly to the *code_name* symbol that runs the program, except that it points to the debug version of the code. Although the *code_name* symbol and the *DEBUG_code_name* symbol may be defined in SPONSOR_SYMS.COM in CAMCON\$ROOT:[SYMBOLS], the debug version source code is not in [CAMCON]; thus, the DEBUG symbol should point to the sponsor's working directory. An example of defining a DEBUG symbol is as follows:

```
$DEBUG_code_name=="$disk{directory}code_name_DEBUG.EXE"
```

12.5 FLINT, FORTRAN Code Analyzer

12.5.1 Sponsorship and Version

Name: FLINT: A FORTRAN source code analyzer
Author: Information Processing Techniques Corporation, Palo Alto, CA
Sponsor: A. P. Gilkey
Version / Date: C-2.71VV/August 1990
Version Base Case: C-2.71VV equivalent to version 2.71 acquired August 1990 with Sandia site license.

12.5.2 Function

Fortran-LINT is a commercial source code analyzer designed to simplify the debugging of FORTRAN programs.

12.5.3 Execution

At the system prompt, type the following (this code is not available through CAMCONexec):

```
FLINT[ /qualifiers][source-file-spec.ext[,...]]
```

12.5.4 Source File Specification

The *source-file-spec.ext* parameter specifies one or more FORTRAN source codes to be analyzed. If a file type is not specified, FLINT uses a default file type appropriate with the /SYS switch setting. If no /SYS switch is present, the default type is *.FOR.

Temporary defaults are used in the file specification list. If a directory name is explicitly specified for a file specification, it becomes the default for any following file specifications with omitted directory names. Wild cards are permitted. File specifications may be separated by either commas or spaces.

FLINT interprets the file extension, *ext*, as follows:

.LBT files

If a file with the extension 'LBT' is specified, it is taken to be a FLINT library. FLINT libraries are used on /GLOBAL runs to allow call argument checking without having to re-parse all the sources each time.

.TLB files

If a file with the extension 'TLB' is specified, it is taken to be a text library. When FLINT comes across a text library include statement without a text library file name associated with it (e.g.

INCLUDE '\$FOOBAR'), it searches all command-line text libraries in the order specified. If the module is not found, it then searches the user text library 'FORT\$LIBRARY', and then the system default library 'SYS\$LIBRARY:FORSYSDEF.TLB'.

.TTB files

If a file with the extension '.TTB' is specified, it is taken to be a tree table file. All source processing is bypassed, the symbol table is loaded from the tree table, and a call tree can be generated without having to re-parse the sources.

12.5.5 Qualifiers

Qualifiers (or "switches") for FLINT (*/qualifier*) are described as follows:

Source File Qualifiers. The following qualifiers control the interpretation of the input source files:

/DLINES

/DLINES processes source lines that begin with a 'D' (debug lines).

/EXTEND

/EXTEND extends source code line length from 72 columns to 132 columns.

/FILES=file_spec

/FILES specifies a list file that contains names of source files to be processed. These file names are treated as if they were included on the command line itself. The format of this list file is the same as the command line, except that switches are not allowed in the file. File specifications may be of any form, including wild cards, and may be separated by any white space.

/I4 <Default>

/NOI4

By default, INTEGER and LOGICAL declarations are interpreted as INTEGER*4 and LOGICAL*4. If the /NOI4 switch is specified, INTEGER and LOGICAL declarations are interpreted as INTEGER*2.

Output File Qualifiers. The following qualifiers determine which output files will be generated by FLINT:

/LIBRARY=file_spec

/LIBRARY creates or updates the specified library. The default extension is .LBT. Interface information from subprograms can be stored in libraries to be used in analysis at a later date. No diagnostic output is given when creating or updating libraries, so the file should compile without errors before this switch is used. (Further information is available in Section 12.4.6.)

/OUTPUT=*file_spec*

/OUTPUT specifies the file to which the output from FLINT is directed. This switch is overridden by the /SPLIT switch. By default, the output is sent to SYS\$OUTPUT. (See also /SPLIT.)

/SPLIT=*file_root*

/SPLIT splits the output and redirects each stage of the analysis into its own file. The file names for output are built by adding various extensions to the base name *file_root*. Any extension on the file specification *file_root* is discarded. Output is redirected into the following files:

Analysis output	—>	<i>file_root</i> .LNT
Symbol table (/XREF)	—>	<i>file_root</i> .XRF
Call tree (/TREE)	—>	<i>file_root</i> .TRE
Summary (/SUMMARY)	—>	<i>file_root</i> .SUM
Statistics (/STAT)	—>	<i>file_root</i> .STT

By default, the output is sent to SYS\$OUTPUT. (See also /OUTPUT.)

/STATISTICS

/STATISTICS produces statistics about the files (e.g., number of source lines, number of errors, etc.).

/SUMMARY

In conjunction with the /SPLIT switch, /SUMMARY creates a summary file showing only the more significant diagnostics. All error messages with a '+' after the type code in FLINT.ERR are listed in the summary file. (See also /SPLIT.)

/TREE

/TREE produces a graphical representation of which routines call other routines. Only one /TREE may be specified per FLINT run. (See also /TRIM, /SQUISH, /GRAPHICS.)

/TTB=*file_spec*

/TTB creates a tree table file. The default extension is '.TTB'. The tree table stores all information required to generate a call tree for this run. This table can be used later to regenerate a call tree without having to reprocess the sources.

/XREFERENCE

/XREFERENCE produce a cross reference as a part of the symbol table listing.

Diagnostic Qualifiers. The following qualifiers control the diagnostics file generated by FLINT:

/ANSI

/ANSI flags various extensions to the ANSI FORTRAN-77 standard. It has the same effect as /PORT=ANSI.

/FYI

/FYI prints hints (for your information) which may be cause for concern.

/GLOBAL

/GLOBAL analyzes all subprograms as a group. If this switch is not specified, subprograms are processed on an individual basis and call interface checking is not performed. This switch also improves variable usage checking by allowing analysis results of one subprogram to be applied to another (such as usage of a variable passed as an actual argument).

/IMPLICIT

/IMPLICIT reports the use of implicit data typing.

/INCLUDE

/INCLUDE lists included files in the source listing.

/LISTING

/LISTING produces a source listing with line numbers.

/PORTABILITY=(target,target,...)

/PORTABILITY prints warnings relating to problems the code might have while being ported to the specified compiler(s). The following is a list of valid compilers:

VAXVMS	= VAX FORTRAN under VMS <Default>
SUN	= SunOS
OS32	= Concurrent OS/32
ANSI	= a generic ANSI-77 compiler

/SUPPRESS=(n,n,n,n, ...)

/SUPPRESS suppresses individual diagnostic messages. Arguments are generally the numbers of the messages to be suppressed. The forms the arguments may take are

<i>nnn</i>	suppress message # <i>nnn</i> .
<i>+nnn</i>	"unsuppress" message # <i>nnn</i> .
<i>all</i>	suppress all nonvital messages.
<i>+all</i>	"unsuppress" all messages.

The message numbers are too numerous to repeat here. The usual mode of operation is to make a FLINT analysis without any suppression. If too many superfluous or

meaningless messages are produced, redo the FLINT analysis with the meaningless message number suppressed.

/SYSTEM=opsys <VAXVMS>

/SYSTEM specifies the target compiler by system name. The following are valid operating systems:

VAXVMS	For VAX FORTRAN under VMS
SUN	For SunOS
OS32	For Concurrent OS/32

/USAGE <Default>

/NOUSAGE

/USAGE displays variable usage diagnostics. If the /NOUSAGE switch is specified, variable usage checking is suppressed.

/WARNINGS <Default>

/NOWARNINGS

/WARNINGS displays warning level diagnostics. If the /NOWARNINGS switch is specified, warning messages are suppressed.

Cross-Reference Table Qualifiers. The following qualifiers control the cross-reference table generated with the /XREFERENCE qualifier:

/LOCALSYMS <Default>

/NOLOCALSYMS

/LOCALSYMS specifies that local symbols are to be included in the cross reference listing. If the /NOLOCALSYMS switch is specified, local symbols are omitted from the cross reference.

/PARAMETERS

/PARAMETERS includes unused parameter declarations in the cross reference listing.

Call Tree Qualifiers. The following qualifiers control the call tree generated with the /TREE qualifiers:

/GRAPHICS=xx:xx:xx:xx:xx

The /GRAPHICS switch allows you to specify which graphic characters to use in producing the call tree. The five parameters are the hexadecimal codes for the following characters:

Example: /GRAPHICS=C4:B3:C2:C3:C0

/SQUISH

/SQUISH compresses the call tree in the vertical direction. It is used primarily with the /GRAPHICS switch.

/TRIM

/TRIM trims the tree to prevent printing duplicate subtrees.

Miscellaneous Text Format Qualifiers. The following qualifiers set the format for all text files generated:

/LPP=*n*

/LPP sets the number of lines per page. If set to 0, there is no pagination. Either 0 or any positive number greater than 3 is valid. If output is being redirected, the page length is usually 60 lines. Otherwise it is usually 0 (no pagination).

/WIDTH=*n*

/WIDTH specifies the output width in columns. Any value between 40 and 500 is valid. If output is being directed to SYS\$OUTPUT, the default width is 80 columns. Otherwise, it is 132 columns.

12.5.6 Library

A FLINT file can be produced for a library to allow software sponsors to check the interface between an application program and any libraries (e.g., CAMCON libraries). A FLINT library is created with the following command:

FLINT/LIB = *code_name*.LBT *src*₁.FOR ... *src*_{*n*}.FOR

All routines in the source files are added to the FLINT library file *code_name*.LBT. If *code_name*.LBT already exists, it is updated; otherwise, *code_name*.LBT is created. The source files must be debugged before FLINT/LIB is issued because errors within the libraries are not reported.

In the case of imported libraries, the source for the library routines may not be available. The sponsor can make up a dummy source file that contains the calling parameter sequence with special FLINT options on the arguments. This file contains enough information to allow program sponsors to check the interface to the library. FLINT/LIB is run on the dummy source file as if it were a normal source file.

The special options follow:

- /s - an argument that is set in the routine
- /r - an argument that is referenced in the routine
- /i - an argument that is indeterminate
- /v - a parameter passed by value
- /q - suppress error #251 (scalar passed to array) and data type checking
- /z - suppress all interface checking with regard to this argument
- /o - optional argument
- /l - the rest of the argument list from the preceding comma is optional

The following example is a dummy source file for two CAMSUPES_LIB routines:

```
SUBROUTINE MDINIT (USERV/sq)
DIMENSION USERV(*)
END

SUBROUTINE MDRSRV (TNAME1/r, NEWLOC/s, NEWLEN/r)
CHARACTER*(*) TNAME1
INTEGER NEWLOC, NEWLEN
END
```

12.6 FORMRENUM, Format and Renumber

12.6.1 Sponsorship and Version

Name: FORMRENUM, a FORTRAN format and renumber program
Author/Sponsor: A. P. Gilkey
Version/Date: X-1.00VV/February 1990

12.6.2 Function

The main purpose of FORMRENUM is to create aesthetically pleasing code, but it is also useful for identifying some syntax errors (such as mismatched END IFs, duplicate labels, and misplaced continuation characters).

12.6.3 Execution

At the system prompt, type the following (this code is not available through CAMCONexec [Rechard, 1992]):

FORMRENUM /*qualifiers code_name.ext*

The *code_name.ext* parameter specifies the FORTRAN source file. If *ext* is omitted, FOR is assumed. The input file is replaced by an output file, but with a higher version number.

12.6.4 Overview

FORMRENUM formats and/or rennumbers a FORTRAN source file. FORMRENUM handles standard FORTRAN and most VAX-specific FORTRAN constructs. The main advantage of FORMRENUM as opposed to other formatters is that the user can easily tailor FORMRENUM to conform to an individual programming style.

Formatting Features. If formatting is selected, FORMRENUM strips all leading blanks and tabs from the input source file and indents according to the options the user has specified.

Blocks of text within a DO-loop or an IF-THEN-ELSE structure are indented an optional number of spaces. VAX-specific constructs (e.g., the UNION structure) are also indented.

Continuation lines are indented either a specified amount from the current indentation or with respect to the first line of the statement (i.e., if the input continuation line is indented n spaces from the first line, the continuation line is indented n spaces from the current indentation).

The current indentation should be zero at each END statement. If it is not, the statement is flagged with an error message and the current indentation is reset to zero.

Renumbering Features. If renumbering is selected, FORMRENUM renumbers all labels and all (correct) references to labels. Labels are renumbered in the order they are defined, not in the order they are referenced. Labels on FORMAT statements can be numbered differently from labels on other statements.

The VAX-specific DO-END DO construct can be changed to a DO-CONTINUE statement and labeled with a new label. The appropriate statement label is inserted in the corresponding DO statement. DO WHILE statements and their corresponding END DOs are left intact.

The label numbers are initialized at the start of the file and after each END statement. Multiple definitions of a label are flagged with an error message; labels that are not referenced are flagged with a warning.

Miscellaneous Features. Blanks and tabs are stripped from the end of each line. Only tabs at the beginning of a line are converted to blanks and only if formatting is selected. Other tabs are left intact. All labels are right-justified in the label field (if either formatting or renumbering is selected).

All continuation characters can be set to a user-supplied character. They can also be renumbered so that the first numeric continuation character is changed to a 1, and the continuation character increments on each following line until the end of the statement. The character after 9 becomes # (since 0 is not allowed), then cycles to 1 again.

FORMRENUM can format and renumber lines that start with a special comment sequence. This is useful for commenting out sections of code or handling machine-dependent code. If you are interested in this capability, please contact the FORMRENUM sponsor.

12.6.5 Qualifiers

FORMRENUM qualifiers (*qualifier*) are listed below.

Formatting Qualifiers

/FORMAT <default>

/FORMAT specifies that the file should be formatted.

/NOFORMAT

/NOFORMAT specifies that the indentation should not be changed. The other formatting qualifiers have no meaning.

/INDENT=*n* <3>

/INDENT sets the block indentation (for DO and IF-THEN-ELSE blocks) to *n* characters. By default, *n* is 3.

/INDCONT=*n* <block indentation set by /INDENT>

/INDCONT sets the continuation line indentation to *n* characters. If *n* is less than zero, the continuation line is indented with respect to the first line of the statement. By default, *n* is equal to the block indentation.

/INDFORMAT=*n* <0>

/INDFORMAT sets the FORMAT statement indentation to *n* characters.

Renumbering Qualifiers

/RENUMBER <default>

/RENUMBER specifies that the file should be renumbered. This is the default.

/NORENUMBER

/NORENUMBER specifies that the labels should not be changed. The other renumbering qualifiers have no meaning.

/LABSTMT=*n* <100>

/LABSTMT sets the starting label number for non-FORMAT statements to *n*. If *n* is less than or equal to zero, non-FORMAT statement labels are not renumbered.

/LABFORMAT=*n* <10000>

/LABFORMAT sets the starting label number for FORMAT statements to *n*. If *n* is zero, FORMAT statement labels are numbered the same as non-FORMAT statement labels. If *n* is less than zero, FORMAT statement labels are not renumbered.

/INC=*n* <10>

/INC sets the statement label increment for FORMAT and other statements to *n*.

/VAXDO

/VAXDO changes the DO-END DO construct into a DO-CONTINUE construct with appropriate labeling. If this option is selected, the /LABSTMT option must be a positive number. By default, the DO-END DO constructs are left intact.

Miscellaneous Qualifiers

/NUMBER <default>

/NUMBER specifies that numeric continuation characters should be renumbered.

/NONUMBER

/NONUMBER specifies that numeric continuation characters should not be renumbered. If the /CONT option is specified, all continuation characters are set to the default continuation character.

/CONT="α"

/CONT sets the default continuation character to α. All the non-numeric continuation characters are set to α. Numeric continuation characters are set to α if the /NONUMBER option is specified. If the /NUMBER option is active and α is numeric, all continuation characters are numbered consecutively. By default, the continuation characters are not changed.

/COMMENT="α"

/COMMENT sets the default comment character (in column 1) to α. If α is not a blank, the comment character in all comment lines (including blank lines) is changed to α. If α is a blank, lines that consist of only a comment character are changed to blank lines. By default, the comment characters are not changed.

/MAXCONT=n <19 (the FORTRAN standard)>

/MAXCONT sets the maximum number of continuation lines for a statement to n. If this limit is exceeded, the statement is flagged with an error message.

12.6.6 In-Source Control

The program can be controlled with commands inserted in the source file. This is a useful way of implementing special features, such as indenting a loop in a CONTINUE-GOTO structure or numbering sections of a file differently. However, these commands should be used with care.

The commands are comment lines and must start in column 1. The formatting commands are valid only if the /FORMAT option is specified and the renumbering commands are valid only if the /RENUMBER option is specified.

Formatting Commands

C\$\$\$OFF

C\$\$\$OFF turns off the formatting.

C\$\$\$ON

C\$\$\$ON turns on the formatting.

C\$\$\$+*n*

C\$\$\$+*n* increments the current indentation by *n* characters. If *n* is omitted, *n* is assumed to be the block indentation.

C\$\$\$-*n*

C\$\$\$-*n* decrements the current indentation by *n* characters. If *n* is omitted, *n* is assumed to be the block indentation.

Renumbering Commands

C\$\$\$R OFF

C\$\$\$ROFF turns off the label renumbering. References to renumbered labels continue to be changed.

C\$\$\$R ON

C\$\$\$RON turns on the label renumbering.

C\$\$\$R *nstmt nfmt*

C\$\$\$R *nstmt nfmt* sets the next label number for non-FORMAT statements to *nstmt* and for FORMAT statements to *nfmt*. If *nstmt* or *nfmt* is zero, the respective label remains unchanged. If *nstmt* or *nfmt* is less than zero, the respective statement labels are not renumbered. This command affects only the labels in the current program unit (subroutine, function, etc.). At the start of the next program unit, the labels are reset as specified by the /LABSTMT and /LABFORMAT qualifiers.

12.6.7 Errors and Restrictions

If any errors are encountered in the input file, an error message is displayed on the screen and inserted in the output file (normally above the source line that caused the error). A warning message is displayed on the screen only. An error message in the output file starts with "\$\$\$." It is automatically stripped from the file when FORMRENUM is rerun (although it is regenerated if the error is not corrected). Since error messages are not compilable, the source should be error-free before compilation.

Most errors flagged would cause compilation errors, but some are generated by formatting and renumbering. A line-too-long error may result if the formatted or renumbered line is longer than the input line. A label-too-long error results if a debug line (which has a *D* in column 1) has a five-character generated label.

The input line is limited to 132 characters. Characters input in columns number 73 and after are treated as statements characters, not comment characters. Therefore, input lines cannot include a sequence field and should not continue a character string over two lines. If an output line is too long (72 characters for code and 80 characters for comments), the line is flagged with an error message, but up to 132 characters are output.

The source file can be in upper or lower or mixed case. The keywords "GOTO," "ENDIF," and other VAX-specific END keywords can be written as two words (e.g., "GO TO"). Most other keywords cannot be split. Bizarre (but legal) programming practices, such as splitting keywords over lines, will confuse FORMRENUM.

12.6.8 Example

The following is an example of a source file:

```
WRITE (*, 99)
99  FORMAT ('Enter the number of items to sort',
3/, ' then the items to be sorted, one item per line')
READ (*, *, ERR=10) NSORT
DO I = 1, NSORT
READ (*, *) ITEM(I)
END DO

DO 30 I = 1, NSORT
DO 40 J = I+1, NSORT
IF (ITEM(I) .GT. ITEM(J)) THEN
CALL SWAP (ITEM(I), ITEM(J))
END DO
40  CONTINUE
30  CONTINUE
```

The following is the output source file after the FORMRENUM command has been issued with default qualifiers:

```
        WRITE (*, 10000)
10000 FORMAT (' Enter the number of items to sort',
             1/, '   then the items to be sorted, one item per line')
$$$ Undefined statement number: 10
        READ (*, *, ERR=10) NSORT
        DO I = 1, NSORT
            READ (*, *) ITEM(I)
        END DO

        DO 110 I = 1, NSORT
            DO 100 J = I+1, NSORT
                IF (ITEM(I) .GT. ITEM(J)) THEN
                    CALL SWAP (ITEM(I), ITEM(J))
$$$ Indentation mismatch, expected END IF
                END DO
            100 CONTINUE
        110 CONTINUE
```

12.7 HLPCHK, Check Format and Content of Software Help File

12.7.1 Sponsorship and Version

Name: HLPCHK, a code to check the format and contents of a software help file
Author: J. S. Sandha and D. W. Osborn
Sponsor: K. A. Byle
Version / Date: C-2.01VV/September 1992

12.7.2 Function

HLPCHK is a code for checking the contents and format of a software help file. Its purpose is to ensure that the software help file contains the required identifiers and headers. If the identifier is not in the proper location, preceded and followed by the appropriate identifiers, the program displays an error message indicating that the identifier is out of sequence or missing.

12.7.3 Execution

At the system prompt, type the following:

HLPCHK *code_name.hlp*

where *code_name.hlp* is the name of the CAMCON help file providing data for the software abstract. See ABSGEN for a description of how to extract *code_name.hlp* from the CAMCON help library.

12.7.4 Required Identifiers and Headings

HLPCHK searches for the following identifiers and headings:

1 CODE NAME

Title:
Purpose:
Authors:
Sponsor:
Consultant:

2 UPDATE_HISTORY

Version:
Language:
Date:

2 QA_INFO

QA_Level: see UPDATE_HISTORY
Limitations:

Keyword:

Origin:

Parent Program:

Classification:

Description:

Type:

Verification:

Hand Calculation

In-Use Test

Comparison with Analytic Solutions

Comparison with Other Verified Programs

Parametric Sensitivity Analysis

Documentation:

User's Reference

Theoretical Reference

Verification/Sample Problems Reference

Other Reference

Primary Reference

2 EXECUTION:

2 EXAMPLE:

and either

2 COMMANDS

2 DATA INPUT

or

2 ROUTINES

The general instructions given to software sponsors for constructing help files are given in Section 4.6, "On-Line Documentation."

12.8 LISTDCL, List DCL File

12.8.1 Sponsorship and Version

Name: LISTDCL, a code to create a listing of a DCL command file
Author / Sponsor: A. P. Gilkey
Version / Date: X-1.01VV/February 1991

12.8.2 Function

LISTDCL lists and prints a DCL source file in a standard format. The listing includes a count of the active DCL and comment lines.

12.8.3 Execution

At the system prompt type **LISTDCL** (this code is not available through CAMCONexec [Rechard, 1992]). The following items may follow LISTDCL on the command line; otherwise they will be prompted for:

- The name of the DCL file (default extension of .COM) or, if printing only, the listing file (default extension of .COMLIST)
- Whether a listing or printout is needed: <ALL>
 - LIST to create listing only
 - PRINT to print listing only
 - ? to create listing and optionally print
 - ALL to create listing and print
- If a printout is requested, the following information will be prompted for:
 - The print queue (JOAN or ANNE) <JOAN>
 - The print format per side (2 for two pages per side with border, 1 for one page per side with border, 0 for one page per side with no border) <0>
 - Whether double-sided output is requested <NO, unless compressed>
 - The printer tray (BOTTOM, MIDDLE, or TOP) <BOTTOM>

12.8.4 Preparation

A form feed forces a new page to be generated. In addition, **NAME=routine_name* line in the source code causes a new page to be generated and the *routine_name* to be used as the routine name. The routine name is printed in the margin of the listing. This special line does not appear on the listing.

12.8.5 Output

LISTDCL categorizes each input line and tallies the number of lines of each type for each routine and for all routines. The following counts are maintained and displayed:

- The total number of lines, including blank lines
- The number of lines with any DCL code
- The number of DCL statements (the same as above, but DCL continuation lines are not counted)
- The number of comment lines, including blank lines and DCL lines with trailing comments
- The number of comment lines with alphabetic characters, including DCL lines with trailing comments

12.9 LISTFORTRAN, List FORTRAN Source

12.9.1 Sponsorship and Version

Name: LISTFORTRAN, a code to create a listing of a FORTRAN source
Author/Sponsor: A. P. Gilkey
Version/Date: X-1.01VV/February 1991

12.9.2 Function

LISTFORTRAN lists and prints a FORTRAN source file in a standard format. The listing includes a count of the active FORTRAN and comment lines.

12.9.3 Execution

At the system prompt type **LISTFORtran** (this code is not available through CAMCONexec [Rechard, 1992]). The following items may follow LISTFORTRAN on the command line; otherwise they will be prompted for:

- The name of the FORTRAN file (default extension of .FOR) or if printing only, the listing file (default extension of .FORLIST)
- Whether a listing or printout is needed <ALL>:
 - LIST to create listing only
 - PRINT to print listing only
 - ? to create listing and optionally print
 - ALL to create listing and print
- If a printout is requested, the following information will be prompted for:
 - The print queue (JOAN or ANNE) <JOAN>
 - The print format (2 for two pages per side with border, 1 for one page per side with border, 0 for one page per side with no border) <0>
 - Whether double-sided output is requested <NO, unless compressed>
 - The printer tray (BOTTOM, MIDDLE, or TOP) <BOTTOM>

12.9.4 Preparation

A form feed forces a new page to be generated. Furthermore, LISTFORTRAN starts a new page whenever a PROGRAM, SUBROUTINE, FUNCTION, or ENTRY (if last statement was RETURN) statement is found. The routine name is printed in the margin of the listing.

In addition, a **NAME=routine_name* line in the source code causes a new page to be generated and the *routine_name* to be used as the routine name. An **END* line causes a page break after the line. These special lines are useful for INCLUDE files and do not appear on the listing.

If several routines are present in a single file and there are comments between the END and the routine start lines, the program must decide whether to associate these lines with the end of the last routine or the start of the current routine. Normally, they are associated with the start of the current routine unless one of the lines is a *NAME or *END-line or a form feed.

12.9.5 Output

The program categorizes each input line and tallies the number of lines of each type for each routine and for all routines. The following counts are maintained and displayed:

- The total number of lines, including blank lines
- The number of lines with any FORTRAN code
- The number of FORTRAN statements (the same as above, but FORTRAN continuation lines are not counted)
- The number of comment lines, including blank lines and FORTRAN lines with trailing "!" comments

12.10 QA_PREP, Setup for QA_PRINT

12.10.1 Sponsorship and Version

Name: QA_PREP, a setup program for users of QA_PRINT
Author: D. W. Osborn
Sponsor: K. A. Byle
Version / Date: X-1.00VV/April 1992

12.10.2 Function

QA_PREP creates a file named ROUTINES.TXT, which is used as input into QA_PRINT.

12.10.3 Execution

At the system prompt, type the following (this code is not available through CAMCONexec [Rechard, 1992]):

```
QA_PREP
or
QA_PREP directory_name
```

QA_PREP will then scan the directory for all *.FOR and *.INC files and will produce the file ROUTINES.TXT as a result.

12.10.4 Limitations

QA_PREP assumes that there is only one main program file in the directory it is scanning.

12.10.5 Preparation

The software sponsor is required to provide only the directory that QA_PREP is to search.

12.10.6 Example

The following are examples of how to use QA_PREP:

```
$ QA_PREP CAMCON$ROOT:[GENMESH]
```

In the above example, QA_PREP will scan the directory CAMCON\$ROOT:[GENMESH] for all *.FOR and *.INC files. It will then build the file ROUTINES.TXT containing the result of its scan.

```
$ QA_PREP
```

In this example, QA_PREP will ask the user the name of the directory to be scanned and then scan that directory for all *.FOR and *.INC files. It will then build the file, ROUTINES.TXT, containing the result of its scan.

12.11 QA_PRINT, Quality Assurance Notebook Print Procedure

12.11.1 Sponsorship and Version

Name: QA_PRINT, quality assurance notebook print procedure
Author/Sponsor: J. S. Rath
Version/Date: C-1.06VV/April 1992

12.11.2 Function

QA_PRINT generates an 8 1/2 x 11 in. listing (hardcopy) of the source code, help file abstract, FLINT (FORTRAN code analyzer) output of the code, and the CAMCONexec driver for the software notebooks (see Section 4.7, "External Documentation").

12.11.3 Execution

At the system prompt, type **QA_PRINT** (this code is not available through CAMCONexec [Rechard, 1992]). Subsequent questions in the procedure file request the following information:

Required

- Name of the code to be printed in the QA format
- The program's source code directory (specify full directory path)
- File containing all the source code file names. In the CAMCON directories, this is typically called ROUTINES.TXT (see Section 12.11.5, below). Specify full directory path plus the file name if the file resides in a different directory than the source code. <ROUTINES.TXT>
- The program's help file (specify full directory path plus filename if file resides in a different directory than the source code). <PROGRAM.HLP>

Optional

- Request to cancel all print jobs. Typing NO_PRINTing in either upper or lower case will cancel all print jobs

In addition, by specifying all this information on the command line, the interactive mode may be bypassed. For more information on this enhancement, see Section 12.11.6, "Example."

12.11.4 Limitations

QA_PRINT requires a file, ROUTINES.TXT, listing all files of the source code.

FLINT runs with the following options:

```
$ FLINT /DLINES /FYI /GLOBAL /INCLUDE /LOCAL /NOWARNINGS /OUTPUT -  
=FLINE /PARAMETERS /PORTABILITY=VAXVMS /SPLIT -  
=FLINT /STATISTICS /SUMMARY /TREE
```

12.11.5 Preparation

Prior to executing QA_PRINT, the code sponsor must generate a file containing all source code file names, typically called ROUTINES.TXT. Proper generation of ROUTINES.TXT is essential for executing FLINT on the code and for generating a source code listing for the software notebooks.

If the user has been using the CAMCON_LIB routine CREATE_PROGRAM or UPDATE_PROGRAM, ROUTINES.TXT should already exist. However, the file is easy to generate. Either use QA_PREP or prepare the file manually as follows: Go to the source code directory and type the command:

```
DIRECTORY/COLUMNS=1/OUTPUT=ROUTINES.TXT *.FOR,*.INC,*.CMN
```

The above command generates a file with only one file name per record (1 column). Next, edit the ROUTINES.TXT file and remove all version identifiers (e.g., change SUBROUTINE.FOR;5 to SUBROUTINE.FOR). Also, remove all erroneous lines of text, such as blanks, directory names, total number of files, etc. In addition, check that the ROUTINES.TXT indeed contains all the types of files associated with their program, i.e., *.FOR, *.INC, *.CMN, etc.

The order that the source files are listed in ROUTINES.TXT is important. The ROUTINES.TXT file should first list FORTRAN files (usually *.FOR), followed by other files like INCLUDE files (usually *.INC or *.CMN), and any other types.

It is strongly recommended that the first FORTRAN file listed in ROUTINES.TXT be the main program (if you rename your main program file to A1MAIN.FOR, the above mentioned copy command will list files in ROUTINES.TXT in the correct order).

12.11.6 Example

The following are QA_PRINT examples.

The first example uses the command line mode and assumes that the ROUTINES.TXT, GENMESH.SRC, and GENMESH.HLP files reside in the same directory as the source code (the dash is a record continuation mark).

```
$ QA_PRINT -  
  GENMESH -  
    CAMCON$ROOT:[GENMESH.A_LEVEL] -  
  ROUTINES.TXT -  
  GENMESH.HLP
```

The second example uses the command line mode and assumes that the user (code sponsor) is in the directory where the GENMESH source code exists. The example also shows how to use the fifth data field command line argument, NO_PRINTing, to execute QA_PRINT without sending the print jobs to the printer.

```
$ QA_PRINT GENMESH "" "" "" NO_PRINTing
```

12.12 UPDATE_PROGRAM, Compile, Update, and Link

12.12.1 Sponsorship and Version

Name: UPDATE_PROGRAM, a code to compile and link a routine
Author/Sponsor: A. P. Gilkey
Version/Date: X-1.01VV/June 1992

12.12.2 Function

UPDATE_PROGRAM compiles the specified *.FOR file, updates the object library, and links the program. A debug version may also be updated in the sponsor's directory. CREATE_PROGRAM must be executed once before UPDATE_PROGRAM is executed.

12.12.3 Execution

At the system prompt, type the following (this code is not available through CAMCONexec):

```
UPDATE_Program code_name  
or  
UPDATE_Program "code_name, code_name, ..."
```

where *code_name* is the name of the file to be compiled. As shown, multiple files can be specified for compilation by surrounding the file names in double quotes and separating them with commas.

12.12.4 Preparation

As UPDATE_PROGRAM compiles a specified source file(s), a listing file is created. Each listing file is deleted if the compile is successful. Also, the object file(s) are inserted or replaced in the object library named *code_name*_LIB.OLB. The individual *.OBJ files are deleted.

If there were no compile errors, the program is then linked to create an executable file, *code_name*.EXE. The options for linking are "/TRACE/MAP". If the symbol DEBUG_*code_name* is defined, a debug version of the code is also created. (Refer to CREATE_PROGRAM for an example of this symbol definition.) The given source file(s) are recompiled with debug options, the object library, *code_name*_LIB_DEBUG.OLB, is updated, and an executable file, *code_name*_DEBUG.EXE, is linked with the options /DEBUG/TRACE.

12.13 VAX/VMS Debugger

12.13.1 Sponsorship and Version

Name: VAX/VMS Debugger
Author: Digital Equipment Corporation, Maynard, MA
Version / Date: VMS Version 5.4/June 1990

12.13.2 Function

The VAX/VMS Debugger is an important tool for the CAMCON programmer. The Debugger is easy to implement and easy to use. The basic commands discussed here cover the majority of debugging situations.

12.13.3 Reference

More detail and more sophisticated commands can be found in the VMS Debugger Manual (DEC, 1988c).

12.13.4 Execution

To use the Debugger, the code must be compiled and linked with DEBUG options turned on as shown below. It has been found convenient to maintain two parallel libraries of object code—one for debugging, stored in the software sponsor's directory, and one for general use, stored in the [CAMCON] directory.

To compile source code, at the system prompt, type:

FORTTRAN/DEBUG/NOOP *code_name.for*

To link the object code, at the system prompt, type:

LINK/DEBUG *code_name.obj, lib.olb/lib ...*

To execute, either build a symbol as follows:

code_name* ::= \$dev:[path ...] *code_name.exe
and type ***code_name***

or type:

RUN *dev:[path ...] code_name*

Execution will then take place in the Debugger automatically and will be user-controlled by typing commands at the Debug prompt, DBG>. The Debugger can be turned off by typing:

RUN/NODEBUG *code_name*

12.13.5 Commands

The most often-used commands are grouped under the following headings: *Setting Break Points* (SET BREAK), *Executing* (GO, STEP, EXIT, CTRL C), *Listing Source Code* (TYPE), *Examining Values* (EXAMINE), and *Miscellaneous* (SHOW CALLS and DEPOSIT).

Debugging commands can be abbreviated to the first set of unique characters. In the discussion below, these are shown with capital letters.

Setting Break Points

SEt Break routine

SET BREAK *routine* sets a break point at the beginning of *routine*; for example, SET B PREPRO.

SEt Break %Line n

SET BREAK %LINE *n* sets a break point at source line *n* in the current routine; for example, SET B %LI 122.

SEt Break routine\%LI n

SET BREAK *routine* \%LI *n* sets a break point at source line number *n* in *routine*; for example, SET B PREPRO \%LI 122.

SEt Break routine\%LI n WHEN (condition)

SET BREAK *routine* \%LI *n* WHEN (*condition*) sets a break point at source line number *n* in *routine* when *condition* is true. The *condition* is written in the source code syntax, for example, SET B PREPRO \%LI 122 WHEN (I.EQ. 20).

SHow Break

SHOW BREAK shows all defined break points.

CANcel Break

CANCEL BREAK cancels break points defined with the same format as SET BREAK, for example, CAN BR PREPRO \%LI 122.

CANcel ALL

CANCEL ALL cancels all break points.

Executing

Go (keypad: ,)

GO executes to the next break point, error, stop, or interrupt.

Step (keypad: 0)

STEP executes a single line of code.

Step *n*

STEP *n* executes *n* lines of code.

Step/INto (keypad: GOLD 0)

STEP/INTO steps into a subroutine. The default is to step over (i.e., execute the entire subroutine).

Step/RETurn

STEP/RETURN executes until a RETURN is encountered.

Ctrl C

Ctrl C interrupts the current execution and returns to the debug prompt.

EXit

EXIT exits or quits the debug session.

Listing Source Code

Type

TYPE lists the current line of source code.

Type *n:m*

TYPE *n:m* lists lines *n* to *m* in the current routine.

Type *routinen:m***

TYPE *routine* \ *n:m* lists lines *n* to *m* in *routine*.

SET SCoPe *routine*

SET SCOPE *routine* sets the current routine for typing and examining.

Examining Variable Values

EXamine *var₁, var₂ ...*

EXAMINE *var₁, var₂ ...* lists the values of the variables *var₁*, *var₂*, etc. in their default format.

EXamine *array (i:j,n:m)*

EXAMINE *array (i:j,n:m)* lists the values of *array* from *(i,n)* to *(j,m)*.

EXamine/ [BINARY, DECIMAL, HEXADECIMAL, OCTAL, ASCII, G_FLOAT, D_FLOAT]

EXAMINE with any of the format types as a qualifier lists values in the designated format, overriding the default format.

Miscellaneous

SHoW CALLs

SHOW CALLS lists the subroutine call sequences to the current position.

DEposit *var=value*

DEPOSIT *var=value* resets the value of *var*.

For *i=m* TO *n* BY *j* DO ()

The FOR ... DO construct repeats the operation in parentheses; for example,
FOR I = 1 TO 10 DO (DEPOSIT A(I)=0.).

SPAWN *command*

SPAWN *command* executes a DCL command and then returns to debug; for example,
SPAWN TYPE GENMESH.INP.

EValuate *expression*

Evaluates a simple arithmetic expression of variables or array elements.

References

- ANSI C. 1989. *Programming Language C*. New York, NY: American National Standards Institute, Inc.
- ANSI FORTRAN. 1978. *American National Standard Programming Language FORTRAN*. ANSI X3.9-1978. New York, NY: American National Standards Institute, Inc.
- Bertozzi, G., A. Saltelli, and H.C. Burkholder. 1985. "A Performance Assessment Code for Geological Repositories of Radioactive Waste," *International Topical Meeting on High-Level Nuclear Waste Disposal: Technology and Engineering, Pasco, WA, September 24, 1985*. Columbus, OH: Battelle Press. 607-616.
- Bertram-Howery, S.G., and R.L. Hunter, eds. 1989. *Preliminary Plan for Disposal-System Characterization and Long-Term Performance Evaluation of the Waste Isolation Pilot Plant*. SAND89-0178. Albuquerque, NM: Sandia National Laboratories.
- Campbell, J. E., C. D. Leigh, and D. E. Longsine. 1991. *NEFTRAN-S: A Network Flow and Contaminant Transport Model for Statistical and Deterministic Simulations Using Personal Computers*. SAND90-1987. Albuquerque, NM: Sandia National Laboratories.
- DEC (Digital Equipment Corporation). 1988a. *VMS Librarian Utility Manual, VMS Version 5.0, Programming Subkit, Vol. 2B*. Maynard, MA: Digital Equipment Corporation. Lib-3 to Lib-10.
- DEC (Digital Equipment Corporation). 1988b. *VAX FORTRAN Language Reference Manual, VAX FORTRAN Version 5.0*. Maynard, MA: Digital Equipment Corporation.
- DEC (Digital Equipment Corporation). 1988c. *VAX FORTRAN User's Manual, VAX FORTRAN Version 5.0*. Maynard, MA: Digital Equipment Corporation.
- DEC (Digital Equipment Corporation). 1990. *VMS Debugger Manual, VMS Version 5.9*. Maynard, MA: Digital Equipment Corporation.
- Dormuth, K.W. and G.R. Sherman. 1981. *SYVAC: A Computer Program for Assessment of Nuclear Fuel Waste Management Systems, Incorporating Parameter Variability*. AECL Report 6814. Pinawa, Manitoba, Canada: Atomic Energy of Canada Limited.
- EPA. 1985. "40 CFR 191: Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes: Final Rule," *Federal Register*. Vol 50, no. 182, 38066-38089.
- Erickson, K.M., and R.W. Simons. 1982. *Functional Specification of the Sandia Virtual Device Interface (SVDI)*. SAND81-1900. Albuquerque, NM: Sandia National Laboratories.
- Flanagan, D. P., W. C. Mills-Curran, and L. M. Taylor. 1986. *SUPES - A Software Utilities Package for the Engineering Sciences*. SAND86-0911. Albuquerque, NM: Sandia National Laboratories.
- Gilkey, A.P. 1988. *ALGEBRA - A Program That Algebraically Manipulates the Output of a Finite Element Analysis (Exodus Version)*. SAND88-1431. Albuquerque, NM: Sandia National Laboratories.

References

- Gilkey, A.P., and J. H. Glick. 1989. *BLOT - A Mesh and Curve Plot Program for the Output of a Finite Element Analysis*. SAND88-1432. Albuquerque, NM: Sandia National Laboratories.
- Goodwin, B.W., T.H. Andres, P.A. Davis, D.M. Leneveu, T.W. Melnyk, G.R. Sherman, and D.M. Wuschke. 1987. "Post-Closure Environmental Assessment for the Canadian Nuclear Fuel Waste Management Program," *Waste Management*. Vol. 8, nos. 2-3, 241-272.
- Helton, J. C., J. W. Garner, R. D. McCurley, and D. K. Rudeen. 1991. *Sensitivity Analysis Techniques and Results for Performance Assessment at the Waste Isolation Pilot Plant*. Contractor Report SAND90-7103. Albuquerque, NM: Sandia National Laboratories.
- IAEA (International Atomic Energy Agency). 1989. *Evaluating the Reliability of Predictions Made Using Environmental Transfer Models*. Safety Series Report No. 100. Vienna, Austria: International Atomic Energy Agency.
- Kernighan, B. W. and P. J. Plauger. 1974. *The Elements of Programming Style*. New York, NY: McGraw-Hill.
- Kernighan, B. W. and D.M. Ritchie. 1988. *The C Programming Language*. 2nd ed. Englewood Cliffs, NJ: Prentice Hall.
- Marietta, M. G., S. G. Bertram-Howery, D. R. Anderson, K. F. Brinster, R. V. Guzowski, H. J. Iuzzolino, and R. P. Rechard. 1989. *Performance Assessment Methodology Demonstration: Methodology Development for Evaluating Compliance with EPA 40 CFR 191, Subpart B for the Waste Isolation Pilot Plant*. SAND89-2027. Albuquerque, NM: Sandia National Laboratories.
- McLendon, P. 1991. *Silicon Graphics Graphics Library Programming Guide*. Document number 007-1210-040. Mountain View, CA: Silicon Graphics, Inc.
- Mills-Curran, W. C., A.P. Gilkey, and D.P. Flanagan. 1988. *EXODUS: A Finite Element File Format for Pre-and Post-Processing*. SAND87-2957. Albuquerque, NM: Sandia National Laboratories.
- Osborne, W.M. 1988. "Developers Must Design in Maintainability," *IEEE Software*. Vol. 5, no. 3, 104-105.
- Powers, D.W., S.J. Lambert, S.-E. Shaffer, L.R. Hill, and W.D. Weart, ed. 1978. *Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico*. SAND78-1596. Albuquerque, NM: Sandia National Laboratories. Vols. 1-2.
- Rechard, R. P. 1989. *Review and Discussion of Core Linkage and Data Flow in Nuclear Waste Compliance Assessments*. SAND87-2833. Albuquerque, NM: Sandia National Laboratories.
- Rechard, R. P. 1991. "Overview of Calculations," *Preliminary Comparison with 40 CFR Part 191, Subpart B for the Waste Isolation Pilot Plant, December 1991. Volume 2: Probability and Consequence Modeling*. SAND91-0893/2. Albuquerque, NM: Sandia National Laboratories.
- Rechard, R. P. ed. 1992. *User's Reference Manual for CAMCON: Compliance Assessment Methodology Controller, Version 3.0*. SAND90-1983. Albuquerque, NM: Sandia National Laboratories.
- Rechard, R.P., P.J. Roache, R.L. Blaine, A.P. Gilkey, and D.K. Rudeen. 1991. *Quality Assurance*

- Procedures for Computer Software Supporting Performance Assessments of the Waste Isolation Pilot Plant*. SAND90-1240. Albuquerque, NM: Sandia National Laboratories.
- Rechard, R.P., D.K. Rudeen, and P.J. Roache. 1992a. *Quality Assurance Procedures for Analyses and Report Reviews Supporting Performance Assessments of the Waste Isolation Pilot Plant*. SAND91-0428. Albuquerque, NM: Sandia National Laboratories.
- Rechard, R.P., K.M. Trauth, and R.V. Guzowski. 1992b. *Quality Assurance Procedures for Parameter Selection and Use of Expert Judgment Panels Supporting Performance Assessments of the Waste Isolation Pilot Plant*. SAND91-0429. Albuquerque, NM: Sandia National Laboratories.
- Red-Horse, J.R., W.C. Mills-Curran, and D.P. Flanagan. 1990. *SUPES Version 2.1: A Software Utilities Package for the Engineering Sciences*. SAND90-0247. Albuquerque, NM: Sandia National Laboratories.
- Rottler, J. S., A.P. Gilkey, and P.L. Hopkins. 1986. *Guidelines for Computer Software Development in Directorate 1500*. SAND86-0378. Albuquerque, NM: Sandia National Laboratories.
- Saltelli, A., G. Bertozzi, and D.A. Stanners. 1984. *LISA: A Code for Safety Assessment in Nuclear Waste Disposal Program Description and User Guide*. Luxembourg: Commission of the European Communities.
- Saltelli, A., T. Homma, P. Prado, and C. Torres. 1990. "Development of the LISA Code," *Proceedings of the International Symposium on Safety Assessment of Radioactive Waste Repositories, Paris, France, October 9-13, 1989*. Paris, France: Organisation for Economic Co-operation and Development. 639-648.
- Sherman, G.R., K.J. Hoffman, and D.C. Donahue. 1985. "The Program SYVAC, For Stochastic Assessment of Nuclear Fuel Waste Disposal," *Waste Management '85: Waste Isolation in the U.S., University of Arizona, Tucson, AZ, March 24-28, 1985*. Ed. R.G. Post. Tucson, AZ: University of Arizona. 403-408.
- Taylor, L.M., D.P. Flanagan, and W.C. Mills-Curran. 1987. *The GENESIS Finite Element Mesh File Format*. SAND86-0910. Albuquerque, NM: Sandia National Laboratories.
- Unsworth, M.D. 1989. *VANDAL Technical Overview*. DOE/RW/89.107. London, England: Department of the Environment.
- Weiss, E. H. 1982. *The Writing System for Engineers and Scientists*. Englewood Cliffs, NJ: Prentice-Hall.

WIPP Performance Assessment Procedures

- PAP02. 1993. *Computer Software Supporting Performance Assessment of the Waste Isolation Pilot Plant*. Albuquerque, NM: Sandia National Laboratories.
- PAP05. 1993. *Report Review Quality Assurance Procedures..* Albuquerque, NM: Sandia National Laboratories.

References

WIPP Quality Assurance Procedures

QAPD. *Sandia National Laboratories WIPP Quality Assurance Program Description*. Department 6303, Current Revision. Albuquerque, NM: Sandia National Laboratories.

QAPP. 1990. *Sandia National Laboratories Nuclear Waste Technology Department Waste Isolation Pilot Plant Quality Assurance Program Plan*. Department 6340, Current Revision. Albuquerque, NM: Sandia National Laboratories.

Appendix A:

Assessing the Performance of the WIPP

Assessing the compliance of the Waste Isolation Pilot Plant (WIPP) is reviewed here to provide the programmer with background on the demands placed on the users of CAMCON software and thereby help them better understand the customer's needs. In general, the discussion in this appendix focuses on the mechanics of the calculations (the "how") rather than on the more theoretical foundations (the "why"). If nothing else, this chapter strives to show the fundamental importance of software in the task of assessing the compliance of the WIPP with numerous regulations. The assessment task, in fact, would be impossible without this software.

An extensive description of (1) the WIPP can be found in Bertram-Howery and Hunter, eds., 1989, and (2) performance assessments (PA) can be found in Helton, 1991. In addition, the theoretical foundation for Sandia's approach to PA is thoroughly explained in reports by Tierney, 1991, and Helton et al., 1991.

A.1 Background on the WIPP

A.1.1 Purpose

The Department of Energy (DOE) was authorized by Congress in 1979 to build the Waste Isolation Pilot Plant (WIPP) as a research and development facility to safely manage, store, and eventually dispose of transuranic (TRU) waste generated by DOE defense programs (WIPP Act, 1979). Only after demonstrating compliance with the Environmental Protection Agency's (EPA) standard *40 CFR 191, Subpart B* (EPA, 1985) and other laws and regulations (e.g., RCRA, 1976, and NEPA, 1969) will the DOE permanently dispose of TRU waste at the WIPP repository.

A.1.2 Waste

The TRU waste generated by nuclear weapon facilities consists of laboratory and production trash such as glassware, metal pipes, disposable laboratory clothing, cleaning rags, solidified sludges, etc. The trash is contaminated by α -emitting, TRU elements (atomic numbers greater than uranium [92]) with half-lives greater than 20 years and curie contents greater than 100 nCi/g waste. Other radionuclide contaminants include uranium and several radionuclides with half-lives of less than 20 years. Approximately 60 percent of the trash may also be co-contaminated with RCRA (1976) hazardous waste such as lead (WEC, 1990).

A.1.3 Location

The WIPP site is located within a large sedimentary basin, the Delaware Basin, in southeastern New Mexico, an area of low population density, approximately 42 km (26 mi) east of Carlsbad.

A.1.4 Repository

The repository is located in the Delaware Basin because the 600-m (2,000-ft)-thick Salado Formation of marine bedded salts eventually encapsulates the nuclear waste through salt creep. The bedded salts, consisting of thick halite and interbeds of minerals such as clay and anhydrides approximately 255 million years old¹ (Late Permian Period), do not contain flowing water.

The repository level is located within these bedded salts about 658 m (2,160 ft) below the surface (381 m [1,250 ft] above sea level). The WIPP repository is composed of a single underground disposal level connected to the surface by four shafts. The repository level consists of an experimental area at the north end and a disposal area at the south end.

A.1.5 Sandia Role

Besides the DOE project office in Carlsbad, NM, which oversees the project, the WIPP has two major participants (WIPP Strategy, 1989): (1) Sandia National Laboratories (Sandia) functions as scientific investigator/advisor, and (2) Westinghouse Electric Company (WEC) is responsible for the WIPP site operations. A past participant was Bechtel, Inc., who was responsible for repository design.

The specific tasks of Sandia are as follows:

- Characterizing the disposal system and surrounding region and responding to specific concerns of the State of New Mexico
- Assessing the performance of the WIPP (i.e., assessing regulatory compliance with 40 CFR 191, Subpart B, except the Assurance Requirements)
- Performing analytic, laboratory, field experiments, and applied research to support disposal system characterization and performance assessment relevant to nuclear waste disposal in salt
- Providing ad hoc scientific and engineering support (e.g., supporting environmental assessments)

A.2 Performance Assessment of the WIPP

A.2.1 Compliance Strategy

A performance assessment (PA) is the general process of *assessing* whether a system meets a set of *performance criteria*. For *assessments* of long-term consequences of the full-scale Waste Isolation Pilot Plant (WIPP), the technique is performed by necessity with computer simulations. Hence, the *system* for the PA is a computational model that represents the WIPP's deep, geologic disposal system for waste

1. This time period reflects the revised 1983 geological time scale.

contaminated with transuranic radionuclides and hazardous chemical constituents. Because it is not practical to build, modify, and solve a single, three-dimensional model of the WIPP that contains enough detail to simulate the phenomena, events, and features of the entire disposal system, several models (a composite function) are used to simulate the WIPP's major physical components.

For the WIPP, the *performance criteria* are various environmental metrics in government regulations. The Environmental Protection Agency's (EPA) Containment Requirements in *40 CFR 191 (Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste)* is a regulation that specifies criteria that must be met for the next 10,000 yr. Because complying with this regulation is a computationally demanding exercise, it is an excellent driver for the development of the modeling methodology and analysis tools used by Sandia National Laboratories. It is expected that, with minor modifications, these same tools can be used to assess compliance with other long-term environmental regulations.

Although *40 CFR 191* does not require that risk be evaluated, its requirements are risk-based. Also *40 CFR 191* explicitly recognizes the uncertainty in scientific explanation (i.e., that hypotheses can only be judged based on current knowledge and therefore must be continuously refined as knowledge increases). Consequently, Sandia's approach to evaluating WIPP compliance resembles a scenario-based, probabilistic risk assessment in which the performance metric—radioactive release specified in probabilistic terms—is a complementary cumulative distribution function (CCDF) (or probability of exceedance curve). In essence, the performance assessment can be viewed as the process that estimates this CCDF.

Sandia's methodology approach was developed simultaneously with both the EPA's standards and the Nuclear Regulatory Commission's regulations. The methodology has been used to evaluate many early options for deep geologic repositories (e.g., Chu et al., 1983; Campbell and Cranwell, 1988) and to perform feasibility studies with the international Nuclear Energy Agency for subseabed disposal in deep oceans (e.g., Marietta and Simmons, 1988). These exploratory computational tools provided guidance for the methodology currently used in evaluating long-term performance of the WIPP.

A.2.2 Six General Tasks of PA

A convenient way to mathematically describe a PA is by viewing the risk-based performance criterion of the Containment Requirements in *40 CFR 191* as a set of ordered triples (Helton, 1993) that consists of answers to the following three questions:

- What can happen? (scenarios)
- What are the outcomes of these things happening? (consequences of scenarios)
- How likely are these things to happen? (probabilities of scenarios)

The answer to the first question is a systematic collection of features, events, and phenomena, which

provides a set of similar occurrences that specify what may happen to the disposal system in the future, $S_j(x)$. Answering the second question requires the use of a modeling system to estimate consequences of the j th scenario occurring, $C(S_j(x), x)$. The answer to the third question is an estimate generated by a modeling system of how likely these scenarios are to happen, i.e., the probability of the j th scenario, $P(S_j(x), x)$. A CCDF displays the second and third elements, consequence and probability, of this ordered triple. Uncertainty in the calculation of the CCDF can arise from any of the three elements of the triplet (scenario, consequence, and probability) or the underlying parameters ($\mathbf{x} = x_1, \dots, x_n$). The WIPP PA Department uses a Monte Carlo technique to propagate uncertainty through the PA and thereby quantitatively evaluate the uncertainty in the calculation. Although the predictive uncertainty cannot be evaluated quantitatively (e.g., through a parameter), it may be evaluated qualitatively by peer review (Rechard et al., 1992a; 1992b).

The theoretical foundations of CCDF construction are explained elsewhere (e.g., Tierney, 1991; Helton, 1993); however, the mechanical process of a PA consists of six general tasks. The components of these basic tasks are shown below:

1. **WIPP disposal system and regional characterization** through collection of data on waste properties, facility design and regional geology and hydrology
2. **Scenario development**, $S_j(x)$, which identifies the features, events, and phenomena whereby contaminants might be released to the EPA-defined accessible environment, and scenario selection for modeling
3. **Consequence analysis**, which predicts contaminant amounts released, $C(S_j(x), x)$, including evaluating the uncertainties associated with the predictions
4. **Probability modeling**, which provides estimates of the likelihood that the selected scenarios will occur, $P(S_j(x), x)$
5. **Regulatory compliance assessment** through construction of CCDFs and other performance metrics and comparison of them with long-term environmental regulations
6. **Sensitivity analysis**, which determines the parameters that most influence the performance metrics and thereby provide guidance to the WIPP project

The first two PA tasks listed above are referred to collectively as model conceptualization (Figure A-1). Characterization of the disposal system and surrounding regional hydrology has been in progress since project inception in 1975 (e.g., Powers et al., 1978) and is nearing completion. Screening of events and processes that may affect performance of the system during the next 10,000 years is also nearly complete, and significant summary scenarios have been identified for consideration in consequence modeling (Guzowski, 1990; Helton, 1991) where scenario means a class or grouping of similar possible future conditions (histories) of the disposal system.

For Task 3, a probability model is developed to evaluate probabilities of detailed scenarios for analysis. Currently, the probabilities are evaluated assuming human intrusion (drilling for resources) is a Poisson process (Helton, 1991; Miller and Freund, 1977, p. 81).

TRI-6342-2156-0

Figure A-1. Sandia's method for assessing WIPP repository compliance involves six tasks (after Rechar, 1989, Figure 3.1).

A major portion of the methodology consists of simulating physical processes to estimate the amount of radionuclides released to the accessible environment following the hypothetical event that someone drills into the repository over the next 10,000 years. This process is referred to as consequence modeling and actually is a composite function of several models (Task 4) (Figure A-2). This task is more thoroughly described in the next section.

Several generic computational models are used to simulate major physical components of the WIPP disposal system (Figure A-2). Usually the codes are generic and implement a variety of mathematical models using several numerical solution techniques. Hence, some codes are used to model several different physical features of the WIPP and are repeated in several places. Furthermore, the need to benchmark results requires that several different codes be able to model similar features and phenomena; thus, some WIPP features show more than one code being used (refer to Rechar, 1992, for description of codes).

Because of imprecisely known parameters, uncertainty is incorporated into the performance assessment through a Monte Carlo analysis (part of Task 4), since Monte Carlo analysis can accommodate large uncertainty in input and large nonlinearity in the models. Monte Carlo analysis consists of first identifying the important parameters to vary and assigning ranges and distributions.

Figure A-2. Major computational models (codes) and the physical features they simulate in the WIPP disposal system (after Rechar, 1991, Figure 1-2). (Refer to *User's Reference Manual for CAMCON* [Rechar, 1992] for descriptions of codes listed.)

Second, sample elements are generated from these distributions. In the WIPP performance assessment, Latin hypercube sampling (LHS) is used to minimize the number of sample elements needed to capture variability in the parameters adequately.

From the consequence results using Monte Carlo analysis, the final two tasks naturally follow. In Task 5, the results are compared with the regulations. In Sandia's approach to Task 5, estimated releases are combined into CCDFs (exceedance probability curves) as suggested in Appendix B, *40 CFR 191*.

Task 6, performing sensitivity analyses, is a significant part of the WIPP performance assessment. Sensitivity analysis involves determining the contributions of an individual parameter to influence the consequences and its uncertainty. The analysis involves plotting scatter plots and developing regression models between the parameters and the various results. Two important purposes of the sensitivity analysis are (1) to help gain understanding and insight about the WIPP disposal system and (2) provide input so that decision makers can allocate data collection resources toward those parameters that most influence the results (e.g., CCDF), based on what is already known about the site. This thorough analysis also helps verify the correctness of the calculations.

A.2.3 Multiple Iterations through PA

The strategy of performing several PA iterations is beneficial because each iteration brings new information to the process. Initially, available data and information are used to develop preliminary scenarios, which are then analyzed with simple models to calculate bounding results. If these initial results are either indefensible or indecisive, better data, more complete conceptual models, and more complex computational models are used for subsequent calculations, which incorporate additional details of known phenomena, as appropriate. By repeating this process, defensible calculations are eventually constructed on which a final decision about radioactive waste disposal at the WIPP can be made. Sandia's PA Department has performed periodic PAs of the WIPP since 1989 (Marietta et al., 1989; Bertram-Howery et al., 1990; WIPP PA Division, 1991; WIPP PA Department, 1992).

Iterative refinement is not necessarily confined to the overall PA but can also occur in many subprocesses (Morgan and Henrion, 1990). Although iterations frequently occur during disposal system design and characterization, they are not limited to this step and can occur elsewhere within the PA process. A particularly important subprocess iteration for the PA is the assignment of parameters appropriate to the scale and detail of the models chosen for the PA analysis, given the facility design and what is known about phenomena at the site.

Multiple PA iterations achieve six goals (Rechard et al., 1992a; Rechard, 1989):

- The analysis team focuses on customer and stakeholder expectations and, through multiple iterations, can alter the process to satisfy a customer or stakeholder expectation; conversely, the customers and stakeholders are given several opportunities to learn about the PA process. This activity is especially important for decisions such as nuclear waste disposal, which must be made by more than one authority or agency over a period of years.

- Analysts develop insight about the disposal system because different hypotheses about the system performance can be tested.
- Through periodic peer reviews, analysts receive scientific feedback from multidisciplinary teams.
- In some instances, analyses can be partially validated through multiple iterations (e.g., when critical questions are posed in early iterations and then validated in later iterations based on newly collected data).
- Multiple iterations of sensitivity analyses for both system-wide and individual components provide project managers and, more important, the participants themselves, with information to help more wisely allocate resources for data collection and either elaborate or simplify models.
- Large, long-term projects such as the WIPP can be divided into several parts with more easily agreed-upon constraints and schedules (i.e., the project becomes a series of small steps repeated several times—a useful technique to produce a quality product).

A.3 Overview of Consequence Modeling

The following discusses the calculations using the framework of the PA methodology. Task 4, consequence modeling, is emphasized. Prior to discussing the mechanics of the calculations, some general issues are discussed.

A.3.1 Model Subdomains in Consequence Modeling

A three-dimensional model with the necessary detail to analyze hydrologic processes (or transport) both far from and near to the repository for every scenario would take too long to build, modify, and solve. Hence, models are scaled to make an analysis tractable. However, disposal system analysis has an additional complication: the use of different model scales or subdomains that must pass pertinent results to each other. The modeling systems associated with the different subdomains are in addition to those required for evaluating different processes such as fluid flow or radionuclide transport.

Modeling Scales. For disposal systems, three scales are frequently used (Figure A-3):

- Repository
- Regional
- Local

The primary function of the repository scale model is to calculate migration of radionuclides (or other hazardous waste) from the consolidated waste-disposal rooms through the seals, drifts, and shafts. The time versus radionuclide concentration curves are then used as a source term for evaluating transport in the local scale models. The complexity of the physical processes affecting the repository requires that initial source-term calculations involving several codes modeling various coupled processes be carefully linked together. In other words, a microcosm of the overall compliance assessment is needed. For the WIPP project, the analysis of the repository scale has been divided into a cuttings model system and a repository/shaft/borehole modeling system, which are described later.

TRI-6330-7-8

Figure A-3. Three model scales are typically used in compliance assessment (after Bertram-Howery and Hunter, eds., 1989, Figure II-1).

The primary function of the regional scale model is to establish groundwater flow patterns in a large region bounding the controlled area of the repository. The flow conditions (e.g., heads, fluxes, or brine densities) are then used to establish boundary conditions for the next scale model, the local model.

The function of the local scale model is to predict more precisely the flow field within the controlled area for transport calculations. The local scale model is completely embedded with the regional scale model. Two scales, a regional and a local scale, are used in the Culebra groundwater modeling system in the analysis of the WIPP.

Setting Boundary Conditions. Embedding models can reduce unnecessary model complexity (operations per grid point per time step) and thereby model run times. However, when embedding models, an important process that affects the flow of data is setting boundary conditions. The process of embedding meshes as previously described involves interpolating from a coarse grid to a fine grid just the opposite of what is mathematically convenient. Simple or complex interpolation schemes can cause discontinuities in the fields, the simple by ignoring too much detail and the complex by fabricating more detail than is warranted from the information contained in the coarse mesh.

The development of interpolation programs is not trivial. Several questions must be answered:

- How will changes in vertical resolution of stratigraphy between the regional and local model be handled?
- How will time scales between the local and regional models be separated to permit different time steps, thereby increasing computational efficiency?
- How many surrounding grid points will be included in spatial interpolations?

A.3.2 Modeling Systems

As alluded to above, the WIPP disposal system was divided into three systems for modeling: Repository/Shaft/Borehole, Culebra Groundwater Flow and Transport, and Cuttings. Each of these modeling systems are analyzed in parallel. The results from these consequence modeling systems are combined with the results from the probability model to construct the complementary cumulative distribution functions (CCDFs) for the regulatory assessment and sensitivity analysis tasks. Besides the model and parameter selections, the general steps in each modeling system are (1) data preparation, either from the parameters or from results stored in the data bases, (2) simulation, and (3) examination of intermediate results (Figure A-4).

In the following discussions, typical code names from the CAMCON system are used as a way of identifying items in Figure A-4. The description of these codes is in the *User's Reference Manual for CAMCON* (Rechard, 1992). Other codes from the CAMCON modules identified on the edge of Figure A-4 may be used. Translators that may be necessary for several of the codes are not discussed or shown in Figure A-4.

TRI-6342-56-9

Figure A-4. Overview of PA calculations (after Rechar, 1991, Figure 1-3) (Refer to *User's Reference Manual for CAMCON* [Rechar, ed., 1992] for descriptions of codes listed.)

Model and Parameter Selection. The calculations start with model and parameter selection. This can be a time-consuming process, but in short, the process involves compiling data and then developing conceptual, mathematical, and computational models if necessary. It is then followed by evaluating and selecting parameters to vary. Following these decisions, data are entered in the data base and are sampled. Once this critical step is completed, the analysts can begin the task of performing the calculations (Figure A-4).

Cuttings Modeling. The Cuttings Modeling System predicts the radionuclide release by transport of cuttings to the surface assuming intrusion by drilling sometime within the next 10,000 years. The mechanics of modeling the initial human intrusion by drilling into the repository is fairly simple. It involves input preparation such as the data base set up and extraction of pertinent data from the data base and sampled parameters. Then the CUTTINGS code is run for each sample element for each time.

Repository/Borehole Modeling. The repository/borehole modeling system models phenomena around the repository. These phenomena include gas generation from corrosion and microbiological degradation of the waste, brine movement around the waste over time, and the possible saturation of the waste by the brine reservoir following intrusion and creep closure. The two-phase numerical codes BRAGFLO and BOAST II and the one-phase analytic code PANEL model these phenomena.

Culebra Groundwater Flow Modeling. The Culebra Modeling System evaluates flow and transport in the Culebra Dolomite Member of the Rustler Formation following intrusion. Flow and transport are grouped into the same modeling subdivision because they model the same unit, the Culebra Dolomite Member at the Rustler Formation. However, the modeling and number of simulations are different and are separated in this discussion.

The groundwater flow component of the Culebra modeling system is more complicated. It not only consists of a normal data-preparation steps, such as mesh generation (GENMESH) and setting material properties (MATSET) and boundary conditions, but it also consists of evaluating the uncertainty of the transmissivity field of the Culebra (GENOBS, FITBND, and SWIFT). This can be followed by the analysis of the groundwater flow on the regional scale with SECO_2D.

Culebra Groundwater Transport Modeling. The second part of the Culebra modeling system is the evaluation of radionuclide transport from the intrusion borehole to the 5-km boundary of the accessible environment and through the Culebra. The TRACKER code is used. The RELATE code is used to evaluate boundary conditions for fluid flow on a greatly decreased local mesh. STAFF2D (Huyakorn et al., 1991) can then be used to evaluate first flow and then transport on this local two-dimensional domain. Currently, no borehole model is used; rather, the radionuclide concentrations (mass flux only) from the repository/borehole modeling system are directly injected into the Culebra at a point directly above the center of the disposal area. Following the STAFF2D simulations, a support program, ALGEBRA, is used to evaluate radionuclide transport across the 5-km boundary of the accessible environment.

A.4 Requirements for the PA Software

Based on the compliance assessment procedure just described, software to aid in PA calculations is needed to meet several requirements. Generally, the requirements can be grouped into two categories: built-in flexibility and built-in quality assurance (QA) features. Specifically, the software must

- Accurately link several distinct model components with little analyst intervention to eliminate tedious preparation of parameters (previous results from the chained analysis) (QA and flexibility)
- Trace the calculations so that they can be repeated (QA), in addition to software QA features on individual modules
- Propagate uncertainty by Monte Carlo analysis, uniquely identifying calculations to avoid misinterpretation (QA and flexibility)
- Permit an analyst to examine a large number of intermediate and final results (QA and flexibility)
- Allow interpolation between modeling scales (flexibility)
- Permit iteration between computer codes (flexibility)
- Aid in exploring phenomena modeled by codes (e.g., of the repository model) (flexibility)
- Be flexible in switching between codes to aid in scenario screening, model/model comparisons, sensitivity analysis, and fine-tuning of the system for final compliance assessment calculations (flexibility)
- Be computationally tractable

In other words, the variety of scenarios analyzed, the varying complexity of models used, and the need to switch codes when cycling through the procedure are characteristic of compliance assessments that require a flexible and versatile implementation. Furthermore, the number of repetitive computer runs, the need to properly identify runs, and the need to recreate runs are characteristics that require adequate quality assurance implementation.

Although several software analysis systems have been built to perform the numerous computer simulations necessary for a PA, the Sandia WIPP PA Department chose instead to build CAMCON, an analysis tool box that links together separate codes (either complex numerical or simple analytic codes) (Rechard, ed., 1992). This approach (1) directly makes use of the interdisciplinary expertise represented in pre-existing codes as opposed to indirectly incorporating these concepts into one comprehensive code, and (2) allows the same modeling system to be used for both detailed examination of the individual components and the overall disposal system (with the possible exception of substituting fast-running codes or modeling subdomains in the latter analysis when necessary). Both points are especially important for radioactive waste disposal where the calculations are under intense scrutiny and elaborate procedures are sometimes necessary to ensure that all steps taken in the analysis are defensible. A PA system that is capable of handling both detailed and simplified computational models is invaluable in this regard.

A simplified “behind the scenes” view of the structure (CAMCON system) that supports the Repository/Shaft/Borehole Modeling System shown in Figure A-5 hints at the complexity of the flow of information in the PA calculations. Besides the flow of information, the parts of the CAMCON system shown are the secondary data base and numerous CAMDAT files. Basically, behind each of the modeling systems (Repository/Shaft/Borehole, Culebra Groundwater Flow and Transport, and Cuttings) are the numerous CAMDAT files storing the information for each of the sample (LHS) vectors.

Figure A-5. CAMDAT, a primary component of the CAMCON system, is the behind-the-scenes structure that supports the PA calculations depicted in Figure A-4.

References

- Bertram-Howery, S. G., and R. L. Hunter, eds. 1989. *Preliminary Plan for Disposal-System Characterization and Long-Term Performance Evaluation of the Waste Isolation Pilot Plant*. SAND89-0178. Albuquerque, NM: Sandia National Laboratories.
- Bertram-Howery, S. G., M. G. Marietta, R. P. Rechard, P. N. Swift, D. R. Anderson, B. L. Baker, J. E. Bean, Jr., W. E. Beyeler, K. F. Brinster, R. V. Guzowski, J. C. Helton, R. D. McCurley, D. K. Rudeen, J. D. Schreiber, and P. Vaughan. 1990. *Preliminary Comparison with 40 CFR Part 191, Subpart B for the Waste Isolation Pilot Plant, December 1990*. SAND90-2347. Albuquerque, NM: Sandia National Laboratories.
- Campbell, J. E., and R. M. Cranwell. 1988. "Performance Assessment of Radioactive Waste Repositories," *Science*. Vol. 239, no. 4846, 1389-92.
- Chu, M. S. [Y.], N. R. Ortiz, K. K. Wahi, R. E. Pepping, and J. E. Campbell. 1983. *An Assessment of the Proposed Rule (10CFR60) for Disposal of High-Level Radioactive Wastes in Geologic Repositories*. Vol. 1. SAND82-2969, NUREG/CR-3111. Albuquerque, NM: Sandia National Laboratories.
- EPA (U.S. Environmental Protection Agency). 1985. *Environmental Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, Federal Register*. Vol. 50, no. 182, 38066-38089.
- Guzowski, R. V. 1990. *Preliminary Identification of Scenarios That May Affect the Escape and Transport of Radionuclides from the Waste Isolation Pilot Plant, Southeastern New Mexico*. SAND89-7149. Albuquerque, NM: Sandia National Laboratories.
- Helton, J. C. 1991. "Performance-Assessment Overview," *Preliminary Comparison with 40 CFR Part 191, Subpart B for the Waste Isolation Pilot Plant, December 1991. Volume 1: Methodology and Results*. SAND91-0893/1. Albuquerque, NM: Sandia National Laboratories.
- Helton, J. C. 1993. "Risk, Uncertainty in Risk, and the EPA Release Limits for Radioactive Waste Disposal," *Nuclear Technology*. SAND91-1255J. Vol. 101, no. 1, 18-39.
- Helton, J. C., J. W. Garner, R. D. McCurley, and D. K. Rudeen. 1991. *Sensitivity Analysis Techniques and Results for Performance Assessment at the Waste Isolation Pilot Plant*. Contractor Report SAND90-7103. Albuquerque, NM: Sandia National Laboratories.
- Huyakorn, P. S., H. O. White, Jr., and S. Panday. 1991. *STAFF2D, Version 3.1: A Two-Dimensional Finite Element Code for Simulating Fluid Flow and Transport of Radionuclides in Fractured Porous Media with Water Table Boundary Conditions*. Herndon, VA: HydroGeologic, Inc.
- Marietta, M. G., and W. F. Simmons. 1988. *Feasibility of Disposal of High-Level Radioactive Wastes into the Seabed: Dispersal of Radionuclides in the Oceans: Models, Data Sets, and Regional Descriptions*. SAND87-0753. Albuquerque, NM: Sandia National Laboratories.
- Marietta, M. G., S. G. Bertram-Howery, D. R. Anderson, K. F. Brinster, R. V. Guzowski, H. [J.] Iuzzolino, and R. P. Rechard. 1989. *Performance Assessment Methodology Demonstration: Methodology Development for Evaluating Compliance with EPA 40 CFR 191, Subpart B, for the Waste Isolation Pilot Plant*. SAND89-2027. Albuquerque, NM: Sandia National Laboratories.

- Miller, I., and J. E. Freund. 1977. *Probability and Statistics for Engineers*. 2nd ed. Englewood Cliffs, NJ: Prentice-Hall.
- Morgan, M. G., and M. Henrion. 1990. *Uncertainty, A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis*. Cambridge, UK: Cambridge University Press.
- NEPA. 1969. *National Environmental Policy Act of 1969*. Public Law No. 91-190, 83 Stat. 852.
- Powers, D. W., S. J. Lambert, S-E. Shaffer, L. R. Hill, and W. D. Weart, eds. 1978. *Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico*. SAND78-1596. Albuquerque, NM: Sandia National Laboratories. Vols. 1-2.
- RCRA. 1976. *Resource Conservation and Recovery Act of 1976*. Public Law No. 94-580, 90 Stat. 2795.
- Rechard, R. P. 1989. *Review and Discussion of Code Linkage and Data Flow in Nuclear Waste Compliance Assessments*. SAND87-2833. Albuquerque, NM: Sandia National Laboratories.
- Rechard, R. P. 1991. "Overview of Calculations," *Preliminary Comparison with 40 CFR Part 191, Subpart B for the Waste Isolation Pilot Plant, December 1991. Volume 2: Probability and Consequence Modeling*. SAND91-0893/2. Albuquerque, NM: Sandia National Laboratories.
- Rechard, R. P., ed. 1992. *User's Reference Manual for CAMCON: Compliance Assessment Methodology Controller, Version 3.0*. SAND90-1983. Albuquerque, NM: Sandia National Laboratories.
- Rechard, R. P., D. K. Rudeen, and P. J. Roache. 1992a. *Quality Assurance Procedures for Analyses and Report Reviews Supporting Performance Assessments of the Waste Isolation Pilot Plant*. SAND91-0428, Albuquerque, NM: Sandia National Laboratories.
- Rechard, R. P., K. M. Trauth, and R. V. Guzowski. 1992b. *Quality Assurance Procedures for Parameter Selection and Use of Expert Judgment Panels Supporting Performance Assessments of the Waste Isolation Pilot Plant*. SAND91-0429. Albuquerque, NM: Sandia National Laboratories.
- Tierney, M. S. 1991. *Combining Scenarios in a Calculation of the Overall Probability Distribution of Cumulative Releases of Radioactivity from the Waste Isolation Pilot Plant, Southeastern New Mexico*. SAND90-0838. Albuquerque, NM: Sandia National Laboratories.
- U.S. DOE (Department of Energy). 1991. *Recommended Strategy for the Remote-Handled Transuranic Waste Program*. DOE/WIPP 90-058, Revision 1. Carlsbad, NM: Waste Isolation Pilot Plant.
- WEC (Westinghouse Electric Corporation). 1990. *Waste Isolation Pilot Plant No-Migration Variance Petition*. DOE/WIPP 89-003, Rev. 1. Prepared for U.S. Department of Energy. Carlsbad, NM: Westinghouse Electric Corporation.
- WIPPA. 1979. *Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980. Title II - General Provisions: Sec. 213(a), Waste Isolation Pilot Plant, Delaware Basin, NM*. Public Law No. 96-164, 93 Stat. 1259.
- WIPPA Department. 1992. *Preliminary Performance Assessment for the Waste Isolation Pilot Plant, December 1992. Volume 1: Third Comparison with 40 CFR 191, Subpart B*. SAND92-0700/1. Albuquerque, NM: Sandia National Laboratories.

Appendix A
References

WIPP PA Division. 1991. *Preliminary Comparison with 40 CFR Part 191, Subpart B for the Waste Isolation Pilot Plant, December 1991. Volume 1: Methodology and Results*. SAND91-0893/1. Albuquerque, NM: Sandia National Laboratories.

WIPPStrategy. 1989. *Waste Isolation Pilot Plant Compliance Strategy for 40 CFR Part 191*. DOE-WIPP 86-013. Prepared by Sandia National Laboratories and Westinghouse Electric Corporation for the U.S. Department of Energy. Carlsbad, NM: WIPP Project Office.

Appendix B:

CAMCON System Personnel and Software Sponsors

This appendix lists individuals within the PA Department that programmers may wish to contact to answer questions about the CAMCON system.

B.1 WIPP Computer System Administrator

The administrator and operators of the WIPP computer system are responsible for the day-to-day operation of the computer and implementing any major acquisition plans approved by the Sandia WIPP Project Manager.

A list of the current operators and how to contact them is obtained by typing **CONTACT** at the system prompt.

In addition to the system operators, a local system expert has been assigned by the PA Department to handle questions on PA Department computer equipment (e.g., PCs and printers), local computer equipment application software (e.g., spreadsheets), and the local area network.

PA Department Contact: Bruce L. Baker (BLBAKER)
 Technadyne, Inc
 505-766-9629

B.2 Performance Assessment QA Coordinator

The QA coordinator implements quality assurance tasks for software, data, analysis, document review, and expert judgment panels. Responsibilities related to software development for CAMCON are summarized below (see PAP02, 1993, or Rechard et al., 1991, for a complete list of responsibilities for software and PAP03, PAP04, PAP05, and PAP06 [all 1993] for other responsibilities):

- Select software sponsors and software consultants
- Select software review committee
- Assist individuals in interpreting the meaning of QA procedures
- Approve content of software abstract
- Categorize software as to calculation type (Scientific/Engineering Software [SES] or non-SES) and source type (internal Sandia software or external software)
- Coordinate any assistants

QA Coordinator: Rob P. Rechard (RPRECHA)
 Sandia National Laboratories
 505-766-9629

B.3 Assistant to QA Coordinator for Software

The primary responsibility of the assistant is to support the QA coordinator in the five main areas controlled by the QA procedures in the PA Department. The currently designated tasks for the software QA assistant are as follows

- Maintain software notebooks
- Send updates of software notebooks to WIPP QA chief
- Track and report status of CAMCON system software
- PA Department application software for local computer equipment (e.g., spreadsheets)

Contact: Kathleen A. Byle (KABYLE)
New Mexico Engineering Research Institute
505-766-9629

B.4 CAMCON System Task Leader

The CAMCON system task leader is responsible for coordinating the development of software tools for performance assessments. Several of the more prominent responsibilities are as follows:

- Set up and administer the CAMCON system (software management system described in PAP02, 1993, or Rechard et al, 1991)
- Periodically publish user's manuals summarizing codes within the CAMCON system (e.g., Rechard, 1992)
- Answer general questions on preferred programming practices (this manual)
- Define user interfaces and data flow in the CAMCON system for all software (e.g., coordinate development of translators) (this manual)
- Periodically publish the use of software libraries (this manual)
- Coordinate programmers who are developing software tools (utilities and support codes), thus directing CAMCON system support (this manual)

Contact: Rob. P. Rechard (RPRECHA)
Sandia National Laboratories
505-766-9629

B.5 CAMCON System Sponsors

Table B-1 alphabetically lists the software and corresponding software sponsor reported within this programmer's manual. Other CAMCON system software is reported in the CAMCON User's Manual (Rechard, 1992). The sponsors are the best source of answers to detailed questions on the use of CAMCON system software; however, a general contact for programmers on the use of CAMCON system software within codes is as follows:

Contact: J. S. Rath
New Mexico Engineering Research Institute
505-766-9629

Table B-1. CAMCON System Sponsors

Software	Sponsor
ABSGEN	K. A. Byle ¹
[CAMCON] Directories	A. P. Gilkey ¹
CAMCONexec	A. P. Gilkey
CAMCON_LIB	A. P. Gilkey
CAMSUPES_LIB	A. P. Gilkey
CAMDAT_LIB	A. P. Gilkey
CHANGES	A. P. Gilkey
CREATE_PROGRAM	A. P. Gilkey
DVDI_LIB	A. P. Gilkey
FLINT	A. P. Gilkey
FORMRENUM	A. P. Gilkey
HLPCHK	K. A. Byle
HJIPLT_LIB	H. J. Iuzzolino ²
LISTDCL	A. P. Gilkey
LISTFORTRAN	A. P. Gilkey
PLT_LIB	A. P. Gilkey
QA_PREP	K. A. Byle
QA_PRINT	J. S. Rath ¹
SDBREAD_LIB	H. J. Iuzzolino
UPDATE_PROGRAM	A. P. Gilkey

¹New Mexico Engineering Research Institute, University of
New Mexico, Albuquerque, NM

²Geo-Centers, Inc., Albuquerque, NM

References

Rechard, R. P. ed. 1992. *User's Reference Manual for CAMCON: Compliance Assessment Methodology Controller, Version 3.0*. SAND90-1983. Albuquerque, NM: Sandia National Laboratories.

Rechard, R.P., P.J. Roache, R.L. Blaine, A.P. Gilkey, and D.K. Rudeen. 1991. *Quality Assurance Procedures for Computer Software Supporting Performance Assessments of the Waste Isolation Pilot Plant*. SAND90-1240. Albuquerque, NM: Sandia National Laboratories.

WIPP Performance Assessment Procedures:

PAP02. 1993. *Computer Software Supporting Performance Assessment of the Waste Isolation Pilot Plant*. Albuquerque, NM: Sandia National Laboratories.

PAP03. 1993. *Parameter Selection Quality Assurance Procedure*. Albuquerque, NM: Sandia National Laboratories.

PAP04. 1993. *Analysis Quality Assurance Procedures*. Albuquerque, NM: Sandia National Laboratories.

PAP05. 1993. *Report Review Quality Assurance Procedures*. Albuquerque, NM: Sandia National Laboratories.

PAP06. 1993. *Use of Expert Judgment Panel Quality Assurance Procedures*. Albuquerque, NM: Sandia National Laboratories.

Glossary

Acronyms

ASCII	- American Standard Code for Information Interchange
CAMCON	- Compliance Assessment Methodology CONTroller—computational system for assessing the performance of the WIPP
CAMCONexec	- CAMCON executive package, a suite of procedural files that act as an interface between separate codes within CAMCON
CAMDAT	- Compliance Assessment Methodology DATaBase—computational data base developed for the WIPP (extensive modification of EXODUS)
CCDF	- Complementary Cumulative Distribution Function—the performance measure for spent nuclear fuel, HLW, and TRU repositories specified in 40 CFR 191.
CDB	- Computational Data Base (neutral file)
CH	- Contact Handled (TRU waste)
DCL	- Digital Equipment Corporation Command Language for the VAX/VMS operating system
DOE	- U.S. Department of Energy, formed by DOE Organization Act (Public Law 95-91, 91 Stat. 565), which replaced the Energy Research and Development Agency (ERDA). The ERDA was formed by the 1974 Energy Reorganization Act (Public Law 93-438), and replaced the Atomic Energy Commission (AEC), formed in 1946 (August 1, 1946, 60 Stat. 755).
DVDI	- Dual Virtual Device Interface—an extension to SVDI to allow two plot devices to be active during a plotting session.
EPA	- U.S. Environmental Protection Agency
EXODUS	- Computational data base file format developed by Engineering Sciences Center at Sandia (Mills-Curran et al., 1988)
FD	- Finite difference numerical implementation of a mathematical model
FE	- Finite element numerical implementation of a mathematical model
HLW	- High-Level Waste, meaning (1) liquid wastes from reprocessing irradiated reactor fuel (spent nuclear fuel), (2) solids into which the wastes have been converted, and other highly radioactive material requiring permanent isolation
PA	- Performance Assessment (see glossary definition)

QA	- Quality Assurance (see glossary definition)
QAP	- Quality Assurance Procedure for the portion of the WIPP project conducted at Sandia
QAPP	- Quality Assurance Program Plan for Sandia WIPP project
RCRA	- Resource Conservation and Recovery Act of 1976 (Public Law 94-580) and subsequent amendments (e.g., HSWA–Hazardous and Solid Waste Amendments of 1984, Public Law 98-616).
RH	- Remote Handled (TRU waste)
SDB	- Secondary Data Base (neutral file)
SVDI	- Sandia Virtual Device Interface—a collection of subroutines that perform basic graphic operations with the capability to interface to several graphic devices.
SWCF	- Sandia WIPP Central File—archives for WIPP QA records produced by Sandia National Laboratories
TRU	- Transuranic radionuclide waste—trash contaminated with more than 10 nCi transuranic radionuclides (atomic number greater than 92) emitting α radiation with halflife greater than 20 years and an activity greater than 100 nCi.
WIPP	- Waste Isolation Pilot Plant—a deep geologic repository for TRU waste generated by the DOE nuclear weapons facilities authorized in Public Law 96-164, 93 Stat. 1259.
40 CFR 191	- Code of Federal Regulations, Title 40, Part 191, <i>Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear</i>

Definitions

Accessible environment - "... (1) the atmosphere, (2) land surfaces, (3) surface water, (4) oceans, and (5) all of the lithosphere that is beyond the controlled area" (40 CFR 191.12(k)) where "controlled area" means" (1) [a] surface location, to be identified by passive institutional controls, that encompasses no more than 100 square kilometers and extends horizontally no more than five kilometers in any direction from the outer boundary of the original location of the radioactive wastes in a disposal system; and (2) the subsurface underlying such a surface location (§191.12(g)).

Alternative conceptual models - Multiple working sets of hypotheses and assumptions of a system that are all scientifically acceptable (i.e., consistent with the purpose of the model, logically consistent with one another, in agreement with existing facts and observed data, and able to be tested).

Alternative models - Alternatives in model form that may exist at each stage of model development. Alternative conceptual models are often of the most concern.

Analysis - Analysis is the rational investigation of a natural or artificial phenomenon to discover principles that underlie the phenomenon. More formally, analysis is the five-step process of (1) defining (developing hypothesis and planning), (2) investigating, (3) validating, (4) reviewing, and (5) documenting the study of a system. This rational study often involves "teasing" the system "apart" i.e., the division of the whole system into simpler components to gain understanding. However it may also involve synthesis, i.e., the bringing together of diverse facts to comprehend the whole system. Consequently, analysis is at the heart of the method of scientific discovery and explanation. (See engineering analysis.)

Applied model - The analyst's application of the generic computational model to a particular system, using appropriate values for dimensions of the system components, parameters, and boundary and initial conditions. In a waste management, the system is a waste disposal site, and so this model is also referred to as a site-specific model.

Attribute parameters or properties - Parameters that have a rough characteristic range for each material but vary spatially and are thus differ at each element in the computational mesh. They are attributes of each node or element in the mesh (the numerical discretization of the material)

Benchmarking - The comparison of predictions of a particular problem or test case made with one applied model with predictions made with other numerical or analytical computational models, where all models were designed to solve comparable mathematical models. Verification (and occasionally process validation) exercises may use benchmarking.

Cache - The process of storing information, data, and software necessary for the PA process at Sandia so that it can be retrieved in computer form and duplicated relatively easily. The stored information may eventually enter the official WIPP archives but not necessarily, and so the term *archive* is purposely avoided.

Class A Software - Class A (Adjudicated) software has been evaluated by the Software Review Committee. The software satisfies the quality assurance requirements for traceability, retrievability, documentation, and verification.

Class C Software - Class C (Candidate) software is a candidate for Class A, but currently satisfies only the traceability and retrievability requirements (as evaluated by the QA Coordinator).

Class D Software - Class D (Dormant or Dead) software is obsolete, cached software that was formerly classified as Class A or C, where obsolete means that a new version of the same class has replaced the cached version.

Class X Software - Class X (Experimental) software is currently being developed and has not been processed through any formal quality assurance procedures. The primary reason for the Class X classification is to make the existence of this software known to potential users. The software is available to any interested user within the WIPP Project at Sandia, but usually only from the developer.

Code - Software, but often implying SES software that groups together one or several different computational models.

Computational Data Base (CAMDAT) - The collection of neutral files, generated during a PA simulation, that link CAMCON codes together.

Computational model - The solution and implementation of the mathematical model. The solution may be either analytic (exact), numerical (approximate), or empirical. Conceivably, the implementation can be either by hand or evaluated in a computer code. However because the latter is more frequent, the computational model is often called a computer model. Generic until site-specific data are used.

Computer model - See computational model.

Configuration management - A system of controls that prevents ambiguity about which version of software is used for a particular computation and that tracks, protects, and preserves requested modifications or corrections to these codes.

Conceptual model - The set of hypotheses and assumptions that postulates the description and behavior of a system. To be scientifically acceptable, the set of hypotheses must be (1) consistent with the purpose of the model, (2) logically consistent with one another, (3) in agreement with existing information and observed data, and (4) able to be tested (i.e., capable of being falsified by the collection of more data). At a minimum, these hypotheses and assumptions describe the following about the system, including whether it is time dependent: (1) the simplified physical arrangement of system components, (2) the initial and boundary condition types, and (3) the nature of the relevant chemical, physical, cultural, or biological phenomena.

Customer - The customer is the recipient, purchaser, or beneficiary of the product, service, work, or other outcome of an ongoing process or project.

Data - Information that is purposely collected, organized, and used in preparing values for parameters of computational models in an analysis or used as the basis of a decision. As used here, data is a subset of general information.

Discrepancy - A term for a condition adverse to data, software, or analysis quality that refers to any of the following: errors, bugs, failures, malfunctions, deficiencies, defective items, and nonconformances with established standards.

Disposal system - Any combination of engineered and natural barriers that isolate spent nuclear fuel or radioactive waste after disposal (*40 CFR 191.12(a)*). The natural barriers extend to the accessible environment.

Engineering analysis - An engineering analysis is similar to a general scientific analysis except that engineering analysis (1) has formal constraints on purposes (specifications) rather than the limits of human curiosity, (2) has formal constraints on resources (time and money) rather than the limits of human energy, (3) uses fairly accepted methods rather than novel approaches, and (4) seeks to clarify rather than to discover new knowledge (i.e., the study is likely to further understanding of a system through the application of already discovered knowledge). The term "engineering analysis" applies to the WIPP disposal system provided one understands the formal constraint on the analysis purpose, which is an analysis that is intended to investigate the entire system for the primary purpose of determining compliance with environmental regulations. (See analysis.)

Formal report - Formal reports are SAND reports (official reports issued by Sandia National Laboratories and other scholarly publications such as journal articles or books written by Sandia staff and contractors) that undergo the formal peer review procedure (PAP05).

Information - A collection of cognitive or intellectual material. Information includes both observational data and communicated knowledge derived by inference and interpretation.

Management review - A review conducted by management to (1) assess the impact of a document or data on the project and (2) evaluate concurrence with broad corporate or government policy.

Material parameters or properties - Parameters or characteristics that vary only with material regions or not at all. Material parameters are defined for each material region for the mesh.

Mathematical model - The mathematical representation of a conceptual model (i.e., the coupled algebraic, differential, or integral mathematical equations that approximate the appropriate processes in a specified domain of the conceptual model).

Module - A grouping or category of codes in the CAMCON system; the module name describes the primary function provided in the performance assessment.

Neutral file - A data file that is stored in a common format and can be read or altered by either SDBREAD_LIB or CDBREAD_LIB. A neutral file is associated with either the secondary data base or the computational data base.

PA Analyst - The PA Department person selected by a task leader directing a task requiring analysis who designs and conducts the analysis of a PA problem. The analyst must ensure a quality analysis by (1) developing one or several conceptual models (working hypotheses) of a system, with the complexity level consistent with model purpose; (2) developing a mathematical description and implementing a solution and/or selecting the proper software; (3) providing approximate system parameters (data) and modeling features, such as discretization of values, types of initial conditions, and boundary conditions; (4) conducting convergence tests and interpreting results, including parameter sensitivity studies, (5) validating a conceptual model to the extent possible or reporting results from a plausible alternative conceptual model to properly state uncertainty, (6) co-authoring documents on the analysis with the task leader, (7) caching the computational model parameters and results, and (8) improving software quality by reporting suspected errors and suggested enhancements or acquiring/developing software when warranted (as required in the software QA procedures).

Parameters - The underlying fundamental entities ($\mathbf{x} = x_1, \dots, x_n, \dots, x_N$) of a computational model. As $\mathbf{x}$ changes, so does the model result. The individual parameters, x_n , are usually scalar quantities, but they may also be vectors or functions. Furthermore, the individual parameters are usually coefficients of the mathematical model, but they may also relate to scenario uncertainty or model form uncertainty. Two types of parameters are recognized in the CAMCON system: material parameters and attribute parameters.

Peer - A person with expertise comparable to that of the person whose work (software, data, or analysis) is being examined (or with expertise in a critical subset of the work) and who did not perform the original work.

Performance assessment (PA) - The process of assessing whether a system meets a set of performance criteria. For the WIPP, the system is a computational model (which, in turn, is a composite of several models) that represents a deep geologic repository disposal system for waste contaminated with transuranic radionuclides and hazardous chemical constituents; and the performance criteria are various long-term environmental metrics in U.S. government regulations (not short-term operational safety issues).

Primary Data Base - Stores the raw measured data of the experimentalist. In some cases, the data are interpreted.

Process validation - The supposition that the validation of a conceptual model and the corresponding mathematical and computer models at another sufficiently similar system can be used to bolster confidence that a system phenomenon can be sufficiently and accurately modeled at another system under study. For waste management systems, this includes (1) simulation of short-term laboratory experiments under controlled conditions and (2) analogy with a similar and previously validated conceptual and mathematical model. The complete validation of the conceptual model and corresponding mathematical and computational models require adequately explaining the phenomena under study with system-specific data.

QA coordinator - The PA Department Manager or the designated appointee within the Performance Assessment department who coordinates the implementation of the quality assurance tasks for data, software, analysis, and document review, and expert judgment panels.

Quality assurance (for a product) - Quality assurance is ensuring that the product does what it is supposed to do to meet the expectations of the customer. The customer expectation, as related to the performance assessment process, is that the analysis results present an adequate view of the WIPP performance based on currently available data and information.

Release - A unique issue of software that generally contains minor corrections to errors that existed in previous issues of the software. Documentation for a new release of software generally remains the same as the preceding release.

Repeatability - The ability to repeat any part or all of a product or service (e.g., analysis) through sufficient documentation to understand all nonobvious inputs and the basis of important decisions or conclusions. Repeatability may or may not include traceability and retrievability as requirements.

Retrievability - The ability to retrieve essential information in a reasonable period of time. For a large PA analysis, retrievability implies that the information can be retrieved in computer form from a cache.

- Scientific/engineering software (SES)** - Software that models a physical process, often by the numerical solution of mathematical equations. Software that is used to establish the spatial variation of modeling parameters is also scientific/engineering software (SES). A significant distinction of SES is that validating the software is often subjective, difficult, and sometimes impossible.
- Secondary Data Base** - Stores interpreted data from the Primary Data Base for use as parameters for the PA simulation models. The information is stored in a tabular format within a relational data base system, under the control of the PA Department.
- Site-specific model** - See applied model.
- Software** - A set of computer operations specified in any language that can be translated unambiguously into machine language. Common synonyms are computer program, computer code, and operating system procedural files.
- Software consultant** - The PA department person selected by the QA coordinator to provide technical expertise in mathematical and numerical basis and application of software, occasionally shortened to "consultant."
- Software sponsor** - The PA department person selected by the QA coordinator to sponsor or guide a particular piece of software through the quality assurance process, often abbreviated to sponsor."
- Stakeholder** - A person, group, or agency who is not a customer but who nevertheless has a keen interest in a product or service and the recognized right to impact the process.
- SWCF records manager** - The Sandia WIPP Central Files (SWCF) records manager is chosen by the Sandia WIPP project manager or designated department manager. One of the SWCF records managers may be the Waste Management and Transportation (WMT) librarian. One of the SWCF records manager's many project tasks is to maintain quality assurance records in accordance with QAP 17-1 on Performance Assessment studies as required in the PA quality assurance procedure.
- Task leader (TL)** - The PA department person selected by the PA department manager and assigned responsibility for conducting the activities described in the periodically updated Sandia work plan for the WIPP project, which can include conducting an analysis, developing software, selecting data, and coordinating review and expert judgment panels. The TL is frequently called principal investigator or PI within Sandia, but TL was selected for use here so that this term cannot be confused with the PI in a formal contract with persons outside of Sandia.
- Technical review** - A review of a document by peers to (1) evaluate documents as to their applicability, correctness, and completeness, (2) evaluate whether the conclusions are reasonably supported by the evidence, results, and other facts, (3) generally verify compliance with common scientific, engineering, and industry practice and standards, and (4) evaluate the presentation of these points in the document.
- Traceability** - The ability to duplicate any part or all of a product or service exactly through records on (1) versions of all software tools used, (2) all analysis methods used, and (3) all required data and information. Traceability may or may not include retrievability as a requirement.

Validation - The process of making valid by confirming, corroborating, substantiating, or supporting, where valid means of good authority, well founded, sound and to the point, and applicable to the subject or circumstances against which few objections can be fairly brought.

Validation of an (applied) model - The process of validating through sufficient testing (subjective) using system-specific observed data that a conceptual model and the corresponding mathematical and computational models explain a system with sufficient accuracy (subjective), consistent with the purpose of the model. In other words, model validation is the process of confirming that the applied model is solving the appropriate idealization of the system (correct applied model produced). Verification of a computational model precedes validation of an applied model. Model validation is an ongoing process.

Verification of a (computational) model - The process of verifying that a computational model appropriately solves and implements the mathematical model. In other words, model verification is the process of illustrating that the mathematical model is being solved appropriately (computational model correctly produced). Often the computational model is implemented as a code and verification of the computational model is closely connected to verification of the software. Given that the computational model is verified, the assumptions of the conceptual model underlying the mathematical and computational model using system-specific data (the applied model) should be validated.

Verification of software - The process of illustrating through sufficient testing (subjective) that the software satisfactorily performs its stated capabilities (subjective) and providing a point of reference for future modifications. The extent to which the software is tested is determined by the complexity of the software.

Version - A unique configuration of a code that differs in its capabilities from other configurations of the same code.

Index

Symbols

/ANSI
 FLINT 12-15
/COMMENT
 FORMRENUM 12-22
/CONT
 FORMRENUM 12-22
/DLINES
 FLINT 12-13
/EXTEND
 FLINE 12-13
/FILES
 FLINT 12-13
/FORMAT
 FORMRENUM 12-20
/FYI
 FLINT 12-15
/GLOBAL
 FLINT 12-15
/GRAPHICS
 FLINT 12-16
/I4
 FLINT 12-13
/IMPLICIT
 FLINT 12-15
/INC
 FORMRENUM 12-21
/INCLUDE
 FLINT 12-15
/INDCONT
 FORMRENUM 12-21
/INDENT
 FORMRENUM 12-21
/INDFORMAT
 FORMRENUM 12-21
/LABFORMAT
 FORMRENUM 12-21
/LABSTMT
 FORMRENUM 12-21
/LIBRARY
 FLINT 12-13
/LISTING
 FLINT 12-15
/LOCALSYMS
 FLINT 12-16
/LPP
 FLINT 12-17
/MAXCONT
 FORMRENUM 12-22
/NOFORMAT
 FORMRENUM 12-20
/NOI4
 FLINT 12-13
/NOLOCALSYMS
 FLINT 12-16
/NONUMBER
 FORMRENUM 12-22
/NORENUMBER
 FORMRENUM 12-21
/NOUSAGE
 FLINT 12-16
/NOWARNINGS
 FLINT 12-16
/NUMBER
 FORMRENUM 12-22
/OUTPUT
 FLINT 12-14
/PARAMETERS
 FLINT 12-16
/PORTABILITY
 FLINT 12-15
/RENUMBER
 FORMRENUM 12-21
/SPLIT
 FLINT 12-14
/SQUISH
 FLINT 12-17
/STATISTICS
 FLINT 12-14
/SUMMARY
 FLINT 12-14
/SUPPRESS
 FLINT 12-15
/SYSTEM
 FLINT 12-16
/TREE
 FLINT 12-14
/TRIM
 FLINT 12-17
/TTB
 FLINT 12-14
/USAGE
 FLINT 12-16
/VAXDO
 FORMRENUM 12-21

/WARNINGS
 FLINT 12-16
 /WIDTH
 FLINT 12-17
 /XREFERENCE
 FLINT 12-14
 [CAMCON] directory 2-5
 [LIBRARIES] subdirectory 2-19

A

ABORT 8-8
 ABSGEN 12-3–12-4
 Identifiers and headings 12-4
 Abstract generation 12-3–12-4
 ADD
 CHANGES 12-6
 Advance page 11-28
 Advanced routines
 CAMSUPES_LIB 9-2, 9-23
 SDBREAD_LIB 7-9, 7-32
 AHSAX 10-150
 ALGEBRA 3-2
 Analysis results 6-2, 6-14, 6-69
 CAMDAT_LIB 6-14, 6-69
 Analysis-specific modifications 3-17–3-18
 Attribute parameters 6-2, 6-7
 AXIS 10-151, 10-152
 Axis scaling 10-65, 10-66

B

Background color 11-31
 BANNER 4-3, 8-9
 Basic plotting primitives
 PLT_LIB 10-6, 10-7
 BATCH 8-10
 Bell 11-12
 BIGLET 8-11
 BLOCK_DATA
 CREATE_PROGRAM 12-10
 BLOT 2-15
 Bound for range 10-182
 Boundary condition data 6-7–6-9
 Bounds defined 10-183
 BOX 10-153
 BROADCAST
 CHANGES 12-6

C

C and FORTRAN
 Mixing 5-19

C codes
 Interfacing 5-19
 Linking 5-19
 C language 3-4, 2-6
 C programming language 5-19
 C\$\$\$+n
 FORMRENUM 12-23
 C\$\$\$-n
 FORMRENUM 12-23
 C\$\$\$OFF
 FORMRENUM 12-22
 C\$\$\$ON
 FORMRENUM 12-23
 C\$\$\$R
 FORMRENUM 12-23
 CAMCON approach 2-2–2-3
 CAMCON coordinator 1-4
 CAMCON defined 1-1
 CAMCON system 2-1
 CAMCON_LIB 10-1, 2-20–2-22, 4-3, 8-1
 Common internal routines 8-58
 Error messages 8-1
 File processing routines 8-22
 QA and user interface routines 8-6
 Routine calls 8-6
 String processing routines 8-51
 CAMCON_LIB free field input 8-35
 CAMCONexec 2-6
 CAMCONexec procedural files 3-12
 CAMCONexec sponsor 2-5
 CAMDAT 2-3, 2-15–2-22, 6-1–6-16
 CAMDAT file format 6-1
 CAMDAT_LIB 2-20–2-22, 6-1
 Analysis results 6-14, 6-69
 Execution 6-12
 File initialization 6-20
 General routines 6-12, 6-17
 Heading 6-4
 Model description 6-13, 6-41
 Overview 6-10–6-12
 QA information 6-13, 6-34
 Routine calls 6-17
 CAMSUPES_LIB 2-20–2-22, 9-1–9-2
 Advanced routines 9-23
 Debugging routines 9-34
 Memory management routines 9-11–9-13
 System queries 9-3
 CANCEL ALL
 VAX/VMS debugger 12-39
 CANCEL BREAK
 VAX/VMS debugger 12-38

- Change records 4-23
- CHANGES 12-5-12-8
- Character font 11-35
- Character size 11-33
- Character string angle 11-41
- Character string length 10-54
- Check software help file 12-26-12-27
- Class A software 3-5, 3-6, 3-11, 5-12
- Class C software 3-5, 3-6, 3-10, 5-12
- Class D software 3-5, 3-6
- Class X software 3-5, 3-6, 3-9
- Clipping
 - 2D polygons 10-118
 - 2D vectors 10-121
 - 3D Vectors 10-122
 - Points 10-91, 10-92, 10-119, 10-120, 10-124, 10-126
 - Points, lines, and polygons 10-117
 - Polygons 10-91, 10-92, 10-123
 - Vectors 10-91, 10-92, 10-125, 10-127
- Clipping routines
 - PLT_LIB 10-8, 10-117
- Code Consultant 3-9
- Code directory structure 2-10
- Code operation 4-10
- Code Review Committee 3-6
- Code sponsor 3-9
- Codes, computer 2-9
- Color index 10-129, 10-130
- Color intensity 10-131
- Color name 10-129, 10-130
- Color palette routines
 - PLT_LIB 10-9, 10-128
- Color parameters
 - Getting 10-25
- Color paramters
 - Setting 10-24, 10-137
- Color spectrum 10-135
- Color table 11-17, 11-32
- Color values 10-134
- Commands subtopic 4-17
- Comment identifier 4-8
- Comments 5-12, 8-30
- Common internal routines
 - CAMCON_LIB 8-3, 8-58
- Compile program 12-9-12-11, 12-36
- COMPILE_OPTIONS
 - CREATE_PROGRAM 12-10
- Computational data base 2-3, 2-15-2-22
- Computational Data Base Interface Library 6-1
- Computer codes 2-9

- Conceptual model stratigraphy 7-1
- Continuation indicator 8-30
- Continuing statements 4-9
- CREATE_PROGRAM 12-9-12-11
- Ctrl C
 - VAX/VMS debugger 12-39
- Current position 11-18

D

- Data base model size 6-5
- Data base version 6-5
- Data bases 2-10-2-19
- Data field 8-30
- Data subtopic 4-18
- Date stamp 4-1
- DBERRUNI 6-18
- DBFIXMEM 6-19
- DBIATNAM 6-44
- DBIATTR 6-42
- DBICLOSE 6-24
- DBIELBLK 6-46
- DBIEVROK 6-70
- DBIINFO 6-35
- DBILINK 6-51
- DBIMAP 6-53
- DBINDSET 6-55
- DBINELB 6-58
- DBINSTSTEP 6-76
- DBINVAR 6-72
- DBIOPEN 6-21, 6-22
- DBIPRNAM 6-61
- DBIPROP 6-59
- DBIQAREC 6-38
- DBISDSET 6-62
- DBISIZES 6-27
- DBISTEP 6-74
- DBITIME 6-77
- DBITITLE 6-29
- DBIVAR 6-79
- DBIVERS 6-32
- DBIVRNAM 6-82
- DBIXYZ 6-67
- DBOATTR 6-43
- DBOCLOSE 6-25
- DBOELBLK 6-47
- DBOEVROK 6-71
- DBOHEAD 6-49
- DBOINFO 6-36
- DBOLINK 6-52
- DBOMAP 6-54
- DBONDSET 6-56

- DBOOPEN 6-23
- DBOPROP 6-60
- DBOQAREC 6-39
- DBOSDSET 6-64
- DBOSTEP 6-75
- DBOTIME 6-78
- DBOTITLE 6-30
- DBOVAR 6-81
- DBOVRNAM 6-83
- DBOXYZ 6-68
- DBPAPNAM 6-45
- DBPDBNAM 6-26
- DBPELBLK 6-48
- DBPINFO 6-37
- DBPNDSET 6-57
- DBPNVAR 6-73
- DBPQAREC 6-40
- DBPSDSET 6-66
- DBPSIZES 6-28
- DBPTITLE 6-31
- DBPVERS 6-33
- DBPVARNAM 6-85, 6-86
- DCL 3-4
- DCL driver headers 5-18
- DCLIMIT 10-154, 11-10
- DEBUG_COMPILE_OPTIONS
 - CREATE_PROGRAM 12-10
- Debugger 12-37–12-40
- Debugging routines
 - CAMSUPES_LIB 9-2, 9-34
- DEC Command Language 3-4, 2-6
- Declarations 5-5
- DEFFIL 8-24
- DELETE
 - CHANGES 12-7
- Delimiters 4-8
- DEPOSIT
 - VAX/VMS debugger 12-40
- Developer 3-9
- Device capabilities 10-19, 11-19
- Device code 11-3–11-5
- Device coordinates 10-20, 10-63, 10-64
- Device driver 11-51
- Device parameters 10-28
 - Getting 10-27
 - Restoring 10-29
 - Saving 10-28
 - Setting 10-26, 10-138
- Device selection 11-48
- Device x-coordinate 10-190
- Device y-coordinate 10-191
- Devices
 - DVDI 11-45–11-51
 - SVDI 11-2–11-5
- Digits
 - Number of 10-172
- Directories 2-5
- DIRECTORY
 - CHANGES 12-7
- Directory
 - Code 2-5
 - Drivers 2-5
 - Libraries 2-5
 - SDB 2-5
 - Symbols 2-5
 - Utilities 2-5
- Directory structure 2-5–2-6, 2-10
- Documentation
 - External 4-20–4-23
 - Internal 5-11–5-18
 - On-line 4-10
- DOEDIS 8-13
- Downgrading software 3-13–3-15
- Draw
 - Box 10-153
 - Centered marker 10-167
 - Logarithmic axis 10-166
 - Piecewise continuous line 10-163, 10-164, 10-165
 - To point 10-174, 10-175
- Draw a line 11-25
- Draw a point 11-29
- Draw a polygon 11-30
- Draw text 11-43
- Drawing
 - 2D points 10-94
 - 2D polygon 10-93
 - 2D symbols 10-95
 - 2D vectors 10-96
 - Arrows 10-58, 10-72
 - Curves 10-62, 10-68
 - Polygons 10-76
 - Vectors 10-74, 10-82, 10-83
- Drivers 2-6–2-7
- Dual Virtual Device Interface 11-1
- DVDI 11-1
- DVDI graphics interface 11-1
- DVDI_LIB 2-20–2-22
- E
 - ECHO 8-25
 - EDIT
 - CHANGES 12-7

Efficiency 5-11
 ELEM 8-59
 Element block ID 6-6
 Element block name 6-6
 Element connectivity 6-6
 Element side sets 6-7, 6-8
 Enhancement reporting 12-5-12-8
 Entering file names 4-6-4-19
 Error handling 11-7
 Error messages 10-6, 4-10, 6-12
 Error reporting 12-5-12-8
 Escape code 11-14
 Escape codes 11-2-11-5
 Escape inquiry 11-22
 EXAMINE
 VAX/VMS debugger 12-40
 Example subtopic 4-19
 EXCPUS 9-4
 EXDATE 9-5
 Executing
 VAX/VMS debugger 12-39
 Execution fields 4-17
 Execution of CAMDAT_LIB 6-12
 Execution subtopic 4-17
 EXIT
 CHANGES 12-7
 VAX/VMS debugger 12-39
 EXNAME 9-7
 EXPARM 9-9
 External documentation 4-20-4-23
 EXTIME 9-10

F

FFISTR 8-39
 Field separator 8-30
 FILDAT 9-6
 File extensions 4-5
 File initialization 6-20
 CAMDAT_LIB 6-13, 6-20
 File names, entering 4-6-4-19
 File naming conventions 4-4-4-19
 File processing routines
 CAMCON_LIB 8-2, 8-22
 File reading 4-6
 File types 4-4-4-19
 Find end of text 10-53
 Find next line 10-55
 Finite-difference mesh 6-6
 FLINT 12-12-12-18
 Call tree qualifiers 12-16
 Cross-reference table qualifiers 12-16

 Diagnostic qualifiers 12-15
 Output file qualifiers 12-13
 Source file qualifiers 12-13
 Text format qualifiers 12-17
 Flush buffer 10-2, 10-16
 Flush buffers 11-13
 FOR ... DO
 VAX/VMS debugger 12-40
 Foreground color 11-34
 Formal reports 4-23
 Format utility 12-19-12-22
 FORMRENUM 12-19-12-22, 5-4
 Formatting commands 12-22
 Formatting qualifiers 12-20
 Renumbering commands 12-23
 Renumbering qualifiers 12-21
 FORTRAN and C
 Mixing 5-19
 FORTRAN code analyzer 12-12-12-18
 FORTRAN language 3-3, 5-10
 FPARSE 8-27
 Frame limits 10-154, 11-10
 Free field input
 CAMCON_LIB 8-30
 Free-field input 8-30-8-35
 Free-field input routines
 CAMCON_LIB 8-2
 FREFLD 8-37, 8-41, 8-43, 8-45, 8-46

G

General routines 6-17
 CAMDAT_LIB 6-12, 6-17
 SDBREAD_LIB 7-9, 7-13
 Generate a format 10-158, 11-14, 11-16
 Generic computational data base 6-2
 GENFMT 10-158, 11-14, 11-16
 GETINP 8-49
 GETPRG 8-14
 Getting
 Color parameters 10-25
 Device parameters 10-27
 Global mapping parameters 10-39
 Graph parameters 10-34
 Text parameters 10-43, 10-48
 Global mapping parameters 10-40
 Getting 10-39
 Restoring 10-41
 Saving 10-40
 Setting 10-37, 10-143
 Go
 VAX/VMS debugger 12-39

Graph coordinates 10-63, 10-64
 Graph parameters
 Getting 10-34
 Restoring 10-36
 Saving 10-35
 Setting 10-30, 10-139
 Graphics application interface 11-45
 Graphics library 10-1
 Graphing
 Two-dimensional 10-57
 Graphing routines
 PLT_LIB 10-7
 Grid block information 6-5

H

Hardware text 10-51
 Header
 Main program 5-12-5-16
 Header frame 10-17, 11-15
 Headers
 DCL Driver 5-18
 Include file 5-16
 Subroutine 5-16
 Heading, CAMDAT_LIB 6-4-6-5
 HELP
 CHANGES 12-7
 Help file 2-22, 4-11-4-19
 Help file structure 4-13
 HELP_LIB 2-20-2-22
 HJIPLT_LIB 10-1, 10-147-10-148
 HJIPLT_LIB routines 10-148, 11-1
 HLP2CHK 12-26-12-27
 Identifiers and headings 12-26

I

IJK 8-60
 Inactive software 3-15
 Include file headers 5-16
 Initialize plotting 10-159, 10-160, 10-176, 10-177
 Initialize SVDI 11-16
 Initializing PLT_LIB 10-18, 10-21
 INITPLOT 10-159
 INITPLT 10-160
 Input data base 6-11
 Inquiry
 Color table 11-17
 Current Position 11-18
 Device capabilities 11-19
 Escape 11-22
 NDC limits 11-23

Output status 11-24
 Inspection 3-9
 Intensity 11-36
 Interfacing C codes 5-19-5-21
 Internal documentation 5-11-5-18
 INTRP1 10-161
 ISTOUT 8-7

K

Keyboard coordinates 11-11
 Keyboard locator 11-37

L

Layer elevations 7-2
 LAYRELEV.SDB 7-2
 Legal disclaimer 4-3
 Length of string 10-162
 LENSTR 8-53
 LENTEXT 10-162
 LIBRARIES
 CREATE_PROGRAM 12-10
 Libraries
 CAMDAT_LIB 6-1
 Main 2-20
 Library
 FLINT 12-17
 Line style 11-38
 Line width 11-39
 Linear interpolation 10-161
 LINED 10-164
 LINEW 10-163, 10-165
 Link program 12-36
 Linking C codes 5-19
 Linking libraries 10-1, 10-147, 11-1, 11-45,
 11-47, 6-12, 7-7, 8-1, 9-1
 Linking SDBREAD_LIB routines 7-7
 List DCL file 12-28-12-29
 List FORTRAN source 12-30-12-31
 LISTDCL 12-28-12-29
 LISTFORTRAN 12-30-12-31
 LOCSTR 8-52
 Log an error 11-26
 LOGAX 10-166
 Logicals 2-7
 Lowercase letters 8-30

M

Machine-dependent coding 5-10
 Main program headers 5-12-5-16
 MAINPROG

- CREATE_PROGRAM 12-10
- Manipulating output 10-5
- MAP 10-4, 10-5
- Map
 - X-coordinates 10-188
 - Y-coordinates 10-189
- Mapping 10-4
 - 2D points 10-86, 10-94
 - 2D polygon 10-93
 - 2D polygons 10-85
 - 2D symbols 10-95
 - 2D vectors 10-87, 10-96
 - 3D points 10-89
 - 3D polygons 10-88
 - 3D vectors 10-90
- Mapping routines
 - PLT_LIB 10-7, 10-84
- MARKER 10-167
- Masking 10-78, 10-81, 10-82
- Material block information 6-5–6-7
- Material parameters 6-2, 6-7
- MAXERR 8-16
- Maximum device coordinates 10-20
- MCCOMP 9-24
- MCDEBG 9-35
- MCDEL 9-14
- MCEFIX 9-25
- MCEROR 9-15
- MCERPT 9-26
- MCEXEC 9-27
- MCFILL 9-16
- MC FIND 9-28
- MCFOFF 9-17
- MCGET 9-18
- MCGIVE 9-19
- MCINIT 9-20
- MCLAST 9-29
- MCLIST 9-36
- MCLONG 9-30
- MC MEMS 9-31
- MCNAME 9-32
- MCPRNT 9-37
- MCRSRV 9-21
- MCSTAT 9-22
- MCWAIT 9-33
- MDCOM₁ 9-24
- MDDEBG 9-35
- MDDEL 9-14
- MDEFIX 9-25
- MDEROR 9-15
- MDERPT 9-26
- MDEXEC 9-27
- MDFILL 9-16
- MDFIND 9-28
- MDFOFF 9-17
- MDGET 9-18
- MDGIVE 9-19
- MDINIT 9-20
- MDLIST 9-36
- MDLONG 9-30
- MDMEMS 9-31
- MDNAME 9-32
- MDPRNT 9-37
- MDRSRV 9-21
- MDSTAT 9-22
- MDWAIT 9-33
- MEMERR 8-17
- Memory management
 - CAMSUPES_LIB 9-2
- Memory management routines
 - CAMSUPES_LIB 9-11
- Mesh
 - Finite difference 6-6
- MINMAX 8-61
- Mixing FORTRAN and C 5-19
- Model description 6-2, 6-13, 6-41
 - CAMDAT_LIB 6-13, 6-41
- Modelling transformations 10-5
- Modifying software 3-13–3-15
- Modularity 5-6
- Modules of the CAMCON system 2-7–2-9
- Move
 - To point 10-174, 10-175
- Move the cursor 11-27
- Move the pen 10-75
- MP2PG 10-85
- MP2PT 10-86
- MP2VC 10-87
- MP3PG 10-88
- MP3PT 10-89
- MP3VC 10-90
- MPCLP2 10-91
- MPCLP3 10-92
- MPD2PG 10-93
- MPD2PT 10-94
- MPD2SY 10-95
- MPD2VC 10-96
- MPD3PG 10-97
- MPD3PT 10-98
- MPD3VC 10-99
- MPGETM 10-100
- MPINIT 10-101

MPLOOK 10-102
 MPORT2 10-103
 MPORT3 10-104
 MPPERS 10-105
 MPPOLA 10-106
 MPPOPM 10-107
 MPPSIHM 10-108
 MPPUTM 10-109
 MPRESE 10-110
 MPRLOC 10-111
 MPROTA 10-112
 MPSCAL 10-113
 MPTRAN 10-114
 MPVIEW 10-115
 MPWIND 10-116

N

Name of software 4-1
 Naming conventions 2-10, 4-4-4-19
 NDC limits 11-23
 NENUM 8-62
 Neutral file 2-15
 Neutral-file format 2-15
 New frame 10-12
 NIDFD 10-172
 Nodal point coordinates 6-5
 Node point sets 6-7
 Node sets 6-7
 Non-SES software 3-12
 Null field 8-30
 NUMBER 10-173
 Numbering statements 5-4
 Numeric field 8-30
 Numerical data 4-9

O

On-line documentation 2-22, 4-10
 OPNFIL 8-26
 Output data base 6-10
 Output status 11-24, 11-40

P

Palette color 10-133
 Parameter data 7-2
 Parameter input 4-7
 Parsing routines 4-8
 PCKSTR 8-56
 Pen position 10-79
 PLOT 10-174
 Plot

Arc-hyperbolic sine axis 10-150
 Characters 10-184
 Linear axis 10-151, 10-152
 Number 10-173
 PLOTD 10-175
 PLOTS 10-176, 10-177
 Plotting
 Characters 10-80
 Graphs 10-59, 10-60, 10-73
 Points 10-77, 10-78
 Symbols 10-81
 Text 10-52, 10-56
 Plotting package 10-1
 Plotting text 10-51
 PLT_LIB 10-1-10-9
 Clipping routines 10-117
 Color palette routines 10-128
 Mapping routines 10-84
 Setting parameters 10-23, 10-136
 Two-dimensional graphing 10-57
 PLT_LIB routines 10-6
 PLTARR 10-58, 10-72
 PLTAXS 10-73
 PLTBEL 10-11
 PLTBGN 10-12, 10-13
 PLTCG2 10-118
 PLTCLIP 10-1, 10-6
 PLTCNM 10-129
 PLTCOL 10-134
 PLTCOLOR 10-9
 PLTCP2 10-119
 PLTCP3 10-120
 PLTCRS 10-14
 PLTCUR 10-62, 10-68
 PLTCV2 10-121
 PLTCV3 10-122
 PLTD2G 10-63
 PLTDRW 10-74
 PLTEND 10-15
 PLTEXT 10-1
 PLTFLU 10-2, 10-16
 PLTFRM 10-17
 PLTG2D 10-64
 PLTGPH 10-59, 10-60
 PLTGRAPH 10-7
 PLTGTC 10-25
 PLTGTD 10-27
 PLTGTG 10-34
 PLTGTM 10-39
 PLTGTT 10-43, 10-48
 PLTICL 10-130

PLTINI 10-65
 PLTINO 10-66
 PLTINT 10-18
 PLTIQC 10-131
 PLTIQD 10-19
 PLTIISP 10-132
 PLTMOV 10-75
 PLTPAL 10-133
 PLTPLY 10-76
 PLTPNT 10-77
 PLTPTM 10-78
 PLTRDC 10-20
 PLTRDQ 10-29
 PLTREG 10-36
 PLTREM 10-41
 PLTRET 10-45, 10-50
 PLTRXY 10-79
 PLTSBM 10-81
 PLTSET 10-4, 10-9
 PLTSPC 10-135
 PLTSTA 10-21
 PLTSTC 10-24, 10-137
 PLTSTD 10-26, 10-138
 PLTSTG 10-30, 10-139
 PLTSTM 10-5, 10-37, 10-143
 PLTSTT 10-42, 10-46, 10-144
 PLTSTV 10-145
 PLTSVD 10-28
 PLTSVG 10-35
 PLTSVM 10-40
 PLTSVT 10-44, 10-49
 PLTSYM 10-80
 PLTVCM 10-82
 PLTVCT 10-83
 PLTVWG 10-123
 PLTVWP 10-124
 PLTVWV 10-125
 PLTWAI 10-22
 PLTXHE 10-53
 PLTXHL 10-54
 PLTXHN 10-55
 PLTXTC 10-52
 PLTXTH 10-56
 PLTZCP 10-126
 PLTZCV 10-127
 Portability of codes 5-10
 Primary data bases 2-12-2-13
 Procedural files 3-12, 2-6-2-7
 PROGNAME
 CREATE_PROGRAM 12-10
 Programming guidelines 5-1

PROGRAMS

CHANGES 12-7
 Projection Transformations 10-5
 Proprietary information 4-3
 Proprietary software 3-6
 Protocols 2-5-2-6
 PRTMSG 8-18
 PRTOUT 8-20

Q

QA coordinator 3-5, 3-9
 QA information 4-15, 6-2, 6-4, 6-13, 6-34
 CAMDAT_LIB 6-13, 6-34
 QA notebook print procedure 12-33-12-36
 QA procedures 2-1, 3-4, 5-12
 QA requirements 3-4, 4-3, 4-10, 4-22
 QA routines
 CAMCON_LIB 8-2, 8-6
 QA_PREP 12-32, 4-22
 QA_PRINT 12-33-12-36, 4-22
 QA_PRINT Setup 12-32
 QAPAGE 8-19
 QASSMB 8-15
 QQQQ01 10-180
 QQQQ02 10-181
 QQQQ03 10-182
 QQQQ01 10-179
 Quality Assurance. *See* QA
 Quality assurance information. *See* QA information
 Quality assurance requirements 3-4
 Quality assurance routine library 8-1
 QUIT
 CHANGES 12-7
 Quoted string 8-30

R

RDCMDL 8-23
 RDFNAM 8-28
 Readability
 Software readability 5-3-5-10
 Readability guidelines 5-3-5-10
 Reading Interactively 4-10
 RELATE 3-2
 Renumber utility 12-19-12-22
 Replacing a program 3-15
 Replacing software 3-15-3-16
 REPLY
 CHANGES 12-7
 Restoring
 Device parameters 10-29

- Global mapping parameters 10-41
- Graph parameters 10-36
- Text parameters 10-45, 10-50
- Return end points 10-179, 10-180, 10-181
- Return tic spacing 10-179, 10-180
- Robustness 5-11

S

- Sandia Virtual Device Interface 11-1
- Sandia virtual device interface 10-1
- Saving
 - Device parameters 10-28
 - Global mapping parameters 10-40
 - Graph parameters 10-35
 - Text parameters 10-44, 10-49
- Saving parameters 10-28, 10-40
- SCANCHANGES 12-5-12-6
- Scientific and engineering software 3-3
- SCREEN 10-183
- SDBARES 7-14
- SDBCASES 7-15
- SDBCLOC 7-16
- SDBCONCR 7-33
- SDBFRES 7-17
- SDBGETF 7-18
- SDBGETL 7-19
- SDBIATR 7-20
- SDBILOC 7-21
- SDBINFO 7-22
- SDBINIT 7-23
- SDBIRES 7-24
- SDBMOV RV 7-34
- SDBNINFO 7-25
- SDBNUMDB 7-26
- SDBPUTL 7-27
- SDBREAD_LIB 2-20-2-22, 7-1
 - Advanced routines 7-32
 - General routines 7-13
 - Linking 7-7
 - Parameter data 7-2
 - Required files 7-7
 - Routine calls 7-13
 - Use 7-9
- SDBRLOC 7-28
- SDBRWIND 7-31
- SDBSCMP 7-29
- SDBSETRC 7-35
- SDBSETRV 7-36
- SDBSKHDR 7-30
- SDBTSTRC 7-37
- Secondary data base 2-3, 2-13-2-15, 7-1-7-3

- Secondary data base interface library 7-1
- SES software 3-3, 3-11
- Set background color 11-31
- SET BREAK
 - VAX/VMS debugger 12-38
- Set character font 11-35
- Set character size 11-33
- Set character string angle 11-41
- Set color table 11-32
- Set foreground color 11-34
- Set intensity 11-36
- Set keyboard locator 11-37
- Set line style 11-38
- Set line width 11-39
- Set output status 11-40
- SET SCOPE
 - VAX/VMS debugger 12-39
- Setting
 - Color parameters 10-24, 10-137
 - Device parameters 10-26, 10-138
 - Global mapping parameters 10-37, 10-143
 - Graph parameters 10-30, 10-139
 - Text parameters 10-42, 10-46, 10-144
 - Vector parameters 10-146
- Setting parameters
 - PLT_LIB 10-6, 10-23, 10-136
- Setting PLT_LIB parameters 10-6
- SHOW BREAK
 - VAX/VMS debugger 12-38
- SHIOW CALLS
 - VAX/VMS debugger 12-40
- Single-analysis software 3-17-3-18
- Software abstract 4-22
- Software acquisition procedures 3-9-3-13
- Software classification 3-5-3-6
- Software development procedures 3-9-3-13
- Software development strategy 3-1-3-4
- Software development utilities 12-1
- Software libraries 2-19-2-22
- Software management system 2-3-2-6
- Software name 4-1
- Software notebook 4-21-4-22
- Software planning 5-1-5-2
- Software review committee 3-11
- Software robustness 5-11
- Software sponsor 3-9
- Software text 10-51
- SPAWN
 - VAX/VMS debugger 12-40
- Spectrum mapping 10-132
- Sponsor 3-9

- Definition 2-5
- SPONSORS
- CHANGES 12-8
- SQZSTR 8-54
- Statement numbering 5-4
- Step
 - VAX/VMS debugger 12-39
- Stratigraphy 7-1-7-2
- String 8-30
- String processing routines
 - CAMCON_LIB 8-2, 8-51
- STRIPB 8-55
- STRTUP 8-21
- Subroutine headers 5-16
- SVDI 10-1, 11-1
- SVDI Devices 11-2-11-5
- SVDI routines 11-6
- SWCF records manager 3-10
- SYMBOL 10-184
- Symbols 2-7
- Syntax conventions 4-8
- Syntax rules 8-30
- System architecture 2-3
- System queries
 - CAMSUPES_LIB 9-2, 9-3

T

- Task leader 3-9
- Terminal bell 10-11
- Terminate SVDI 11-42
- Text parameters
 - Getting 10-43, 10-48
 - Restoring 10-45, 10-50
 - Saving 10-44, 10-49
 - Setting 10-42, 10-46, 10-144
- Text plotting 10-51
- Theory manual 4-24
- Three-dimensional coordinates 10-5
- TL 3-9
- Traceability 4-1-4-3
- Trailer frame 10-17, 11-15
- Transformations 10-4
- Two-dimensional coordinates 10-5
- Two-dimensional graphing 10-57
 - PLT_LIB 10-57
- TYPE
 - VAX/VMS debugger 12-39

U

- UPCASE 8-57

- Update history 4-14
- Update program 12-36
- UPDATE_PROGRAM 12-36-12-37
- User interface 4-1
- User interface routines
 - CAMCON_LIB 8-2, 8-6
- Utilities
 - FLINT 12-12-12-18
 - FORMRENUM 12-19-12-22
 - LISTDCL 12-28
 - LISTFOR 12-30-12-31
 - QA_PREP 12-32
 - QA_PRINT 12-33-12-36
 - UPDATE_PROGRAM 12-36

V

- Variable Names 5-5
- VAX/VMS debugger 12-37-12-40
 - Examining variable values 12-40
 - Executing 12-39
 - Listing source code 12-39
 - Miscellaneous commands 12-40
 - Setting break points 12-38
- VBERRH 11-7
- VDAABU 11-8
- VDABGL 11-9
- VDAGKL 11-10
- VDALOC 11-11
- VDBELL 11-12
- VDBUFL 11-13
- VDESCP 11-2, 11-14
- VDFRAM 11-15
- VDINIT 11-16
- VDIQCO 11-17
- VDIQCP 11-18
- VDIQDC 11-19
- VDIQES 11-22
- VDIQND 11-23
- VDIQOS 11-24
- VDLINA 11-25
- VDLOGE 11-7, 11-26
- VDMOVA 11-27
- VDNWPG 11-28
- VPNTA 11-29
- VPOLY 11-30
- VDSTBC 11-31
- VDSTCO 11-32
- VDSTCS 11-33
- VDSTFC 11-34
- VDSTFN 11-35
- VDSTIN 11-36

Index

VDSTLA 11-37
VDSTLS 11-38
VDSTLW 11-39
VDSTOS 11-40
VDSTSA 11-41
VDTERM 11-42
VDTEXT 11-43
VDWAIT 11-44
Vector parameters
 Setting 10-146
Verification 3-9, 3-16–3-17
Verification records 4-23
Version ID 4-1
VIEW
 CHANGES 12-8
Viewing Transformations 10-5
Viewport 10-4, 10-123, 10-124, 10-125
Viewport transformations 10-5

W

Wait for graphics device 11-8, 11-9
Wait for key 10-14, 10-22
Wait for keyboard 11-10
Wait for return 10-185, 10-186, 10-187
Wait for user 11-44
WAITCR 10-185, 10-186, 10-187
Well locations 7-2
WRCBUS 8-12
WRFNAM 8-29

X

XMAPDC 10-188
XWTODC 10-190

Y

YMAPDC 10-189
YWTODC 10-191

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