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ROME LABORATORY

COMMON MAPPING INTERFACE CONTROL (CMIC)

Sterling Software

David A. Kolassa

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APPROVED: Maria Amodio

MARIA U. AMODIO
Project Engineer

FOR THE COMMANDER:

DELBERT B. ATKINSON, Colonel, USAF
Director of Intelligence & Reconnaissance

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David A. Kolassa

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Sterling Software
Beeches Technical Campus, Route 26N
Rome NY 13440

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This report summarizes the work conducted under the Common Mapping Interface Control (CMIC) task. The objective of this effort was to provide configuration management, software maintenance, and user support for the software developed under the Common Mapping Program (CMP) and the ARC Digital Raster Imagery (ADRI) Exploitation/Data Compression software. CMP supplies digital mapping capabilities for USAF geospatial command, control, and communications (C3), mission planning, and intelligence system applications. The primary software component of CMP is the Common Mapping Toolkit (CMTK). Under this task, Sterling Software performed software analysis, software baselining, configuration management, and software maintenance for the CMTK as well as the ADRI Exploitation/Data Compression software. Extensive technical support was provided to users of the CMTK as well as distribution services.

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Preface

This document presents the Final Technical Report of the Common Mapping Interface Control (CMIC) effort sponsored by Rome Laboratory under Air Force Contract No. F30602-91-D-0007 (Task 19). The CMIC project was directed at systematically controlling, maintaining, and supporting the Common Mapping Program software and the ARC Digital Raster Imagery (ADRI) Exploitation/Data Compression software.

This final report is organized into five chapters and one appendix. Following this introduction, Chapter 2 describes the Common Mapping Program and its components and development history. Chapter 3 outlines the functionality of the Common Mapping Toolkit, and Chapter 4 summarizes the activities and major accomplishments within CMIC. Chapter 5 ends the report with conclusions and recommendations. Appendix A lists the acronyms used throughout this report and a glossary of terms.

Ms. Maria Amodio was the Rome Laboratory/IRRP Project Engineer and Program Leader; Mr. David Kolassa was the Sterling Software/ITD, Rome Department's Principal Investigator and Program Manager. The project was conducted by Mr. David Kolassa, Mr. Michael McQuinn, Ms. Sandra Stoltz, Mr. Mark Maginn, and Mr. Alan Rozanski with support from Mr. William Reid, Mr. Michael Scott, Mr. David Gray, Dr. James Northrup, Mr. Allen Lazzara, Ms. Catherine Cesena, Ms. Laura Richer and Ms. Lori Knapp. The CMIC staff is greatly indebted to Ms. Amodio for her guidance and assistance throughout all stages of this project. We are also grateful to Mr. Jeffery Hanson and Mr. John Baumann of RL/IRRP for valuable technological and operational insights that helped make this project successful.

Chapter 1
Introduction

1.1 CMIC Overview

The Common Mapping Interface Control (CMIC) effort was a major component of Rome Laboratory's Image Products Branch (RL/IRRP) digital cartography program. The main objective of the effort was to provide configuration management, software maintenance, and user support for the software developed under the Common Mapping Program (CMP). It also focused on providing data preservation, duplication, and distribution services for the Arc Digital Raster Imagery (ADRI) software. The following is a list of the major tasks that were accomplished:

- Software Analysis
- Software Baselining
- Configuration Management
- Software Maintenance
- Documentation Support
- Technical User Support
- Electronic Chart Update Manual (ECHUM) Analysis
- Cartographic Traceability Analysis Function (CTAF) Support
- ADRI Support

Chapter 4 will discuss each of the above tasks in detail.

1.1.1 Common Mapping Program Overview

The Common Mapping Program (CMP) is a joint Rome Laboratory, Electronic System Center and Air Force Intelligence Support Agency effort. Its role is to furnish digital mapping capabilities for USAF geospatial, Command, Control and Communications (C^3), mission planning, and intelligence system applications. The CMP will be discussed in greater detail in Chapter 2, however, the following is an overview of the primary components of the CMP program.

- **Common Mapping Standard (CMS)**

  CMS is the data base format for all preprocessed Mapping, Charting, Geodesy and Imagery (MCG&I) data; its specifications are defined in the CMS Interface Control

Document. This document also defines Erasable Optical Disk (EOD) as the standard transfer media for CMS formatted data.

- **Common Mapping Toolkit (CMTK)**

  CMTK is a software library with functions for manipulating and displaying CMS formatted data; its functionality is invoked through calls to CMTK from an application program or system.

- **CMTK Data Base Administrator (CDBA)**

  The CDBA application provides the user with a convenient user interface to a collection of data base utility programs. The CDBA is composed of the CMTK Data Importer (CMDI) and an Imagery Converter. The CMDI produces CMS data from DMA data sources and the Imagery Converter has the capability of converting LANDSAT and SPOT formatted images to the National Imagery Transmission Format (NITF). Both CMS and NITF formats are then utilized by the CMTK.

1.1.2 ADRI Exploitation Software

The ADRI Exploitation Software is software for using ARC Digital Raster Imagery (ADRI). ARC Digital Raster Imagery consists of Mosaicked Orthorectified imagery derived from the SPOT Satellite Panchromatic imagery. The ADRI Exploitation Software has an Exploitation and Data Compression subsystem.

- **ADRI Exploitation Subsystem**

  Provides: Point Positioning, Storage of Points, Image Magnification, Contrast Control, Display, and File Transfer (tape to disk) capabilities.

- **ADRI Data Compression Subsystem**

  Provides: the capability to take the raw, uncompressed ADRI product and compress it by a factor of approximately 18:1.

1.2 CMIC's Role

CMIC's roll has been to manage the release of CMP and ADRI products. The CMP and ADRI software products are the results of previous and ongoing advanced cartographic development projects. They have been brought under configuration management and productized within the CMIC program for dissemination to Common Mapping Program users. Towards this, CMIC put forth policies and procedures to ensure standardization for the continued development, modification, and dissemination of all CMP based cartographic products.

CMIC was primarily concerned with delivering standardized and technically supported software to registered users of CMP products commencing with the introduction of the official CMP baseline, Version 1.4.1. Specifically, the following products have been productized, standardized, and technically supported within the CMIC program:

- Version 1.4 through Version 2.02 of the Common Mapping Toolkit (CMTK) and the Common Mapping Preprocessor Software
- the Common Mapping Preprocessing Interface Software
- the Common Mapping Demonstration Software
- the ARC Digital Raster Imagery Software

These products have been made available to registered users of CMP products.

1.2.1 Availability of Software and Documentation

Each major version release of the software and its supporting documentation was available upon request from Rome Laboratory throughout the duration of the CMIC contract. Request for the CMTK distribution package was directed to the engineer at Rome Laboratory who controlled the release: Ms. Maria Amodio, RL/IRRP.

The distribution release procedures required that an official letter of request, from the Government point of contact, be mailed to RL/IRRP. The letter of request included the organization's point of contact, phone number, sponsoring agency, the program the software will be used on, shipping address and type of distribution media requested. The requesting organization was then issued a Statement of Terms, by Rome Laboratory, which was signed and returned along with the distribution media.

After receipt of the Statement of Terms and distribution media, a distribution copy was created. The software was loaded onto the supplied media, packaged with the hardcopy documentation and shipped by RL according to the information provided by the requesting organization. Each user copy was logged and tracked by Rome Laboratory to provide update notifications as they occurred.

1.3 Overview of Accomplishments

Reviewing the progress made during the CMIC project. A number of major accomplishments highlight the work performed.

- Baselined, released, and supported a number of version of the Common Mapping Toolkit software for the user community.

- Utilized rigorous configuration management and software maintenance procedures to ensure quality products were distributed.
- Processed 150+ Problem Reports and Change Requests in the software suite.
- Simplified end user installation through automatic installation scripts. Improved the ability to meet the user's needs for technical support by implementing an automatic installation script.
- Ported the Common Mapping Toolkit to the DEC Alpha, and the Sun Solaris based platforms, and extended technical support to users of Hewlett Packard, and Silicon Graphics workstations.
- Wrote a complete and detailed set of user documentation for the CMIC software suite.
- Hosted a Common Mapping User Interchange Symposium at Rome Laboratory.
- Developed G-Odesy – a new demonstration software package – to exercise the capabilities and the functionality of the Common Mapping Toolkit.

A detailed explanation of each of these accomplishments will be presented in Chapter 4.

Chapter 2
Common Mapping Program

The Common Mapping Program (CMP) provides standard Mapping, Charting, Geodesy, and Imagery (MCG&I) data and exploitation capabilities to support Command & Control, Mission Planning, and Intelligence. The CMP consists of several components. One of these is the CMTK, which implements a software library to display, manipulate, perform geospatial analysis, and otherwise exploit Common Mapping Standard (CMS) data.

The CMTK consists of a software library of functions to exploit CMS and other data sources. The toolkit functions utilize Motif and X Windows, and operates in the UNIX environment. In addition to the CMTK software library, separate data importing applications are available to produce the CMTK CMS data from Defense Mapping Agency (DMA) sources, and non-CMS data from other sources such as SPOT and LANDSAT, for use by CMTK functions. A demonstration application, G-Odesy, is available with the CMTK that will exercise the CMTK software library and provide detailed programming examples. See Chapter 4 for a detailed discussion of G-Odesy and its functionality.

The CMS defines the standard MCG&I data base format for the CMP and is designed for efficient on-line use. This format governs the implementation of the CMS Data Production System (CDPS). CDPS is the software that translates the various digital cartographic data formats produced by the DMA, along with the Air Force's ARC Digital Raster Imagery (ADRI) products, into the unified CMS format on designated transfer media. The result is a set of digital MCG&I data with a common internal vector, raster and matrix format.

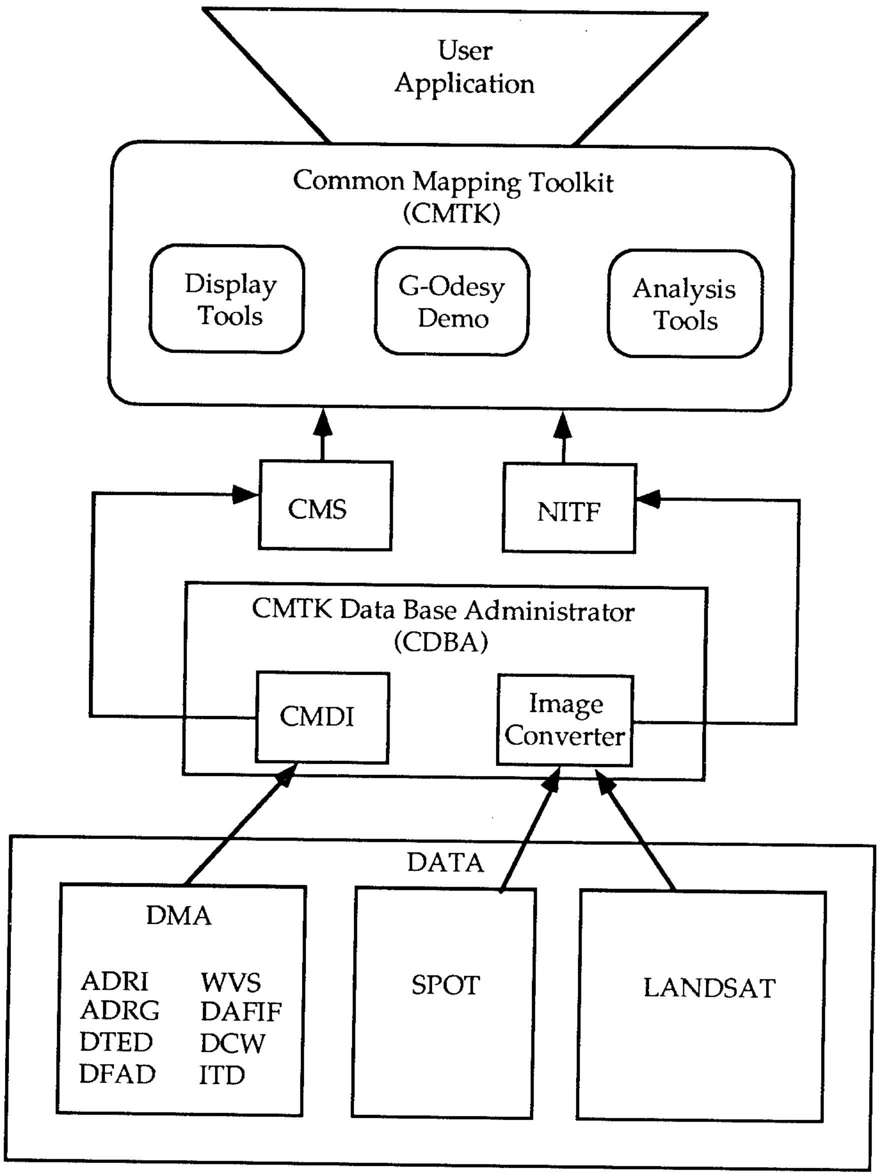
2.1 CMP Components

The Common Mapping approach has several components in its implementation of a common, low-level toolkit of MCG&I functions. These are described below and their interrelationship is shown graphically in Figure 2-1.

Common Mapping Standard (CMS)

The CMS defines a worldwide, seamless, digital data base that uses DMA products to provide a common interoperable cartographic data base structure rather than the many different DMA formats. CMS data may be used by applications independently of the CMTK or toolkit support utilities. This is the basic cartographic data format which CMTK is intended to exploit. The following is a list of the currently supported DMA data bases:

- Digital Terrain Elevation Data (DTED)
- Digital Feature Analysis Data (DFAD)
- World Vector Shoreline (WVS)
- Digital Aeronautical Flight Information File (DAFIF)
- Arc Digitized Raster Graphics (ADRG)
- Arc Digital Raster Imagery (ADRI)
- Digital Chart of the World (DCW)
- Interim Terrain Data (ITD)



Common Mapping Component Overview
Figure 2-1

Common Mapping Toolkit (CMTK)

This toolkit software provides a ready made user application interface to the CMS data. It provides the programmer with functions to display, manipulate, and annotate the geospatial data. It also provides geodetic algorithms, cartographic analysis tools and image processing tools. The geodetic algorithms include coordinate conversions, datum conversions, and magnetic heading and distance calculations. The cartographic analysis categories are perspective views, sensor output simulations, intervisibility analysis, minimum and maximum point calculations, mobility analysis, two dimensional terrain visualization, derived data products, and other analyses. The image processing tools include image filters, tinting and fading of images, cutting and pasting of images, and annotation of imagery. CMTK expands on the cartographic data available through CMS to allow for non-geocoded imagery and the secondary derived data products it produces.

CMTK Data Base Administrator (CDBA)

The CDBA application provides the user with a convenient user interface to a collection of data base utility programs. The CDBA is composed of the CMTK Data Importer (CMDI) and an Imagery Converter. The CMDI produces CMS data from DMA data sources and the Imagery Converter has the capability of converting LANDSAT and SPOT formatted images to the National Imagery Transmission Format (NITF). Both CMS and NITF formats are then utilized by the CMTK.

CMTK Demonstration Software

This application software, named G-Odesy, provides programmers with sample CMTK Application Programming Interface (API) calls, and is used to test the full complement of CMTK APIs. G-Odesy is used to verify a CMTK installation and can be used for regression testing for new CMTK versions. Chapter 4 gives a detailed explanation of G-Odesy and its functionality.

User Applications

This component is added by the programmer using CMS data or the CMTK. This provides the user specific services in a format familiar to, or desired by the user. The CMS data provides a cartographic data base to the user application, and the CMTK provides cartographic and imagery display, manipulation, and annotation capabilities in an environment which is compatible to other Common Mapping user environments.

2.2 CMTK Development History

The Common Mapping Toolkit has been developed through several version releases, and more are planned for the future. The following discusses each of the major releases.

CMTK Version 1.3

This is the originally released version of the toolkit. It runs on a DEC RISC platform and is composed of both C and Ada source code. It contains basic cartographic display and display manipulation and annotation functions, a set of eight image filters, along with cartographic functions to do terrain masking, intervisibility along a path, intervisibility profile, elevation contour lines, and line-of-sight.

CMTK Versions 1.4, 1.4.1 & 1.4.2

These versions supply the same functionality as CMTK 1.3, with some problems fixed and basic improvements. It runs on both DEC and Sun platforms and is composed of all C source code. It has been successfully ported to other platforms, such as a Silicon Graphics.

CMTK Versions 2.0 & 2.02

The CMTK 2.x versions provide more functionality than is available in the CMTK 1.4.x. The software has been reorganized to better isolate and control the interface from the lower levels of the toolkit. These baselined versions run on both DEC and Sun platforms and is all C. Bindings for other languages, such as Ada, have been developed by several Common Mapping users. Support for the CMTK 1.4.x user interface will be maintained through a special binding. Thirty-one image filters have been added, and many cartographic analysis functions have been added in the categories of perspective views, sensor output simulations, intervisibility analysis, minimum and maximum point calculations, mobility analysis, two dimensional terrain visualization, derived data products, and other analysis.

CMTK Version 2.02 was developed and delivered to Rome Laboratory under the Unit Level Prototype Interface effort (ULPI). This version was baselined under the CMIC effort and additional problems corrected prior to a formal release of version 2.02. This baselined version has well over six hundred function calls documented for use at the API level. Over three hundred functions are used in the demonstration software (G-Odesy) which accompanies the distribution package.

CMTK Version 3.0 (the future)

This version is currently under development. It will supply the same functionality as CMTK 2.02 and will run on both Sun and DEC platforms. Support for the CMTK 1.4.x user interface will not be maintained, but may be available through other channels. This version will add client/server capabilities and multiple cartographic windows from a single user application.

Chapter 3 Common Mapping Toolkit Functionality

The Common Mapping Toolkit (CMTK) is a software library that provides a ready made application interface to CMS and CMS-like data along with geospatial tools to exploit that data. The basic toolkit functionality provides the capability to display, manipulate, and annotate the geospatial data. The toolkit, however, goes beyond the basic geospatial interaction functionality by incorporating geodetic algorithms, cartographic analysis tools and image processing tools. As a result, the CMTK is a collection of geospatial tools, from which an application programmer may select any number or combination to create a unique geospatial application.

The geodetic algorithms include coordinate conversions, datum conversions, and magnetic heading and distance calculations. The cartographic analysis categories encompass perspective views, sensor output simulations, intervisibility analysis, minimum and maximum point calculations, mobility analysis, two dimensional terrain visualization, derived data products, and other analyses. The image processing tools include image filters, tinting and fading of images.

Figure 3-1 presents an overview of the functionality contained with the CMTK Version 2.02. In total there are over six hundred API level calls that can be made by the application programmer. The functionality that these API calls provide have been grouped into five areas: Geospatial Support, Object Support, Geospatial Analysis, Terrain Visualization and Image Processing. Each of these areas are discussed in the subsections which follow.

3.1 Geospatial Support

There are a number of functions available in the CMTK that serve as basic geospatial support and display management. Presenting map displays to a user and allowing the user to control scale and position, geospatial queries of the cartographic data, interaction with the CMS & CMS-like data bases and common MC&G functions are grouped into this category. Typical CMTK function calls in this group include:

- Map Displays

  CkOnePointPan - interactively prompts the user for a new map center and display the map centered at the user defined geographic location.

GEOSPATIAL SUPPORT

- Map Displays
  - Raster/Vector Data
  - Registered Imagery
  - Object/Symbology Overlays
  - Legends
  - Grid Overlays
  - Zooming
  - Panning
  - Scale
  - Fade
  - Inset Map Displays
  - Feature Color Definitions
- Queries
  - Position
  - Elevation
  - Bearing
  - Distance Along a Path
  - Great Circle Distance
- Data Base
  - Viewing Parameters
  - Environment Queries
  - Attribute Retrieval
- Utilities
  - Variable Units of Measure
  - Coordinate Conversions
  - Image Registration
  - Surface Materials
  - Datum Transformations
  - Spheroid Transformations
  - Projection Transformations
  - Data Accuracy Displays
  - Precise Monoscopic Positioning

OBJECT SUPPORT

- Primitives
- Adding Objects
- Object Selection
- Object Queries
- Highlighting
- Object Modifications
  - Move
  - Rotate
  - Scale
  - Attribution
- Tracking
- Links
- Annotations
- Symbology
  - Scaling

GEOSPATIAL ANALYSIS

- Intervisibility Analysis
  - Intervisibility Profile
  - Intervisibility Along a Path
  - Terrain Masking
  - Sensor Allocation
  - Line-of-Sight Analysis
- Mobility Analysis
  - Cross Country Movement
  - Trafficability
  - Optimal Path
- Surface Analysis
  - Matrix Merging
  - Surface Materials
- Sensor Output Simulations
  - SAR
  - FLIR
  - LLLTV
  - RADAR
  - RTD
- Ridge Valley Analysis
- Path Profile Analysis
- Area Gradient Analysis
- Point-to-Point Calculations
- Magnetic Inclination Calculation
- Local Min/Max Elevation

TERRAIN VISUALIZATION

- 2D Terrain Visualization
  - Elevation Contour Lines
  - Elevation Contour Polygons
  - Planimetric Hill Shading
  - Hypsometry Shading
- Perspective Views
  - Fast Perspectives
  - Wireframe
  - Terrain Perspectives
  - Threat Envelopes
  - Fly Through
  - Image Warping

IMAGE PROCESSING

- Histograms
- Filters
  - Contrast
  - High Pass
  - Maximum/Minimum
  - Equal Probability
  - Noise Reduction
  - Smoothing
  - Edge Detection
  - Point Detection
  - Thresholding
- Tinting & Fading
- Cut & Paste

CMTK 2.02 Functionality
Figure 3-1

CkTwoPointZoom - Provides an interactive zooming capability based on a rubber band box.

- Queries

CkReturnElevPos - Prompts the user to select a point on the screen and returns the geographic position and elevation value for that location.

CkRetunPos - Returns just the geographic coordinates of a selected screen position.

- Data Base Storage & Retrieval

CkLoadDisplayConfig - Loads the named file as the current display configuration defining which CMS data to be used and how to initially present that data on the screen.

CkSaveSys - Save the state and display configuration of the current map for later use.

- Utilities

CkInqDist - Returns the distance between two positions

CkDatumConversion - Converts latitude and longitude coordinates from one datum to another.

3.1.1 Map Displays

The CMTK furnishes a number of routines that allow the user to alter the map display in a variety of ways. These aspects often reveal useful information, that may not have been obtained otherwise. Some of these operations made available by the CMTK include zooming, panning, color modifications and fading of features.

Map selection, from those available in the display configuration, enables the modification of the map background color as well as its visibility. The same functionality is available for the individual overlays within a map.

Individual features may also be selected, and once they become current, they may be modified by number of CMTK functions. The assigned color may be changed to any other in the current color configuration. In addition, the feature may be faded, through a CMTK call, to enhance the map display.

The CMTK offers functions for zooming, panning, and scaling. The application programmer can choose between interactive and non-interactive as well as proportional verse non-proportional manipulation. With the interactive operations, the user can use a mouse to select those regions used in the analysis. The non-interactive methods, use pre-defined locations or areas of interest when performing the analysis. For instance, a map can be panned, scaled, and zoomed non-interactively by using a fluctuating center point. The CMTK also makes it possible for a map to be panned via an inset map, which is essentially a dialog containing a rough sketch of the entire map as well as a rectangle over the detailed portion being displayed on the regular display.

Proportionality with regard to scaling and zooming is always retained by the CMTK when non-interactive methods are used. When invoking interactive routines, proportionality can be retained by forcing a dependency between the vertical and horizontal lengths of a rectangle; that is the user can not alter both height and width freely. The difference in selecting regions of interest resides in that proportional selections are done by selecting a fixed center point and constructing a rectangle about it, while the non proportional selection is performed by selecting two opposing corners of a rectangle.

3.1.2 Queries

The CMTK furnishes a collection of routines capable of providing feedback for a variety of questions. The information yielded by these operations is useful in understanding the displayed map or geographic area represented by the map. The major query topics handled by the CMTK provide information on

- distance
- position
- elevation
- bearing
- bearing and distance
- measurement units
- display process
- cartographic data

Distance: For distance information requests, the CMTK furnishes routines to display the great circle distance along one or more line segments, display this distance continuously as line segments are drawn, allow the user to pick points on the screen and then display the distances between those points including the additional distance due to elevation, and show either the air or ground distance between two specified points. The CMTK enables the user to calculate a variety of distance measurements based on coordinates selected and in some cases elevation data present. Measurements calculated by the CMTK include Air Path Distance, Great Circle, and Ground Path Distance. The format of reported information by the CMTK is customizable by the application programmer.

The CMTK angle operation takes the two coordinates provided, finds the slope of the line, and calculates the arctan of the slope, thus yielding an angle between -90 degrees and 90 degrees. This operation then evaluates the coordinate pairs and determines which has the longitude coordinate closer to the minimum longitude coordinate (the left vertical edge of the map). If the starting point was this point, the angle is returned, otherwise 180 is added to the angle and then the value is returned.

Position: To deal with position data, the CMTK includes routines capable of displaying the location of the point defined by a cursor position, displaying the location continuously as the mouse is moved, and returning the coordinates of the location selected to the application instead of displaying them. All position related information is output in the format specified by the application programmer.

Elevation: When elevation data is present, the CMTK offers functions accepting the name of a cartographic map and feature containing elevation data that is to be used by all subsequent terrain analysis and elevation query routines. The CMTK also offers functions which display the elevation and corresponding map location under the mouse cursor, display the elevation of the terrain at the location under the mouse cursor when requested, return the terrain elevation at the selected position, and return the terrain elevation for one or more of the selected positions. The format of reported information by the CMTK is customizable by the application programmer.

Bearing: To manage the bearing data, the CMTK enables the user to display the bearing along a line segment from the first point to the second point either continuously or for the end result. The application programmer can tell the CMTK whether to use true or magnetic north when making a calculation. All information supplied is shown in the format selected.

Bearing and Distance: The CMTK furnishes several functions for returning data based on bearing and distance information. The CMTK routines include displaying both the bearing and air distance along each of one or more line segments, returning in lieu of displaying the output information, allowing specification of whether the bearing calculations are relative to true north or magnetic north, and returning a value for magnetic north at any given earth location and date based on the World Magnetic Model of the Naval Oceanographic Office.

Measurement Units: The CMTK provides specific measurement query routines capable of controlling the output coordinate systems for distance, position, elevation, and bearing or heading queries. In addition, the CMTK offers functions allowing the user to specify the desired UPS and UTM spheroids that will be used for all operations involving UPS and UTM coordinates respectfully.

Display Process: The CMTK furnishes routines for handling display process information. Some of the information which can be returned include the name of the display process used by the current feature, the current value of the pickability flag for the current feature, the position of the current map viewer, the current map scale, and the range of the current map window in latitude/longitude coordinates. In addition, there is a CMTK function which searches all the currently pickable Cartographic Display Process Features for a feature item, that is located at the latitude/longitude coordinate indicated.

Cartographic Data: The CMTK furnishes queries on cartographic data. Some of the information, which can be returned, include the map and feature name associated with the current coverage feature, the list of all the cartographic data base maps and features which are referenced in the current display configuration, and the list of all cartographic data base map and feature names in the cartographic data base.

3.1.3 Data Base Storage and Retrieval

Routines are included in the toolkit libraries enabling an application to interface with the data on a storage device. This communication link with secondary storage enables customizations, supporting data, and other CMTK information to be stored and retrieved.

Some of the CMTK data base storage operations enable the following to be stored:

- Snapshots of the state of the current map for later redisplay. Information includes viewing parameters, visibilities, and objects.
- A display configuration.
- The viewing parameters, colors, visibilities, objects, display configuration, object environment, and graphics environment settings. Each of the last three mentioned is maintained within unique files, while viewing parameters, colors, visibilities, and objects are collectively retained by one file.
- The map being displayed.

In addition to allowing the retrieval of those things mentioned under storing, the CMTK's retrieval facilities enable fill patterns, maker fonts, and text fonts to be addressed. However, the real power of the CMTK's retrieval facilities resides in its capacity to load and use significant supplemental map data "on the fly". This information includes elevation, coverage, cartographic, and imagery data and is used to answer detailed queries.

3.1.4 Utilities

The CMTK offers a variety of pre-built tools to aid in the tasks of map manipulation, data retrieval, and analysis. Some of these utilities include

- Legends
- Coordinate Conversions

The CMTK provides a variety of legend operations, enabling the user to display useful information regarding the data being displayed. The standard legend identifies the current map being displayed along with its current display scale and screen center coordinate. Other legend provide accuracy information, cartographic coverage symbology, and coordinate precision values .

The CMTK Coordinate Conversions utility furnishes the user with the capability to translate coordinates in various coordinate systems into other coordinate representations. Coordinates can be represented in virtual screen coordinates (VSC), physical device coordinates (PDC), geographic coordinates (latitude/longitude), Universal Polar Stenographic (UPS) and Universal Transverse Mercator (UTM). The latter two are presented in the Military Grid Reference System (MGRS).

3.2 Object Interaction

The CMTK supports the use of graphic objects. Functions are provided that allow for the creation, modification, query and display of dynamic map objects. Typically these objects are used to represent an entity such as oil wells, Army Divisions, tanks, or aircraft position. These objects are referenced to the earth surface and can be graphically portrayed as an icon positioned at a specific geographic coordinate in the map display. Objects are separately addressable map elements that may consist of any combination of the following primitives:

- Circles
- Ellipses
- Markers
- Polygons
- Polylines
- Polymarkers
- Text
- Vectors
- User Information blocks
- Track History

Some sample CMTK object functions are

CkAddObj – Creates a new object record under the current display configuration feature.

CkCursorMoveObj – Move an object using the cursor.

CkCursorRotateObj – Select and rotate an object.

CkDeleteObj – Delete and erase the current object from the current feature.

CkSetPolylineStyle – Set the line style for the polyline primitive of the current object.

CkHighlightObj – Redraw the current object with the specified color.

Objects can added, accessed and modified in a CMTK map display in a number of different methods. These methods and examples of some of the CMTK functions calls are described in the following sections.

3.2.1 Object Primitives

To the application programmer, the CMTK provides the set of commonly used graphical objects, such as circles, ellipses, polygons, polylines, text string expressions, and a collection of useful symbols. When operating on these simple basic objects, the CMTK is capable of classifying these objects as absolute or relative. Relative objects differ from absolute objects in that a dependency exists between it and the map. For instance, when a map is scaled, all relative objects on the map are scaled, thus proportionality between objects and the map remain intact automatically.

The CMTK allows circles and ellipses to be constructed based on a limited amount of information. These built-in CMTK tools enable high quality circles and ellipses to be generated effortlessly. For instance, the CMTK can generate a circle from either a center and radius point, or three points residing on the circumference.

The CMTK's polygon object enables an object to be constructed from a connected series of points, which are limited to 1000. A straight line links each successive point to the previous point. In addition, a straight line connects the very first point set in the series with the very last point.

The polyline object acts similarly to that of the polygon primitive except a final straight line is not drawn between the first and last points set. This CMTK feature is useful for drawing complex objects which are composed on connected straight lines.

The CMTK enables the application programmer to place text and commonly known symbols on the map. The CMTK contains over 100 symbols from which to choose and provides easy selection facilities. While useful to convey information to the user, both the marker and text primitives are not scale able objects (i.e., They are always absolute).

3.2.2 Adding Objects

The CMTK provides facilities allowing objects to be added. Before an object can be considered, it must be defined using the CMTK's powerful and easy interactive command language and compiled using the CMTK's support utility tkparser. This interactive command language not only adds objects but also enables default attributes to be set up once and frees the application programmer from the complications of routinely having to redefine object characteristics. For instance, when defining a circle object, the interactive command language programmer can define how the center point, radius, edge factor, and the line style are to be expressed.

3.2.3 Selecting Objects

The CMTK enables objects to be selected for manipulation. The selecting of objects may be performed directly by pointing with the mouse, or indirectly by indicating all objects within a specific region. When using the indirect approach, functionality exists in the CMTK to further discriminate objects within the region by looking at some intrinsic value known as the "pick value".

3.2.4 Object Queries

The CMTK furnishes the user with functions capable of answering a variety of queries regarding the objects. Some of the information which can be obtained about an object include the name of the format that was copied to create the current object, whether or not the current object is highlighted, the ids of all objects that match a given search attribute, the number of primitives in the current object, and the ids for all links involving the current object.

In addition, the CMTK provides methods for accessing information on an object's attributes. Some of the attributes which can be queried include the number of bytes or characters associated with an information object, the points which define the object, the current visibility status of an object, the text or marker data associated with the object, the color for the object number within the current object, the id of the font used by an object, the name of the font used by an object, the offset of an object relative to the object origin, the style attributes for the specified object, and the type of a given object (e.g., circle, ellipse).

Finally, the CMTK offers functions enabling the track history record to be accessed. Information returned includes the positions currently stored with a track history, the current status (activated or not) for track history recording, and the current visibility status of a track history.

3.2.5 Highlighting Objects

All objects may be highlighted, which involves drawing an entire object in one specified highlight color, regardless of the original colors of the object. This operation enables the user to easily distinguish between active and inactive objects. Usually, this places an active role in differentiating between selected and non-selected objects on the map.

3.2.6 Modifying Objects

Most individual objects can be modified by the CMTK independent of other objects on the map. These functions allow the user to take an existing object, and transform it into something more appropriate for a given situation. For instance, if the user decides that airbases both friendly and unfriendly are to be represented on the map by a square, then the ability to modify the color of such an object would aid in helping to differentiate between the two.

When manipulating marker and text primitive objects, the fonts used in portraying these objects may be modified. When transforming most objects, the following characteristic attributes are available: fill pattern, line style (thickness), and color. In addition, text may be assigned and a new marker pattern may be chosen.

Some of the modifications supported by the CMTK change the actual internal representation of an object and include rotating, scaling, translating, removing, and direct positioning by some direct map coordinate.

3.2.7 Tracking Objects

The CMTK has built in facilities for retaining the history of an object's locations on the map up to the last 720 past positions. This feature enables the user to rollback an object to former locations. Two forms of track history are available by the CMTK: point tracks, which are represented by a text symbol at each of the positions occupied by the object on the map, and line tracks, which are shown as lines connecting each of the positions.

In addition to keeping track of an object's location on the map, the CMTK's history records the maximum number of past object positions to be stored, the coordinates of the past positions, how a track line is to be drawn (solid, dotted, or dashed), the width in pixels of a line track, the name of a user-defined font in which the symbol for a point track is found, and the character from the font which is to be placed at each position in a point track history.

3.2.8 Object Links

The CMTK enables objects to be bound together, which is shown by a line drawn between the positions of each object. These links can be used to represent an organizational structure, a line of communication, or any other relationship among objects. The attributes defining a link are stored in a link record and include a unique integer identifying the link, the identifiers of the two objects which compose the link, and a flag indicating when the link is to be shown.

3.3 Geospatial Analysis

The toolkit contains a variety of functions that can be exercised to exploit the cartographic data. Many of these functions are based upon standard MC&G analysis tasks and standard algorithms. In general the analysis tools can be grouped into functionality which provides: Intervisibility Analysis; Mobility Analysis; Surface Analysis; Miscellaneous Analysis Tools; and Sensor Output Simulations. Functions calls that can be found in the toolkit for each of these areas are:

- Intervisibility Analysis

  CkGetLOS - returns the line-of-sight distance and visibility from one point to another.

  CkIVProfile - Creates a plot of a terrain profile.

  CkCursPathIVProfile - Allows the user to pick a path on the screen and display an intervisibility profile of the path.

- Mobility Analysis

  CkCCM - Performs cross country movement on the specified SMC product.

  CkGeneratePttoPtPath - Determines the quickest path a vehicle can travel between two road intersections.

  CkOptimalPath - Determines an optimal flight path based on aircraft parameters and waypoints.

- Surface Analysis

  CkCursSMC - Returns the Surface Material Code (SMC) and Feature Identification Code (FIC) values for a specified point.

  CkInqSMC - Returns the SMC, FIC, and Feature Type (point, lineal, or Areal) for a user selected point.

- Miscellaneous Analysis Tools

  CkGenRidgeChannel - Creates the vector data for ridges and channels.

  CkAreaGradient - Produces a display of the magnitude of an areas slope.

  CkSeSlope - Interactively displays point-to-point slope.

- Sensor Output Simulations

  CkGenFlir - Creates a FLIR return as an 8 bit image.

  CkGenRadar - Creates a Radar return as an 8 bit image.

  CkGenSar - Creates a Synthetic Aperture Radar return as an 8 bit image.

3.3.1 Intervisibility Analysis

Intervisibility analysis tools integrated within the CMTK libraries include the capability to perform the following functionality:

- Intervisibility Profile
- Intervisibility Along a Path
- Terrain Masking
- Sensor Allocation Planning
- Line-Of-Sight Analysis

The Intervisibility Profile capability generates a visual LOS display based upon an observer's geographic position, optimal maximum range, and a geographic endpoint. The algorithm used is a modified version of the basic LOS algorithm that includes the calculation of the above-ground shadow height along the entire LOS profile.

A given path and generic observer location off the path are used in the Intervisibility Along a Path capability. This functionality will determine which points along the path are visible to the observer and which points are obscured by the terrain. Both ground routes and air routes are accommodated with optional foliage and velocity shadowing. The SeeFar algorithm is used to calculate the terrain mask over the Minimum Bounding rectangle formed by the specified observer path. A profile is then cut through the ground shadow bitmap for ground paths, or the above -ground shadow height matrix for air routes. The cross-sectional profile display is the same as that produced by the Intervisibility Profile, except that it is generalized to handle multiple points along a path, and air, as well as ground routes.

Terrain Masking uses the SeeFar fast shadow propagation algorithm to generate a ground shadow bitmap and above-ground shadow height matrices over an entire area with respect to a specified observer position. Options include specification of the observers geographic position and above-ground level height, maximum range, line-of-sight azimuth pointing angle, and field-of-view sweep angle. The results are written to a temporary data base.

Sensor Allocation Planning provides tools to semi-automate the process of optimally positioning a set of movable sensors to best cover the set of fixed targets. Sensors can be ground based or in the air.

Line-of-Sight Analysis can be used to determine if a observer's position can see a specific target. The target may be invisible due to terrain obscuration, earth curvature, and/or beyond the maximum range. Inputs include the geographic location and above ground height of both the observer's position, along with the maximum range. The terrain profile is constructed by calculating actual LOS grid intersections. The observer and target are tied to the nearest grid post to be compatible with SeeFar terrain masking algorithm. The Line-of-Sight function returns a yes/no visibility value and distance from the observer to target in meters.

3.3.2 Mobility Analysis

The CMTK has the capability to perform analysis on the geospatial data for determining three different type of mobility. These include Cross Country Movement (CCM), Optimal Path determination, and Trafficability.

The CCM output is performed by the CMTK by rasterizing vector data source themes into a single theme. The functions allow for identification of specific vehicle types along with their associated mobility parameters. The resulting output is categorized into areas of "GO", "SLOW-GO" and "NO-GO".

An optimal flight path can be created through the CMTK functions given a terrain elevation map, a series of Lat/Long waypoints, and initial aircraft parameters. The aircraft parameters incorporated into the calculation are extensive and include:

- Altitude & Velocity
- Maximum climb and dive angles
- Minimum allowable horizontal/vertical set clearances
- Terrain Following/Terrain Avoidance (TF/TA) ratio
- Maximum lateral deviation from reference path
- Maximum turn g's
- Maximum bank angle

These aircraft parameters along with the terrain elevation map covering the flight path are used to calculate an optimum 3D flyable trajectory at a rate of one sample per second. The optimized output consists of the geographic position only. The user may also introduce obstacles and/or threats into the calculations.

Trafficability analysis is available in two forms, Point-to-Point or Radial. Both methods accept as input the type of vehicle and its associated parameters. Terrain is also factored into the calculations to compute road impedance due to grade and true distance along roads. The Point-to-Point method calculates the shortest vehicle route between two specified points on a road network. The distance along the found path and the travel time required to traverse it are then presented to the user. The Radial procedure solves the 'progress along a road' problem by tracing out all paths emanating from a specified start point corresponding to the progress which the vehicle can make along all roads in a user-specified time period.

3.3.3 Surface Analysis

The CMTK functionality to perform Surface Analysis enable the display of surface material data using appropriate color code in raster from taken from DFAD or ITD data bases. Surface materials are grouped into categories of unknown, metal, part metal, stone or brick, composition, earthen works, water, desert or sand, rock, concrete, soil, wetland or marsh, trees, snow or ice, and asphalt.

Surface analysis relies on the CMTK capability to produce derived data products. There are two methods available within the CMTK to generate these products. The first, called Matrix Merge, combines two or more raster matrices of the same type, resolution, and frame size into a single matrix. The raster data may be either elevation data or imagery and can be completely, partially, or non-overlapping. The CMTK provides a number of methods for merging including minimum, maximum, or average.

3.3.4 Miscellaneous Analysis Tools

The CMTK contains several additional analysis tools which can be applied to the terrain data. These analyses include:

- Ridge/Valley Analysis
- Path Profile
- Area Gradient
- Point-to-Point Slope

Ridges/Valleys on the map can be found by using the CMTK. This CMTK operation generates a vector result containing lines representing ridges and/or channels (i.e., slope lines connecting local extrema, traveling perpendicular to contours). In addition to flagging points which lie on ridges and/or channels, the CMTK thins the resulting binary point clouds down to single-bit lines (via classical Pavlidas algorithm) to obtain a raster result. The CMTK then takes this result and applies a contour tracing algorithm to the raster bitmap to produce a vector coordinate result and finally terrain smoothing is applied to control the number of ridge/channel lines generated.

The CMTK has built-in functions to give a profile for a given path. The path provided as data consists of a series of two or more latitude, longitude point pairs. A vertical terrain cross-section display, which plots terrain elevation against 2 dimension distance along the path from the start point (for each change in the path from start to finish), is generated. Waypoints along the path are drawn as asterisk symbols by the CMTK to identify the individual legs of the route.

Area Gradients is one of the many useful features built into the CMTK. Using centered differences in both the horizontal and vertical directions, the CMTK calculates gradients (i.e., surface normals), computes the corresponding gradient vector magnitudes, and converts to a normalized raster image as the final result.

The CMTK can also calculate the slope of two coordinates, which are given by latitude and longitude pairs, on the map. By supplying additional above ground level (AGL) values for the two coordinates, the CMTK will calculate the slope in three dimensions.

3.3.5 Sensor Output Simulations

Several sensor output simulations are provided within the CMTK libraries. These include radar target detection, radar ground clutter, Synthetic Aperture Radar (SAR), Forward Looking Infra-Red (FLIR), and Low Level Light Television (LLLTV).

The CMTK Line-of-Sight functionality is specifically designed for a pulse-based radar system. The algorithms assume a conformal radar of specific radar transmitter power, antenna, gain, beamwidth, transmitter frequency band, pulse repetition frequency, probability of detection, probability of false alarm, receiver noise figure and weather status. These parameters are used to determine the maximum range of the radar to detect a target of a specified Radar Cross Section (RCS) value. The algorithms handle both 'blue-sky' and ground clutter cases using standard models. Surface material categories can be optionally factored into the model. Results that are reported back include maximum radar range to the target, visibility, Line-of-sight distance to the target, signal-to-noise ratio for blue-sky cases, and signal to-clutter ration, sigma-zero, surface reflectivity, and grazing angle for ground clutter cases.

A radar ground clutter map can be simulated by the CMTK using a point light source model centered differencing digital terrain gradients for slope information and the SeeFar terrain masking algorithm. A polar sensor geometry utilizes radar latitude/longitude and above Ground Level location, maximum range, line-of-sight and field of view angles. Sensor display modes include real-beam ground mapping or full-screen polar projections. Optional beamwidth and pulse length error corrections are handled through smoothing filters. Surface materials are optionally factored into the simulation by converting DFAD, FIC, SMC, predominant height, and feature type into radar reflectivity.

The Synthetic Aperture Radar CMTK functions simulate a SAR image from a moving aircraft using a point light source model, centered differing digital terrain gradients for slope information, and the intervisibility profiles algorithm for shadow information along each scanline. A rectangular sensor geometry with parameters such as initial A/C location and above ground height, maximum sensor range and A/C travel distance, and patch orientation angle is employed. Gradients are computed relative to specific patch orientation. Scanline intervisibility is computed to the DTED resolution in use. Pulse Length error (PLE) correction through smoothing filters is optional. Surface materials are optionally factored into the simulation model the same manner as described above for the radar ground clutter map.

The CMTK also provides a capability to simulate a FLIR image. A time-lapsed hill shading technique is used where individual hill shaded images are generated at a user specified number of equally spaced positions along the sun's daytime track. A weighted average of the sun positions is taken with weights calculated as a function of the maximum sun elevation, maximum sun strength, and elapsed time since dawn at the time of FLIR image capture. 3D geometry specification fro passive FLIR sensors include sensor latitude/longitude location, above ground height, line-of-sight and field-of-view angles in both azimuth and elevation. Surface materials can be optionally factored into the model.

A LLLTV image can be simulated by the CMTK. The process using the hill shading capabilities with high ambient factor to simulate moonlight. Moon angle and moon strengths can optionally defined as well as inclusion of surface material factors. 3D geometry specification for passive LLLTV sensors include sensors geographic location, above-ground height, line-of-sight and field-of-view angles.

3.4 Terrain Visualization

CMTK version 2.02 has added capability to enhance the viewing of terrain data. Prior versions allowed for a two dimensional relief shaded grid to be displayed in a map window. Version 2.02 adds to this capability functions which permit the creation of three dimensional views, fractal rendering of sky, overlaying of images in the map display on the terrain perspective and various levels of detail and speed. Some functions used to provide this capability include:

CkSetReleifLightSource - Sets the position of the light source for a relief shading display process.

CkFastPerspective - Highest level interface for the fast perspective function.

CkGenfastPerspective - Creates a fast perspective as an 8 bit image.

CkThreatEnvelope - Produces a Radar threat envelope in a perspective window.

CkPerspective - produces a perspective view of terrain data.

3.4.1 Two Dimensional Terrain Visualization

In conjunction with the elevation data, then CMTK offers a number of methods for viewing the terrain in 2D:

- Elevation Contour Line Generation
- Elevation Contour Polygon Generation
- Planimetric Hill Shading
- Hypsometry Shading

Elevation Contour Line Generation provide the capability to create vector curves at specified elevation intervals. The resulting curves represent continuous contour elevation isolines. The algorithm used to create the contours incorporates a recursive piecewise linear approach, with an optional front-end terrain smoothing filter of selectable window size to speed up processing and create smoother contours through rough areas.

Vector polygons can also be created that will surround the specified elevation range through the Elevation Contour Polygon Generation capability. The resulting polygons represent discrete contours drawn around a specified elevation range. The optional, front-end terrain smoothing filter described above is available here. Large polygons are thinned and will leave slight gaps between neighboring contours.

Planimetric Hill Shading produces a shaded terrain relief map in 2D using a specified sun angle defined in terms of azimuth and elevation angles. Terrain gradients are generated via digital centered differencing. A normalized raster image is created in a one-to-one correspondence to the underlying DTED. A Lambertisan diffuse reflection lighting model with infinite light source is assumed. The lighting model options allow for specification of the percentage of ambient light.

Hypsometry shading produces an elevation tinted map in 2D. Changes in the intensity and color reflect the changes in the elevation values found in the underlying DTED. The result is a normalized raster image.

3.4.2 Perspectives

The CMTK can create a flat or smooth shaded 3D terrain perspective views as well as wireframe representations given a user specified viewing geometry and sun angle. The Area-of-Visibility (AOV) polygon defined by the perspective viewing geometry is calculated automatically. During terrain rendering, a ray-tracing algorithm for hidden surface removal is utilized.

Terrain perspectives can be displayed with a choice of effects including the ground color, sky color and season. The ground color may be set to sandy, grassy or to drape the under lying image over the generated perspective. A sky color of blue or with fractal clouds and a season of summer, autumn or winter may be set as well. Scene and terrain enhancements may also be factored into the perspectives. The scene enhancements include the addition of haze and trees while terrain enhancements include bump mapping, elevation bumping and successive subdivision.

The fast perspective is different in that it creates a basic 3D terrain perspective using gray scales only. The setting of ground or sky color, season, as well as the scene and terrain enhancements is not supported in the fast perspective.

Wireframe perspective is the most basic of the three perspectives in that creates a simple wireframe of the 3D terrain perspective as its name implies.

The Threat Envelope Analysis CMTK function represents threats as generic spherical objects of specified LAT/LONG location, above-ground height, maximum range in meters, line-of-sight and field-of-view angles in both azimuth and elevation. Upper and lower bounds of the resultant 'geometrical' threat model are rasterized to DTED resolution and converted into an 'actual' threat envelope by factoring in terrain masking. Threat envelopes are displayed via 3D shaded terrain perspective views with painted translucent lethality zones. Threat envelopes can not be displayed in the fast or wireframe perspectives.

3.5 Image Processing

The CMTK offers a variety of the common image processing functions know to exist. These pre-built routines enable the user to perform a multitude of analysis on raster data. Sample CMTK image processing functions include:

CkAreaEdgeID - Applies an area edge filter to an image.

CkDifferenceOfGaussiansG - Applies a Difference of Gaussian filter.

CkEdgeSharpeningID - Applies an edge sharpening filter to an image

CkNoiseReductionModal - Applies a Noise reduction Modal filter to an image.

CkSetFlPieces - Sets the number of pieces and the starting and ending values for each piece for Piecewise Linear Contract Enhancement.

CkRegisterImage - Performs image registration

CkAnalyzeTiePoints - Performs an image tiepoint analysis

3.5.1 Filters

The CMTK includes a huge functional data base of routines incorporating a wide diversity of filtering operations. Filtering enables undesirable data to be removed from an image, thereby enhancing some other feature. For instance, when applying edge detection to a region, any smoothness or color information is removed, but the presence of an object like an enemy tank might be enhanced. Although extreme powerful tools, these filters can only be applied to raster images (non-vectors).

All CMTK filtering operations are done on the rectangular region defined by the user. The following describes the composition of the main filtering operations:

- Contrast
- High Pass
- Equal Probability
- Noise Reduction
- Smoothing (low pass)
- Edge Detection
- Point Detection
- Thresholding

3.5.2 Histograms

The histogram functions under the CMTK output the number of colors in a rectangular portion on the map. Some of the customizable CMTK histogram options include allowing a range of colors to be clustered together and picking maximum and minimum color thresholds.

Chapter 4
CMIC Tasks

The CMIC effort was tasked with providing a controlled environment for the configuration management, software maintenance, and technical support of two software components, the ADRI Exploitation Software and the Common Mapping Software. The majority of the effort has focused on the latter of the two. The following discusses the activities performed, products developed, and users supported during the effort.

4.1 Summary of Events and Accomplishments

The CMIC project involved a number of activities to fulfill the contractual requirements. Many of these activities were ongoing throughout the effort with some requiring periodic review, while others required constant attention, e.g., Technical User Support.

A number of significant accomplishments were made during the course of the CMIC project. These range from bringing the initial version of the common mapping toolkit software under configuration management, productizing the toolkit for dissemination to registered users, to developing a new software package to demonstrate the functionality of the toolkit.

- Software Analysis
- Software Baselining
- Configuration Management
- Software Maintenance
- Documentation Support
- Technical User Support
- Electronic Chart Update Manual (ECHUM) Analysis
- Cartographic Traceability Analysis Function (CTAF) Support
- Arc Digital Raster Imagery (ADRI) Support

Software Analysis

The CM plan and software engineering practices provided the foundation from which the remaining tasking under the CMIC effort would take place. With these two documents, the CMIC technical staff undertook the task of analyzing the 1.4 version software to identify differences and or problems that should be addressed. As this task progressed, the CMIC effort began collecting initial PRs/CRs that were encountered by users exploiting the 1.3 version of the toolkit.

Software Baselining

The CMTK 1.4 version was then baselined which included porting the 1.4 software back to the DEC platform. This provided two platforms that the CMTK would run and be supported on. The former software test plan developed for the 1.3 release was used as a regression test for this newly ported version. The result of these efforts was the 1.4.1 version release to the CMP community.

Accomplishment

Baselined (for Subsequent Release) Version 1.4 and 2.02 of the Common Mapping Toolkit software.

The CMIC baseline management concept was founded on technical control points called Configuration Baselines. These are established to support systematic evaluation, coordination, and disposition of all proposed changes. The CMIC effort developed five types of baselines:

- Product - The product baseline was the official and current version of the CMP software. Only tested software and approved changes were placed in the product baseline. The product baseline was the copy that was released to registered users and included object code, libraries, documentation and source by special request.
- Functional - was the approved functional description of the capabilities of CMP components, and the qualification procedures necessary to verify those capabilities.
- Development - The development baseline included the hardware configurations., the most current software, test materials, performance and qualification requirements and documentation. This baseline provided the basis for the orderly maintenance, implementation, and control of enhancements and modifications.
- Testing - The testing baseline was the suite of test materials used with the development baseline to test authorized changes to CMP software. It includes test data, test cases, test configurations and test documentation.
- Documentation - The documentation baseline included the commercial and DoD-STD-2167A documentation describing CMP components that were placed under documentation change control. As with the testing baseline, the documentation

baseline reflects the current state of the software and is included in the development baseline.

Configuration Management

At the initiation of the effort, the primary task was to develop a Configuration Management (CM) plan by which the software, to be maintained, could be controlled and managed. Several resources were used to develop a CM plan which would offer the necessary control over the software yet be flexible enough to permit changes to be integrated quickly. The resulting CM plan was a variation of the CUBIC CM procedures with streamlined routing of documentation and notification procedures.

Concurrent with the development of the CM plan, a set of software engineering practices, unique to the CMIC effort, were prepared. These procedures provided a rigid, but consistent, environment for all CMIC technical engineers to work in. The procedures defined specifically how Problem Reports (PR) and Change Requests (CR) were handled. This included

- Assessment of the PR/CR
- Notifying RL that a valid PR/CR was received
- Analysis of the PR/CR
- Development of a Software Modification plan
- Review procedures
- Unit, integration and regression procedures
- Identification of CM tools and utilities to be used

<u>Accomplishment</u>

Released and supported a number of CMTK versions.

> With the product baselines in place, two versions of the CMTK software and its supporting utilities were released. The first release was numbered Version 1.4.1. The major highlight of this release was its ability to run on both the DEC and Sun platforms from a single baselined and managed copy of the source code. Version 1.4 was a Sun version only. The second official release, Version 1.4.2 contained a number of modifications to resolve problem reports and changes requests and also included the first automatic installation utility.

Utilized rigorous configuration management and software maintenance procedures to ensure quality products were distributed.

> The CMIC technical staff applied strict software engineering practices. These procedures where developed at the start of the effort; they are documented in the Configuration Management Plan appendices. They identify where to apply specific

software engineering procedures, what automated tools to use, and the respective staff member responsibilities within the CMIC's configuration management team. The software engineering practices provide specific details on software coding conventions, maintenance standards, and documentation.

The Software Engineering Note (SEN) was the centerpiece for the majority of these practices. This document, whose purpose, content and procedures for completion were explicitly stated provides a detailed record of what has been done with the software. It describes the assessment of the problem/change request; the subsequent problem analysis; a software modification plan; the modifications made (for tracking purposes); and the results of unit, integration and regression testing. Since the configuration management process may include a time lapse between CM steps, the SEN was the official project instrumental for tracking results. It was critical to meeting schedule and maintenance requirements.

Software Maintenance

During software maintenance activities, the question of how software modifications would be incorporated into future releases was discussed. As a result, a Memorandum of Agreement was prepared and signed by those involved in the CMIC effort and other developers of the CMTK. The memo defined the process by which software modifications would be disseminated and integrated into the future CMTK versions.

Next, the CMIC effort released version 1.4.2 of the CMTK. Version 1.4.2 incorporated a number of changes to correct problems. The most significant improvement, however was the addition of an automatic installation script to reduce users errors during installation. Technical support activities up to this time had focused primarily on the installation of the software, and an automatic installation script drastically reduced the number of technical support required for this purpose.

Special versions of the software were also prepared, at the direction of RL. The first was a port of the CMTK to the DEC Alpha workstation. RL provided a workstation to perform the work and an initial time frame of six weeks was set to perform the port. This schedule could not be met due to the extensive changes necessary to make the CMTK run on the Alpha under the OSF operating system. Consequently, a reduced set of CMTK functions were identified and ported over and demonstrated on the DEC alpha.

Another special version was prepared for the Advanced Planning System to correct specific problems encountered by their application programmers. This version came to be known as 1.4.3 and had several modifications integrated which were transferred into the CMTK 2.02 baseline.

The final major activity that took place under the CMIC effort was the baselining and distribution of the version 2.02. This beta version had additional functionality added to the 1.4 baseline, along with software reorganizations. Additionally, the goal was to release the final version, 2.02, as running on not only the DEC and Sun workstations, but also running under the Sun Solaris 2.1 operating system. To achieve this goal, and maintain a single baseline of the software, a decision was made to utilize the GNU C compiler "gcc". This decision proved beneficial in that the same GNU compiler is now running on all platforms, and will be distributed along with the CMTK. Furthermore, "gcc" is less-forgiving than the compilers found on the Sun and DEC and has detected a number of errors that were not flagged before.

Accomplishments

Processed 150+ Problem Reports and Change Requests.

> The CMIC project received and processed numerous problem reports and change requests concerning the functionality of CMP software components. Specifically, over one hundred and fifty problem reports and/or change request have been levied against the 1.4 baseline. Each of these have been logged and entered into the configuration management process. The majority of these are in regard to the CMTK software, followed secondly by the preprocessor software.
>
> The majority of these problem reports and changes were resolved by the project team. Historically, it takes an average of 75 calendar days to bring a problem report or change request to closure – where closure means fully integrated, tested and documented. The time frame from the assignment of a problem report or change request to a software engineer and subsequent problem closure has averaged 42 calendar days.

Documentation Support

Accomplishment

Wrote a complete and detailed set of user documentation.

> The previous versions of the CMTK were delivered with a standard fare of documentation. Some of this material was incorrect, incomplete, and difficult to understand. Where possible, given the time constraints with the release of the software, the documentation suite was enhanced. Technical support fielded a number of documentation questions. These were clarified and incorporated in subsequent releases. We have attempted to reflect commercial grade documentation, i.e., documentation accompanying commercially available software, rather than standard Government reports.

Technical User Support

Technical support began immediately after the version 1.4.1 release and was designed to provide technical assistance and support for utilizing the CMTK. Users requesting the software were provided registered copies of the distribution package which allowed them unlimited access to the CMIC technical engineers and technical documentation. Primarily this technical support was provided via telephone/fax and later expanded to include E-Mail. Specifically, technical user support included:

Software Environment
Installation
Technical Exchange Memo (2 Newsletters)
Software Development Library
E-Mail Services
Common Mapping Symposium
On-site Support (APS/CATIS)
Demonstration Software (G-Odesy)

<u>Accomplishments</u>

Improved our ability to meet the user's needs for technical support.

The first release of the CMTK Version 1.4.1 defined a specific set of environments that were supported by the CMIC effort - namely, Sun SPARC and DECstation environments. In discussions with RL at the start of the effort, it was decided to limit technical support to not only specific platforms but also specific programming environments, and operating system versions. However, it became apparent that the majority of the recipients of the CMTK distributions did not meet the requirements for the supported environments. Different X/Motif releases and versions, lower and higher operating system releases and even lack of Motif were commonly reported. To overcome these obstacles, the CMIC effort quickly adapted to the user's needs by supporting additional versions of underlying software. On-site visits were made to organizations having problems. The user base became a network that the technical support staff could access to find out who had encountered similar problems and how they were resolved.

Technical support has been the largest consumer of the CMIC resources. Virtually everyone on the CMIC technical staff has contributed to the technical support activities — from answering questions, researching issues, duplication of problems, assisting users in application development, Motif/X programming, UNIX operation and directing individuals to the proper points of contact. The technical support staff has also provided assistance to users who have obtained the source code in order to port the CMTK to other platforms. Specifically, CMIC has provided telephone support to organizations porting the CMTK to the HP and Silicon graphics workstations.

Simplified end user installation through automatic installation scripts.

The initial release of the CMP software was distributed as executable files on either 8mm tape, 4mm DAT, or 1/4 inch streamer tape. Included in the distribution package was a copy of the version description document. This document provides installation instruction. Almost immediately after release of Version 1.4.1 the CMIC effort received numerous requests for assistance in loading the distribution tapes and executing the demonstration software. The problems encountered by the CMP community ranges from lack of experience with UNIX to not having the required environment setup to use the CMTK.

To overcome these problems and to reduce the number of technical support calls, the CMIC effort developed an automatic installation script. This utility queries the user prior to installation about the environment in which the CMTK software is being installed. This includes defining the location of the X and Motif libraries, as well as where the sample data is to be stored. Based upon the information provided, the installation utility extracts the appropriate files from the distribution media, builds user log-in and startup files with the proper environment settings, and rebuilds the demonstration software. The automatic installation script was first packaged with the 1.4.2 release. It has virtually eliminated the need to expend technical support resources on installation questions.

Published Two Technical Exchange Memo's

During the course of the effort two Technical Exchange Memos were issued. These newsletters provided information regarding the status of new releases and current problems, and future development of the CMTK. In addition, each issue addressed specific issues with the CMTK along with descriptions of other CMTK applications.

Provided a Software Development Library

This option was intended to allow CMTK application developers to deposit their application with the CMIC effort for free distribution to other CMTK users. Software made available through this technical support function would be provided to all those requesting it "as is". No attempt was made by the CMIC program to get the software running or correct any problems. Only one software application was provided during the course of the effort and no requests were received for distribution.

Provided E-mail Services to CMTK Users

After the release of version 1.4.2, E-Mail addresses were made available to transmit problem reports and user questions directly to the CMIC engineers. A number of users took advantage of this option. Users were able to send code fragments in which they were experiencing trouble and CMIC engineers were able to send potential solutions and coding examples.

Hosted a Common Mapping User Interchange Symposium at Rome Laboratory.

A Common Mapping User Symposium was sponsored and hosted by Rome Laboratory. The three day event took place in October of 1992 at Griffiss Air Force Base in Rome, New York with over 150 attendees. The three day event brought together military and civilian representatives from the Air Force, Army, Navy, Marines, and the Defense Mapping Agency to discuss a number of common mapping issues. Topics ranged from the development of common mapping applications and using CMS data to configuration management and maintenance of the software.

Sterling Software supported RL by assisting in organizing and administering the activities. The CMIC support staff developed and ran the registration process, distributed symposium materials, provided assistance as necessary to those attending the symposium, and prepared and distributed the symposium's proceedings. The CMIC project team also participated in the symposium with a formal presentation on configuration management, software maintenance, and distribution procedures of CMP products.

Provided On-Site Support for Specific Programs

An unofficial release, Version 1.4.3 was prepared and distributed to the Advanced Planning Program (APS). This release was developed specifically for APS to resolve specific problems that they encountered. It is supported and maintained exclusively for the APS program.

The first of the porting tasks was in support of RL's Computer Aided Tactical Information Systems (CATIS) program. CATIS required CMTK software functionality on a DEC Alpha workstation under OSF/1. The Alpha's sixty-four bit architecture and OSF/1 presented a number of technical challenges. These were resolved and forty-three CMTK functions plus supporting functions were hosted on the Alpha.

A second porting task, also for the CATIS program, was to enable CMTK to function under the Sun Solaris operating system. This port was also successful. The requested CMTK functions now work under Solaris 2.1. Efforts have been made to port Version 2.02 of CMTK to Solaris 2.1.

Developed G-Odesy, a new demonstration software package, to demonstrate the functionality of the Common Mapping Toolkit.

Throughout the contract, technical support has been required to assist CMP users with a wide range of problems, from programming in Motif/X and accessing CMTK functions, to informing users that CMTK is a library of geospatial functions. A common misinterpretation among the users was that the demonstration software provided with the toolkit was more than a sample application. To assist end users in understanding the toolkit, a new demonstration software application, called G-Odesy, was developed for inclusion in the Version 2 distribution package.

The primary purpose of G-Odesy is to demonstrate the use of all of the toolkit's Application Programmer Interface (API) functions. The previous demonstration software exercised only a portion of the available CMTK library calls. G-Odesy consists of over 500 unique CMTK function calls.

G-Odesy offers application programmers a working reference. They will be able to examine a CMTK application to better understand the nuances of using the CMTK. An on-line help function provides a list of CMTK functions referenced to G-Odesy source code and G-Odesy options menus. The user can sort the list, search for specific functions, and step through each instance where the CMTK function has been used in G-Odesy. Every time a CMTK function is selected the corresponding G-Odesy source code file in which it is used is presented in a scrollable window with the function call highlighted. Users can also call up an on-line manual page for that specific CMTK function. This provides an application programmer with powerful tools to understand how the CMTK functions can be used. In addition to educating users about the functionality of CMTK, G-Odesy furnishes support for regression testing and analysis of future CMTK versions.

Finally, G-Odesy provides the Common Mapping Program (CMP) community with a stand-alone package for accessing and manipulating Common Mapping Standard (CMS) formatted data. (The previous demonstration software was setup to work with specific configuration files having specific data types.) G-Odesy permits the use of user defined configurations and data. Although sample data and configurations are provided, the user is not restricted in their use. Unlike the old demonstration configuration files and data, the new configurations and sample data have been designed to demonstrate all the range of possibilities for using the toolkit.

ECHUM Analysis

Performed an analysis of the Electronic Chart Update Manual (ECHUM) and evaluated its use within the CMTK software.

CTAF Support

Maintained the Cartographic Traceability Analysis Function (CTAF) data base and tools.

ADRI Support

With respect to the ADRI exploitation software, Sterling Software distributed, duplicated, and maintained the software, while its subcontractor, TRIFID Incorporated, analyzed the software, developed the ADRI Maintenance Plan and ADRI Software Product Specification, and copied and archived ADRI data tapes.

4.2 Product Status

The CMTK, as a product, has become a more stable suite of software, compared to earlier releases. Technical support, initially was quite high, but was attributed to the inexperience of using X-Windows and Motif as well as understanding the capabilities the toolkit provides. Having overcome these issues with the CMTK users, much of the technical support shifted its focus on developing new and better ways for using the CMTK in a diverse community of MC&G users. The following sections outline what the CMTK encompasses.

4.2.1 Software

The Common Mapping approach has several software components in its implementation of a common, low-level toolkit of MCG&I functions. The final release of version 2.02 of the CMTK includes the following modules and are described below:

- Common Mapping Toolkit (CMTK)
- CMTK Support Utilities
- CMTK Data Base Administrator
- CMTK Demonstration Software

CMTK

The CMTK provides a ready made user application interface to the Common Mapping Standard (CMS) data. It provides the programmer with functions to display, manipulate, and annotate the geospatial data. It also provides geodetic algorithms, cartographic analysis tools and image processing tools. CMTK expands on the cartographic data available through CMS to allow for non-geocoded imagery and the secondary derived data products it produces.

CMTK Support Utilities

Support utilities are provided to prepare files and/or data for use by the CMTK. One of these programs, tkparser, provides a necessary service in establishing the cartographic display configuration for applications utilizing the CMTK. Other support utilities are only for installation functions, such as creating binary files used by CMTK.

CMTK Data Base Administrator

The CMTK Data Base Administrator application provided the user with a convenient user interface to a collection of data base utility programs. There is the Common Mapping Toolkit Data Importer (CMDI) available to produce CMTK data from DMA data sources and the Imagery Converter which converts LANDSAT and SPOT formatted images to the National Imagery Transmission Format (NITF) used by CMTK functions for non-geocoded imagery, and other utilities.

CMTK Demonstration Software

A demonstration program is also provided in the software distribution. This application software, named G-Odesy, provides programmers with sample CMTK Application Programming Interface (API) calls, and is used to test the full complement of CMTK APIs.

4.2.2 Documentation

The CMTK has a documentation suite that has evolved from the earlier releases. The documentation produced for version 2.02 represents a significant change in the organization of the material as well as some minor changes in the document names. The documentation itself can be grouped into two subsets, one for distribution to users and the other for maintenance.

The documentation included in the software release package is a set of materials that are targeted for application programmers, application users, and system administrators. The application programmer is provided with the necessary materials to develop a stand-alone CMTK application. System administrators, users and application programmers will also find the necessary information to build and maintain their site specific data bases that the CMTK will use. Furthermore, documentation is included to build supporting ASCII files and use the CMTK utilities to produce site specific files that will interface with the CMTK. The release documentation suite contains the following:

- **Common Mapping Toolkit Installation Guide** – A description and user guide for running the automatic installation program provided with the software release. This document describes the CMTK system requirements, the installation steps the toolkit requires, and the layout of the CMTK components. The installation program will ensure the software is correctly installed and enables the user/application programmer to execute the demonstration software immediately after installation.

- **Common Mapping Toolkit Programmer's Manual** – This document supplies manual pages for the entire set of CMTK calls available to the application programmer. It also provides a brief view of the CMTK operation from a programmer's point-of-view.

- **Common Mapping Toolkit Support Utilities Manual** – This document describes the use of a utility, tkparser, necessary to the operation of application programs utilizing CMTK.

- **Common Mapping Toolkit Demonstration Manual** – This document describes the use of a demonstration application program which utilizes the CMTK. This program also provides example usage of various CMTK application interface calls.

- **Common Mapping Toolkit Data Base Administrator Manual** – This document describes the use of application programs that produce CMS or CMTK cartographic and imagery data from DMA products and some sources of non-geocoded imagery. The data produced by these are utilized by the CMTK functions.

- **Common Mapping Toolkit Data Base Design Document** – This document provides details about the formats of the various types of cartographic, imagery, and support data files used by the CMTK.

The additional documentation that was prepared for the Version 2.02 release is targeted for the maintenance community. These documents describe the software in more detail with regards to what was delivered as the final Version 2.02 release, the structure and organization of the software, procedures for maintaining and building the software release, and specific instruction on testing. The documents delivered in this group include:

- **Common Mapping Toolkit Maintenance Manual** – Describes the organization of the software and procedures for building the executable libraries.

- **Common Mapping Toolkit Software Test Plan** – Details procedures for testing the functionality in the CMTK 2.02. The foundation of the testing is the demonstration software, G-Odesy, which exercises a majority of the functionality contained in the CMTK.

- **Common Mapping Toolkit Version Description Document** – Identifies the software delivered to Rome Laboratory.

- **CMTK Data Base Administrator's Manual** - Describes the use of application programs that produce CMS or CMTK cartographic and imagery data from DMA products and some sources of non-geocoded imagery. The data produced by these are utilized by the CMTK functions.

- **CM Plan and Appendices C and D** - Identifies the Configuration management plan that was employed during the CMIC effort. Appendix C describes the distribution and support procedures while Appendix D detailed the Problem Report/Changes Request procedures.

- **Common Mapping User Symposium Proceedings** - Documents the presentations and demonstrations that provided at the first Common Mapping User Symposium held on 6-8 October 1992.

Since CMTK software serves a diverse set of users, significant effort within the CMIC program was devoted to enhancing user documentation. The following delineates the available documentation:

Application Programmers will find the following documents helpful:
- Common Mapping Toolkit Programmer's Manual
- Common Mapping Toolkit Support Utilities Manual
- Common Mapping Toolkit Demonstration Manual

System Administrators and the installer of the CMTK will find these documents useful:
- Common Mapping Toolkit Installation Guide
- Common Mapping Toolkit Demonstration Manual
- Common Mapping Toolkit Support Utilities Manual

Data Base Administrators will find these documents useful:
- Common Mapping Toolkit Data Base Administrator Manual
- Common Mapping Toolkit Support Utilities Manual

Design Oriented Developers who want detailed information about the CMTK can consult the
- Common Mapping Toolkit Data Base Design Document

4.2.3 Problem Report/Change Request Status

Figure 4-1 provides a complete list of all the Problem Reports/Change Requests that were received and logged during the CMIC effort.

The numbers found in the Step column of Figure 4-1 are identified below.

No.	Description	No.	Description
1	Receipt/Logging	9a	CMTK ICWG
2	Management Review	9b	CCB
3	Assignment	10	Software Modification
4	Assessment/Short SEN	11	Unit Testing
5	ACSN	12	Integration
6	Analysis	13	Regression Testing
7	Management Review	14	Documentation Update
8	Engineering Charge Proposal	15	Baseline Update
		16	Final Review/Closure

Entry #	Date Received	CCB Priority	Status	Step	Closure Date	Originator	Vers	Type	CSC	Title
CMP-D-001	09/14/92		open	5		ASEC	1.3+	CR	CMIS	DCW Interface
CMP-D-002	09/14/92		open	5		ASEC	1.3+	CR	CMIS	DTED Verification
CMP-D-003	09/14/92	3	closed	16	12/16/92	ASEC	1.3+	CR	CMIS	Automatic Chart Centering in the View Script
CMP-D-004	09/14/92	3	closed	16	12/16/92	ASEC	1.3+	PR	CMIS	Environment Variable Definitions
CMP-D-005	09/14/92		open	5		ASEC	1.3+	CR	CMIS	Verification Utility Upgrade
CMP-D-006	09/14/92		open	9b		ASEC	1.3+	PR	CMPP	ADRG 180 Degree E/W Crossing
CMP-D-007	09/14/92		open	5		ASEC	1.3+	PR	CMPP	Multiple DRs on ADRG CDROM
CMP-D-008	09/14/92		open	5		ASEC	1.3+	PR	CMPP	Displacement Errors on Display of ADRG
CMP-D-009	09/14/92	N/A	closed	4	10/19/92	ASEC	1.3+	PR	CMPP	Preprocessing ADRG over Polar Regions
CMP-S-010	09/14/92	3	closed	16	02/26/93	Sterling Soft.	1.4	PR	CMTK	Relief Shading Plotting
CMP-S-011	09/14/92		open	10		Sterling Soft.	1.4	PR	CMTK	Hard Code String Size Limit
CMP-S-012	09/14/92	N/A	closed	4	10/23/92	Sterling Soft.	1.4	PR	CMTK	Save Display Config
CMP-S-013	09/14/92	N/A	closed	9b	02/05/93	Sterling Soft.	1.4	CR	CMTK	Image Data Window Limitation
CMP-S-014	09/14/92	N/A	closed	4	10/01/92	Sterling Soft.	1.4	PR	CMTK	Makefiles with Hard Code Commands
CMP-S-015	09/14/92	N/A	closed	4	10/23/92	Sterling Soft.	1.4	PR	CMTK	Errors Without Messages
CMP-S-016	09/14/92		open	5		Sterling Soft.	1.4	CR	CMTK	Store Values of Negative Index
CMP-D-017	09/14/92		open	1		ASEC	1.3+	PR	CMPP	Longitudinal Span Limitations on ADRG
CMP-D-018	09/14/92		open	1		ASEC	1.3+	PR	CMPP	ADRG Memory Management
CMP-D-019	09/14/92		open	1		ASEC	1.3+	PR	CMPP	ADRI Memory Management
CMP-S-020	09/14/92		open	5		RL/J. Hanson	1.4	PR	CMTK	Inset Map
CMP-S-021	09/14/92	2	closed	16	12/15/92	RL/J. Hanson	1.4	PR	CMTK	Frame Header Changes
CMP-S-022	09/14/92		open	5		RL/J. Hanson	1.4	PR	CMTK	Profile Elevations
CMP-D-023	09/14/92		open	1		ASEC	1.3+	PR	CMPP	ADRI Subframe Breakup Thresholds
CMP-D-024	09/14/92		open	1		ASEC	1.3+	PR	CMPP	ADRI Feature Item Creation with Padding
CMP-D-025	09/14/92		open	5		ASEC	1.3+	PR	CMPP	DCW Text Displacements
CMP-D-026	09/14/92	1	closed	16	02/28/93	ASEC	1.3+	PR	CMPP	DCW Production Version
CMP-D-027	09/14/92	N/A	closed	4	10/01/92	ASEC	1.3+	PR	CMPP	DCW Memory Management
CMP-D-028	09/14/92		open	1		ASEC	1.3+	PR	CMPP	DAFIF Memory Management
CMP-D-029	09/14/92		open	1		ASEC	1.3+	PR	CMPP	DAFIF Text Displacement
CMP-D-030	09/14/92		open	1		ASEC	1.3+	PR	CMPP	DAFIF 180 Degree E/W Crossing
CMP-D-031	09/14/92		open	1		ASEC	1.3+	PR	CMPP	DAFIF Update Feature Types & Formats
CMP-D-032	09/14/92		open	1		ASEC	1.3+	PR	CMPP	DAFIF Change Record Implementation
CMP-D-033	09/14/92		open	1		ASEC	1.3+	PR	CMPP	DAFIF Maximum Features per Frame
CMP-D-034	09/14/92		open	1		ASEC	1.3+	PR	CMPP	DAFIF Discrepancy Flag Message
CMP-D-035	09/14/92		open	1		ASEC	1.3+	PR	CMPP	DAFIF Download Dataset to HD
CMP-D-036	09/14/92	N/A	closed	4	11/02/92	ASEC	1.3+	PR	CMPP	DTED CDROM
CMP-D-037	09/14/92		open	1		ASEC	1.3+	PR	CMPP	WVS Memory Management
CMP-D-038	09/14/92		open	1		ASEC	1.3+	PR	CMPP	WVS 180 Degree E/W Crossing
CMP-D-039	09/14/92		open	1		ASEC	1.3+	PR	CMPP	WVS Weed, Strain, Join
CMP-D-040	09/14/92		open	1		ASEC	1.3+	PR	CMPP	WVS Text Offsets
CMP-D-041	09/14/92		open	1		ASEC	1.3+	PR	CMPP	WVS Multiple Name Entries
CMP-D-042	09/14/92		open	1		ASEC	1.3+	PR	CMPP	WVS North Pole
CMP-D-043	09/14/92		open	1		ASEC	1.3+	PR	CMPP	CMPP Interface Input Variables
CMP-D-044	09/14/92		open	1		ASEC	1.3+	PR	CMPP	CMPP Interface Hardwired Names
CMP-D-045	09/14/92		open	5		ASEC	1.3+	PR	CMTK	Hardwired Names
CMP-D-046	09/14/92		open	1		ASEC	1.3+	PR	CMTK	Color Map Allocation
CMP-D-047	09/14/92		open	1		ASEC	1.3+	PR	CMTK	Frame Indexing List
CMP-D-048	09/14/92		open	1		ASEC	1.3+	PR	CMTK	Point Elevation Query Constant Read-Out
CMP-D-049	09/14/92		open	6		ASEC	1.3+	PR	CMTK	PMP Resolution of Coordinates
CMP-D-050	09/14/92		open	5		ASEC	1.3+	PR	DEMO	Coordinate Conversion GEO-UTM
CMP-D-051	09/14/92		open	6		ASEC	1.3+	CR	DEMO	Loading Config Files
CMP-S-052	09/14/92		open	6		APS	1.4B	PR	CMTK	Queued X Events
CMP-S-053	09/14/92		open	10		APS	1.4B	PR	CMTK	Path Length
CMP-S-054	09/14/92	3	closed	16	12/15/92	APS	1.4B	PR	CMTK	Process Size
CMP-S-055	09/14/92		open	1		RL/J. Hanson	1.4	PR	CMPP	Security Fields in Frame Headers
CMP-S-056	09/14/92		open	1		APS	1.4	PR	CMTK	Viewing DCW
CMP-S-057	09/14/92		open	1		Sterling Soft.	1.4	PR	CMTK	Mouse Buttons & Menus
CMP-S-058	09/14/92		open	1		Sterling Soft.	1.4	PR	CMTK	Mouse Buttons & MOTIF
CMP-S-059	09/14/92	N/A	closed	4	01/15/93	Sterling Soft.	1.4	PR	CMTK	Mouse Button Hang Ups
CMP-S-060	09/14/92		open	1		Sterling Soft.	1.4	CR	CMTK	Polygons & World Coordinates Absolute
CMP-S-061	09/14/92		open	1		Sterling Soft.	1.4	PR	CMTK	Full Screen & Resizing
CMP-S-062	09/14/92		open	5		Sterling Soft.	1.4	PR	CMTK	Drawing Circles
CMP-S-063	09/14/92		open	5		Sterling Soft.	1.4	PR	CMTK	Lines Crossing 0 Degree Longitude
CMP-S-064	09/14/92	N/A	closed	9b	02/05/93	Sterling Soft.	1.4	PR	CMTK	Sleeping Toolkit
CMP-S-065	09/14/92		open	1		Sterling Soft.	1.4	PR	CMTK	Pointer Warping
CMP-S-066	09/14/92		open	1		Sterling Soft.	1.4	PR	CMTK	8 Bit Plane Limitation
CMP-S-067	09/14/92	N/A	closed	4	09/29/92	Sterling Soft.	1.4	PR	CMTK	Font File for SGI
CMP-S-068	09/14/92		open	1		Sterling Soft.	1.4	PR	CMTK	Toggle Object Visibility
CMP-S-069	09/29/92	N/A	closed	4	09/30/92	APS	1.4B	PR	CMTK	Freeing Matrix Data Array
CMP-S-070	09/30/92	3	closed	16	12/15/92	PRB	1.4.1	PR	CMTK	Unresolved Reference: tku_set_map_bounds
CMP-S-071	10/08/92		open	5		Sterling Soft.	1.4.1	PR	CMTK	Set Ellipse2 Data Broken
CMP-S-072	10/08/92	2	closed	16	12/15/92	Sterling Soft.	1.4.1	PR	CMTK	Inq Config Name: Incorrect Status
CMP-D-073	10/16/92	3	closed	16	12/16/92	Sterling Soft.	1.4.1	PR	CMIS	VIEW Application: New Map Center
CMP-D-074	10/16/92	3	closed	16	02/16/93	Sterling Soft.	1.4.1	PR	CMIS	VIEW Application: Toggle Legend
CMP-D-075	10/16/92	1	closed	16	12/16/92	Sterling Soft.	1.4.1	PR	CMIS	One-Point Zoom
CMP-D-076	10/21/92	2	closed	16	12/15/92	Sterling Soft.	DEV	PR	CMP	Makefile Modifications
CMP-D-077	09/14/92	3	closed	16	02/16/93	GTE Westlake	1.3	PR	CMTK	Font Location

CMIC Problem Report/Change Request Summary
Figure 4-1

Entry #	Date Received	CCB Priority	Status	Step	Closure Date	Originator	Vers	Type	CSC	Title
CMP-D-078	09/14/92	N/A	closed	4	10/22/92	GTE Westlake	1.3	PR	CMP	Problems Running Cmake
CMP-D-079	09/14/92	3	closed	16	02/16/93	GTE Westlake	1.3	PR	CMP	Duplicate Calls to Header Files
CMP-D-080	09/14/92	N/A	closed	4	11/05/92	GTE Westlake	1.3	PR	CMTK	ReturnPos: Nonacceptance of Input
CMP-D-081	09/14/92	N/A	closed	4	11/05/92	GTE Westlake	1.3	PR	CMTK	Help Menus Disappear
CMP-D-082	09/14/92	N/A	closed	4	10/22/92	GTE Westlake	1.3	PR	CMTK	ADA Code Problems
CMP-D-083	09/14/92	N/A	closed	4	11/03/92	GTE Westlake	1.3	PR	CMTK	Map Screens Do Not Refresh
CMP-D-084	09/14/92	N/A	closed	4	11/25/92	GTE Westlake	1.3	PR	CMTK	SetPolyLineData Error
CMP-D-085	09/14/92	3	closed	16	02/16/93	GTE Westlake	1.3	PR	CMP	Use of Long Floats
CMP-D-086	09/14/92	3	closed	16	12/16/92	GTE Westlake	1.3	PR	CMP	Include File Conventions
CMP-D-087	09/14/92	N/A	closed	4	11/03/92	GTE Westlake	1.3	PR	CMP	CodeCenter Errors/Warnings
CMP-S-088	10/19/92	N/A	closed	4	12/17/92	Paramax	1.4B	PR	CMTK	Excess Memory Usage by dca_main
CMP-S-089	10/19/92		closed	4	01/26/93	Paramax	1.4B	PR	CMTK	Frame & Feature List Rebuilding After Init
CMP-S-090	10/19/92	2	closed	16	12/18/92	Paramax	1.4B	PR	CMTK	Set Obj Vis Calling Parameters
CMP-S-091	10/19/92		open	6		Paramax	1.4B	PR	CMTK	AMultTmask Miscalculation
CMP-S-092	10/19/92	3	closed	16	02/19/93	Paramax	1.4B	PR	CMTK	Aterrmask.c: Missing Parameters
CMP-S-093	10/19/92	3	closed	16	02/16/93	Paramax	1.4B	PR	CMTK	Radians to Degrees Conversion
CMP-S-094	10/19/92	3	closed	16	02/16/93	Paramax	1.4B	PR	CMTK	Incorrect Magnetic Bearing
CMP-D-095	10/23/92	3	closed	16	12/18/92	Sterling Soft.	1.4.1	PR	CMIS	Unable to Archive Tapes
CMP-S-096	10/19/92	N/A	closed	6	12/15/92	PRB	1.4.1	CR	CMTK	Placement of Inset Map Window
CMP-S-097	10/28/92	3	closed	16	12/15/92	PRB	1.4.1	PR	CMTK	SetPromptPos
CMP-D-098	11/05/92	3	closed	16	12/18/92	Sterling Soft.	1.4.1	PR	CMTK	ReturnPos Functionality
CMP-S-099	11/18/92		open	3		RL	1.4.1	CR	CMTK	ADRI Color Map Definition
CMP-S-100	11/23/92		open	5		Sterling Soft.	1.4.1	PR	CMTK	Lat/Lon Grid Labels
CMP-S-101	11/23/92	N/A	closed	4	01/07/93	Sterling Soft.	1.4.1	CR	CMTK	Numeric UTM Conversion to GEO
CMP-S-102	11/23/92	N/A	closed	4	01/07/93	Sterling Soft.	1.4.1	CR	CMTK	GEO Conversion to Numeric UTM
CMP-S-103	11/23/92	N/A	closed	4	01/08/93	Sterling Soft.	1.4.1	PR	CMTK	Symbol Rotation Does Not Work
CMP-S-104	11/23/92	N/A	closed	4	01/13/93	Sterling Soft.	1.4.1	CR	CMTK	Numeric UPS Conversion to GEO
CMP-S-105	11/23/92	N/A	closed	4	01/20/93	Sterling Soft.	1.4.1	CR	CMTK	GEO Conversion to Numeric UPS
CMP-S-106	12/09/92		open	5		SAIC	1.4.1	CR	CMTK	Line Symbology
CMP-S-107	12/09/92		open	5		SAIC	1.4.1	CR	CMTK	Inset Map Control
CMP-S-108	12/09/92	N/A	closed	4	01/20/93	SAIC	1.4.1	PR	CMTK	Reusable Object Identifiers
CMP-S-109	12/09/92	N/A	closed	4	01/04/93	SAIC	1.4.1	PR	CMTK	Toolkit Initialization
CMP-S-110	12/15/92		open	5		Sterling Soft.	1.4.1	PR	CMPP	CMPP Corrupts Existing Data
CMP-S-111	12/23/92		open	5		APS	1.4B	PR	CMTK	Line of Sight/Distance Along a Path
CMP-S-112	12/23/92	3	closed	16	02/19/93	APS	1.4B	PR	CMTK	Global Min Max Error
CMP-S-113	12/23/92		open	5		STRATCOM	1.4.1	CR	CMTK	Cursor Shape
CMP-S-114	12/23/92		open	3		STRATCOM	1.4.1	CR	CMTK	NITF Format Conversion
CMP-D-115	01/04/93		open	7		Sterling Soft.	1.4.1	PR	CMTK	Missing ">" in Include Statement
CMP-S -116	12/21/92		open	5		Sterling Soft.	1.4.1	PR	CMTK	CursorPickObj/ Pick Center Assignments
CMP-S-117	10/07/92		closed	16	01/28/93	Paramax	1.4B	CR	CMTK	Max Frames Limitation
CMP-S-118	10/19/92		open	7		Paramax	1.4B	CR	CMTK	Terrain Masking
CMP-S-119	02/09/93		open	7		Paramax	1.4B	CR	CMTK	Freeing Mallocs in DCA Routines
CMP-S-120	02/18/93		open	1		RL	1.4.1	CR	CMTK	Overlay Fading
CMP-S-121	03/15/93		open	4		Sterling Soft.	1.4.2	PR	CMPP	Process DCW Browse Library
CMP-S-122	03/15/93		open	7		Sterling Soft.	1.4.2	PR	CMPP	Process DCW Populated Places
CMP-S-123	03/15/93		open	7		Sterling Soft.	1.4.2	PR	CMPP	Process DCW Drainage Tiles
CMPS-124	03/15/93		open	5		Sterling Soft.	1.4.2	PR	CMTK	Partial Elevation Data
CMP-S-125	03/15/93		open	1		GTE	1.4.1	PR	CMTK	System Dependency of Config Files
CMP-S-126	03/22/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Terrain Masking Direction
CMP-S-127	03/26/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Allowable Number of Subfeatures
CMP-S-128	03/29/93		open	7		GTE	1.4.2	PR	CMTK	ReturnPos Feedback Incorrect
CMP-S-129	03/29/93		open	1		GTE	1.4.2	PR	CMTK	Loading Saved Config Files
CMP-S-130	03/29/93		open	1		PRB	1.4.2	PR	CMTK	Bad Values from ReturnRectangle
CMP-S-131	03/30/93		open	3		Sterling Soft.	1.4.2	PR	CMP	Phase II ICD Compliant Data
CMP-S-132	04/14/93		open	1		Sterling Soft.	1.4.2	PR	CMPP	Preprocessing DCW Land Features
CMP-S-133	04/14/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Reading DTED Contour Line Frame File
CMP-S-134	04/14/93		open	1		Sterling Soft.	1.4.2	PR	CMPP	Error Distinguishing Line/Point Features
CMP-S-135	04/14/93		open	1		Sterling Soft.	1.4.2	PR	CMPP	Makefile Modifications for CCDB
CMP-S-136	05/11/93		open	1		Sterling Soft.	1.4.2	CR	CMTK	Screen Coordinate Conversions
CMP- S-137	05/28/93		open	1		APS	1.4.2	PR	CMTK	SetBackground Mode
CMP- S-138	05/28/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Define flags in CMPMakevars
CMP- S-139	06/16/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	WorldtoVSC - VSCtoWorld
CMP- S-140	06/16/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Saving Object Files
CMP- S-141	06/16/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Color Table Not Loaded
CMP- S-142	06/16/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	SetEllipse2Data Documentation Error
CMP- S-143	06/14/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Saving/Reloading Display Config
CMP- S-144	07/02/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Restore System Problem
CMP-S-145	07/28/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Displaying DSW 1° x 1° Frames
CMP-S-146	08/06/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	Inset Map Interaction Toggle
CMP-S-147	08/26/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	GetGlobalMinMax
CMP-S-148	08/26/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	InqConfigMapList
CMP-S-149	08/27/93		open	1		Sterling Soft.	1.4.2	PR	CMTK	LoadFillPattern Include File Error
CMP-S-150	08/02/93		open	1		GTE	1.4.2	PR	CMTK	Directory Names Ignored by Save Display Config
CMP-S-151	08/02/93		open	1		GTE	1.4.2	PR	CMTK	Map Ordering Within a Feature
CMP-S-152	08/04/93		open	1		GTE	1.4.2	PR	CMTK	ANSI "C" Compliance
CMP-S-153	08/04/93		open	1		RL	1.4x	PR	CMTK	Textports

CMIC Problem Report/Change Request Summary (cont'd)
Figure 4-1

Chapter 5 Conclusion and Recommendations

The CMIC effort was initiated to provide specific support to the CMTK and ADRI Exploitation software. The support envisioned, at the beginning of the effort, was formulated on what was expected to happen. However, full releases of the software to user organizations requiring support, altered the initial expectations. The completion of the CMIC effort has now provided the opportunity to review what occurred and what could be improved in future efforts requiring similar support. Therefore, we present the following recommendations based upon our experience in the CMIC effort:

- *Network CM of a Single Baseline*
- *Define a Technical Support Time Frame*
- *Further Enhance the Demonstration Software*
- *Upgrade the CMTK to be ANSI Compatible*
- *Develop a single baseline for Multiple Platforms*
- *Involve Users in the Configuration Management Process*
- *Eliminate Source Code Distributions*

Communication of information between the CMTK developers and the CMIC effort was facilitated through a Memorandum of Agreement. This document defined the responsibilities of each organization and how information would be disseminated between them. Although the information was exchanged, each developer had independent versions of the CMTK software. These versions were often upgraded independently of the version maintained and controlled under the CMIC effort. Having multiple working versions that are maintained by different organizations poses the risk of excluding changes and upgrades as the software evolves. We recommend that there exist a single baseline for the software that the developers can work from. This would require configuration management over a network.

Technical support, during the CMIC effort, required more time than was originally envisioned. Throughout the effort, steps were taken to reduce the amount of technical support that was needed. Although, these steps provided some relief, technical support still remained a primary consumer of the technical effort. This continued up until the very last scheduled day of the project. Technical support is something that cannot be measured and planned with any degree of certainty. Each problem is unique as is every user. Furthermore, all who call expect results.

Because of this, technical support hampered some of the other requirements under the effort. Namely, documentation, resolving problem reports and development of the new demonstration software.

To minimize the impact technical support has on other project requirements, we suggest that technical support be limited to a set time period. Beginning with an initial date and informing users of the closing date would enable the project staff to focus their attention on the remaining contract requirements. For example, in a twelve month effort, technical support might be restricted to only the first ten months. This would leave, two months to complete the documentation and any remaining requirements.

The software that resulted form the CMIC effort will provide current and future CMTK application programmers and users with a solid base to start from. This software is a direct result of the technical support issues raised during the effort. Many of the ideas implemented in the demonstration came from discussing specific problems with the users. Among these issues is how to use the CMTK functions. When begun, the demonstration software focused on the 317 functions in version 1.4.2. In the final months of the effort, version 2.02 was made available that expanded the function set to over six hundred. However, the arrival of the 2.02 version, the problems encountered, and the continued technical support for 1.4.2 users, inhibited incorporation of all the 2.02 functionality.

Therefore, it is recommended first, that the remaining functionality in the 2.02 toolkit be implemented in the demonstration software. This will provide a valuable resource for all CMTK application programmers. Secondly, we recommend that an open dialog with all CMTK users be maintained to receive comments and suggestions for improving the demonstration software. Many comments and suggestions have already been received from early releases of the demo but time has not allowed there incorporation.

Maintenance and porting activities for the CMTK uncovered problems that could have been avoided if the toolkit was ANSI compatible. Becoming ANSI compatible would make the software more portable to other platforms. The use of ANSI compilers along with the prototyping facilities would eliminate many of problems where one function calls another with different argument types. Becoming ANSI compatible would also provide the potential migration of CMTK to the C++ environment and offer better security, error handling and testability. For these reasons we strongly recommend that the CMTK be upgraded to be ANSI compatible.

The CMTK was supported on the Sun SPARCstation and DECstation platforms. During the course of the project, requests for source code were received and fulfilled for the purpose of porting the software to other platforms. These platforms included the HP, Silicon Graphics and the DEC Alpha workstations. The software was changed to accommodate differences on these platforms but none of the changes, except for the DEC Alpha have been received by the CMIC effort. The Alpha changes exist in their own baseline and are not in the distributed version. This approach requires that the source code be provided for every single platform to which the software is to be ported. This in turn, implies that there is a separate version for each platform, and also separate distribution channels. To eliminate this inefficiency, we recommend that there exist a single baseline that will run on all platforms.

The Configuration Management procedures that were followed during the CMIC effort, involved the CMTK users and application developers to a minimum extent. Many times problems that were already fixed or, in the process ,were reported by other users encountering the same problem in their version. To reduce this duplication and keep the general CMP community aware of what is going on with CMTK support, more frequent communication should be provided. This could take the form of automatic notification of all problems and there status to all registered users.

Finally, as maintainers of software, we have experienced a number of incidents in supporting the toolkit that could have been avoided if the source code was not released. Paramount among these incidents, are the times when application developers have encountered a problem, searched the source code, identified the potential problem and corrected it. The modification is sometimes forwarded to the CMIC effort where it is reviewed and put through regression testing. CMIC has encountered modifications suggested by applications developers, which were not the complete correction and/or corrupted other toolkit functions. These kind of experiences would be eliminated if source code was not released.

In conclusion, we believe the CMIC effort was successful in achieving the stated requirements of the effort. Specifically, the objective was to provide specific support to the CMTK and ADRI Exploitation software. Although our understanding of what that specific support would entail changed as the effort evolved, support was provided continuously to all those requested it. It is clear from the events that took place that technical support is necessary for software such as the CMTK, and that it can be provided in a cost efficient manner.

Appendix A
Notes

This chapter contains general information that aids in understanding the CMTK document suite. It includes an alphabetical listing of acronyms and their meanings, as well as a glossary of terms as used in this suite.

A.1 Acronyms

This section contains a list of acronyms found in the CMTK documentation suite.

ACA	Advanced Cartographic Applications
ACSN	Advance Change Study Notice
ADPE	Automatic Data Processing Equipment
ADRG	ARC Digitized Raster Graphics
ADRI	ARC Digital Raster Imagery
AFB	Air Force Base
AFGIHS	Air Force Geographic Information Handling System
AFISA	Air Force Intelligence Support Agency
API	Application Programming Interface
APS	Advanced Planning System
ARC	Arc-Second Raster Chart/Map
ASCII	American Standard Code for Information Interchange
ASEC	Analytical Systems Engineering Corporation
ASSETS	ACA Segments, System Engineering and Tracking Support
C2I	Command, Control and Intelligence
C3	Command, Control and Communications

CAS	Cartographic Application Support
CASE	Computer Aided Software Engineering
CATIS	Computer Aided Tactical Information Systems
CATSS	Cartographic Algorithms for Tactical and Strategic Systems
CCB	Configuration Control Board
CDBA	CMTK Data Base Administrator
CDF	Cartographic Display Functionality Test
CDPS	CMS Data Production System
CDRL	Contract Data Requirement List
CE	Circular Error
CHUM	Chart Updating Manual
CIDPF	Cartographic & Imagery Data Preprocessing Functionality
CLIN	Contract Line Item Number
CM	Configuration Management
CMDI	Common Mapping Toolkit Data Importer
CMIC	Common Mapping Interface Control
CMIS	Common Mapping Preprocessing Interface Software
CMP	Common Mapping Program
CMS	Common Mapping Standard
CMTK	Common Mapping Toolkit
COTS	Commercial-Off-The-Shelf
CR	Change Request
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CSU	Computer Software Unit

DAFIF	Digital Aeronautical Flight Information File
DBM	Data Base Management
DCA	Digital Cartographic Applications
DCN	Document Control Number
DCW	Digital Chart of the World
DFAD	Digital Feature Analysis Data
DL	Distribution List
DMA	Defense Mapping Agency
DMS	Degrees-Minutes-Seconds
DOD	Department of Defense
DSN	Defense Security Network
DTED	Digital Terrain Elevation Data
ECHUM	Electronic Chart Update Manual
ECP	Engineering Change Proposal
EOD	Erasable Optical Disk
ERIM	Environmental Research Institute of Michigan
ESC	Electronic System Center
ESD	Electronic System Division
FIC	Feature Identification Code
FLIR	Forward Looking Infra-red
FQT	Formal Qualification Test
FSID	Functional Specification Identifier
GEOREF	Geographic Reference
GFI	Government Furnished Information

GIS	Geographic Information System
IAW	In Accordance With
ICD	Interface Control Document
ICF	Intelligence and Cartographic Facility
ICL	Interactive Command Language
ICWG	Interface Control Working Group
ID	Identification
IDHS	Intelligence Data Handling System
IR	Intelligence and Reconnaissance Directorate
IRR	IR Image Systems Division
IRRP	IR Image Products Branch
ITD	Information Technology Division of Sterling Software
ITD	Interim Terrain Data
JNC	Joint Navigation Chart
LE	Linear Error
LLLTV	Low Level Light Television
MCG&I	Mapping, Charting, Geodesy and Imagery
MN	Meeting Note
NDC	Normalized Device Coordinates
NITF	National Imagery Transmission Format
ONC	Operational Navigation Charts
OPR	Office of Primary Responsibility
OSF	Open Software Foundation

PDC	Physical Device Coordinates
PMP	Program Management Plan
POC	Point of Contact
PR	Problem Report
PSF	Pre-processor script file
PTADB	Planning Terrain Analysis Data Bases
PVOD	Probabilistic Vertical Obstruction Data
R&D	Research and Development
RL	Rome Laboratory
RMS	Requirements Management System
SAR	Synthetic Aperture Radar
SCCS	Source Code Control System
SCN	Specification Change Notice
SE	Spherical Error
SEN	Software Engineering Note
SMC	Surface Material Code
SMP	Software Modification Plan
SOW	Statement of Work
SPOT	Satellite Pour l'Observation de la Terre
SRS	Software Requirement Specification
SSA	Structured Systems Analysis
TEM	Technical Exchange Memorandum
TOA	Task Ordering Agreement

TTADB	Tactical Terrain Analysis Data Base
TTD	Tactical Terrain Data
ULPI	Unit Level Prototype Implementation
UPS	Universal Polar Stereographic
UTM	Universal Transverse Mercator
VDD	Version Description Document
VSC	View Surface Coordinates
WDBII	World Data Bank II
WVS	World Vector Shoreline
XIDB	Extended Integrated Data Base

A.2 Glossary

This glossary contains definitions for terms found in the CMTK documentation suite.

Accuracy	Digital cartographic information is only as accurate as the original source and the error inherent in the conversion method to digital form. Accuracy of map data can be expressed as a spatial error, where a marking may be off by so many meters; and as truthfulness of content, where the surface material is not what is recorded.
ARC Digitized Raster Graphics	A DMA raster product and digital representations of hardcopy maps. Maps /charts are converted into digital images and transformed into the ARC system frame of reference. The result is a worldwide seamless geocoded data base separated into several zones.
ARC Digital Raster Imagery	A Rome Laboratory developed raster product based on ADRG and is a geocoded digital representation of geocoded SPOT or LANDSAT imagery. Due to licensing agreements with the corporation that produces SPOT imagery, this data is available only on a limited basis.

Area	A graphics primitive defined by three or more connected endpoints where the endpoint closes to the beginning point. Also called a polygon.
Azimuth	Bearing or direction.
Azimuthality Projection	A projection that maintains scale in all directions from one or two points, but only from those points, is called azimuthal or equidistant.
Bitplane	An element of the graphics screen which is directly related to the number of colors that can appear on the display. Each screen pixel can store one or more bits of color information. Each bitplane is a one bit slice consisting of corresponding bits of each pixel on the screen.
Bump Mapping	This process adds natural looking surface detail where there is none available from the original data. The effect is to alter the shadow or colors of various portions of perspective views.
Cartographic Data Base	A disk resident data base that contains cartographic information in the form of lines, polygons, text, and raster values. The Cartographic data base will contain one or more map coverages.
Cartographic Feature	Within a map, this is a classification of the lines, polygons, text or raster data making up one feature or category of the map (e.g., major_highways, evergreen_forests).
Cartographic Frame	Within a feature, this is a grouping of the map data by rectangular region of the Earth. Each CMS or CMTK map data frame will have the same frame size and will not overlap with any other frame.
Cartographic Map	Within the CMS and CMTK data bases, this is a thematic grouping of map information. Each map will contain one or more features. All data within a map will have the same frame size.
Circle	A graphics primitive defined by a center point and a radius, or a center point and an edge point. A circle may be filled or unfilled.

Common Mapping Standard	A standardized, Government-owned and DMA-validated Cartographic data base structure used as the CMTK data base. The data it incorporates is imported from existing DMA data products such as ADRG, ADRI, DCW, DFAD, DTED, etc. It provides a common format for the use of these disparate DMA data products.
Common Mapping Toolkit	A software library of functions for manipulating and displaying CMS formatted data.
Common Mapping Standard Data Production System	A software system used to create CMS formatted data from existing DMA products.
Conformality Projection	A projection that maintains compass directions at each point is called conformal.
Digital Aeronautical Flight Information File	A DMA product providing 90 day updates on airport, air corridor, and the like, flight information.
Datum	An assumed reference elevation considered to be the zero elevation of a particular Earth spheroid. The spheroid radius, for example, WGS-84. For various regions of the Earth, the choice of the datum, or reference ellipsoid, has been influenced by the local geoid, but large scale maps fit the datum, not the geoid. Datums in the CMTK are made up of two constants: the semi-major and semi-minor axes.
Digital Chart of the World	A DMA product providing 1:1,000,000 scale vector geographic data. DCW was developed as the initial product implementation of a multinational R&D project designed to develop a set of vector product standards oriented toward the Geographical Information System (GIS) environment. DCW data was derived from Operational Navigation Charts over most of the globe and Jet Navigation Charts over Antarctica.
Device Description File	This CMTK file is a set of user-defined colors to be used in the display configuration. This file contains information about the size and location and number of bitplanes of the CMTK cartographic window.

Digital Feature Analysis Data	A DMA product providing spaghetti type vector data describing cartographic features of interest. Originally developed for radar simulation, it contains features such as obstructions, landmarks, and tactical points of interest. It is available in several editions.
Digital Cartographic Application	A Rome Laboratory contract under the Cartographic Applications for Tactical and Strategic Systems (CATSS) program now the Advanced Cartographic Applications (ACA) program. It produced a set of cartographic functions and algorithms that were integrated into the CMTK.
Display Configuration File	The set of all information relating to the appearance of the CMTK cartographic window. A display configuration consists of one or more maps and features within those maps.
Display Process	The method used to draw a map feature in the CMTK cartographic window.
Digital Terrain Elevation Data	A DMA product providing a uniform matrix of terrain elevation values for the Earth's surface at 100 meters resolution. The information content is approximately equivalent to a 1:250,000 scale resolution.
Easting	Eastward (left to right) increasing grid values on a map.
Elevation bumping	This process adds surface detail where there is none available from the original data. It is employed in the CMTK perspective algorithm using a pseudo-fractal texturing function. The effect is to make perspective views produced from coarse elevation data look smoother and more natural.
Ellipse	A graphics primitive defined by a center point, a major axis length, a minor axis length and a rotation; or a center point, a point on the end of the major axis and a point on the end of the minor axis. An ellipse may be filled or unfilled.
Ellipsoid	A mathematical figure generated by the revolution of an ellipse about one of its axes. The ellipsoid that approximates the geoid is an ellipse rotated about its minor axis, or an oblate spheroid.

Equidistant Cylindrical Projection	One of the map projections available through CMTK. The meridians and parallels are all equidistant straight parallel lines with the two sets crossing at right angles. This projection is neither conformal nor equivalent.
Equivalent Projection	A projection that preserves the relative sizes of surface areas is said to be equivalent or equal-area.
Feature	A particular set of data from the Cartographic data base that is to be drawn within a CMTK overlay, plus the method to be used to draw that data.
Field	Some CMTK dialog windows have places to type or select a menu choice. These places are called fields. There are several types of fields: pull down menu field, alphabetic field, numeric field, and alphanumeric field.
Frame Number	An identifier for each CMS or CMTK data base frame which is calculated from the frame size and frame position. Each frame number is unique within a feature.
Frame Position	The location of the lower left corner of a CMS or CMTK data base frame. This location is given in latitude and longitude and can be calculated from the frame size and frame number.
Frame Size	An attribute of the CMS or CMTK map record that defines the width and height of the area that will be covered by each frame of data within the map. The width is specified in degrees of longitude and the height is specified in degrees of latitude (e.g., 1x1 degrees).
Geoid	An equipotential surface whose shape would be approximated by mean sea level. This is an undulating surface that does not vary more than approximately one hundred meters above or below a well-fitting ellipsoid. The geoid generally rises over the continents and drops below the oceans. Elevations on the Earth are reported relative to the geoid.
Graphics Transformation	The conversion of points from one coordinate system to another using a transformation matrix. Graphics transformations include translation, scaling, and rotation.

Great Circle	The shortest distance between two points on the Earth's surface. The plane of a great circle evenly bisects the Earth and the plane contains the Earth's center.
Gouraud Shading	An intensity interpolation shading technique that calculates the intensity of a surface patch by linearly interpolating the vertex intensities along the edges of the patch to get intensities along the edges, and then linearly interpolating between the edges along a scan line to get intensities within the patch.
Inset Map	An overview map that allows the user to visualize the geographical location of the CMTK cartographic window map coverage. The inset window can be used to rescale the CMTK cartographic window display. A CMTK display configuration consists of one or more overlays and may contain one inset map.
Interim Terrain Data	A DMA vector product providing geospatial features and attributes of greater detail and complexity than DFAD. This data is composed of attributed feature information equivalent to the content of either Tactical Terrain Analysis Data Bases (TTADB) or Planning Terrain Analysis Data Bases (PTADB), and enhanced transportation features. This is an interim data product until the DMA Tactical Terrain Data (TTD) product or its successor is released.
tkparser Interactive Command Language	A high-level, English-like interactive command language used in the tkparser support utility to create the CMTK binary Display Configuration file, Device Description file, and Symbol Format file. This language is interpreted by the CMDI run-time parser as well.
Lambert Conformal Conic Projection	One of the map projections available through CMTK. The parallels are unequally spaced arcs of concentric circles, and the meridians are equally spaced radii of the parallel circles, thereby crossing the parallels at right angles. This projection is conformal.
LANDSAT	Multispectral imagery collected by a commercial imaging system.
Line	A graphics primitive defined by two connected endpoints, also called a polyline.

Luminance	Luminous intensity reflected or emitted by a surface in a given direction as it relates to the apparent surface area.
Magnetic North	The compass heading where lies the magnetic North Pole of the Earth, as opposed to the true or geographical North Pole.
Magnetic Declination	The difference between the direction of the true North Pole and the magnetic North Pole at a point on the Earth's surface.
Map	A geospatial coverage. Within a CMTK display configuration, a collection of geographic information from one area of the world to be displayed on all or part of the graphics screen. Each map has a center, scale, orientation, and viewport.
Marker	A graphics primitive defined by a point and one ASCII character to be displayed at that point.
National Imagery Transmission Format	A DOD standard for imagery. *National Imagery Transmission Format (NITF), Version 1.1,* 1 March 1989, Defense Intelligence Agency, Arlington, VA.
Normalized Device Coordinates	A coordinate system used to address pixels on a computer graphics screen. The range of this coordinate system is similar to physical device coordinates, except that the largest dimension (width or height) is set to 1.0. The NDC position (0.0, 0.0) is in the lower left corner of the screen. If the width and height are equal, then the upper right corner of the screen is NDC position (1.0,1.0). If NDC coordinates are used, then graphics objects will take up the same proportion of all computer screens, regardless of the actual PDC dimensions of the screens.
Northing	Northward (bottom to top) increasing grid values on a map.
Object data base	The collection of all objects which are currently part of the CMTK cartographic window map display.
Object	This is a particular instance of a CMTK symbol format. Any number of objects with the same symbol format can be added to the CMTK cartographic map display.
Overlay	Within a CMTK cartographic map, a collection of geographic information to be drawn in an independent set of display

	bitplanes. Updates in one overlay have no effect on other overlays. An overlay consists of one or more features.
Phong shading	An intensity interpolation shading technique that calculates the intensity of a surface patch by linearly interpolating the vertex normals along the edges of the patch to get normals along the edges, and then linearly interpolating between the edges along each scan line to get normals within the patch.
Physical Device Coordinates	A standard coordinate system used to address pixels on a computer graphics screen. The range of this coordinate system is system dependent, but in a typical system the PDC of the upper left pixel will be (0, 0) and the PDC of the lower right pixel will be (width-1, height-1), where width is the number of pixels across the screen in the horizontal direction and height is the number of pixels across the screen in the vertical direction. Some systems may have PDC (0, 0) in a different corner and PDC (width-1, height-1) in the diagonally opposite corner.
Pixel	A picture element. The smallest addressable area of a computer screen or image file.
Polar Stereographic Projection	One of the map projections available through CMTK. The central meridian and a particular parallel are straight lines. All meridians on the polar aspect and the Equator on the equatorial aspect are straight lines, and all others are shown as arcs of circles. This projection is conformal and azimuthal.
Polygon	A graphics primitive defined by three or more connected points where the last point is connected to the first and the interior region is filled.
Polyline	A graphics primitive defined by two or more connected points where the last point is not connected to the first.
Polymarker	A graphics primitive defined by one or more points and one ASCII character (which could correlate to either a text or marker font entry) to be displayed at each of those points.
Point	A graphics primitive defined by a single coordinate.

Primitive	The lowest level graphics element such as a point, line, area, polyline, polygon, polymarker, circle, ellipse, text string, or marker symbol.
Projection	This determines how the spherical Earth is drawn on a flat surface. Different projection schemes emphasize different cartographic qualities of a map. Three major projection qualities are (1) a projection that preserves the relative sizes of surface areas is said to be equivalent or equal-area, (2) a projection that maintains scale in all directions from one or two points, but only from those points, is called azimuthal or equidistant, and (3) a projection that maintains compass directions at each point is called conformal.
Probabilistic Vertical Obstruction Data	A classified DMA vector and raster data product. This contains residual density functions with vector vertical obstruction information extracted from a variety of data sources. It is the same as VOD, but with an additional raster component describing the data error. Vertical obstructions include radio towers, smokestacks, bridges, powerlines, and other objects above minimum elevations specified by mission planners.
Range	Distance.
Rhumb Line	A line of constant compass bearing on the Earth.
Rotation	A graphics transformation in which a coordinate system is rotated about its origin by a fixed angular value.
Scaling	A graphics transformation in which a coordinate system is resized into a larger or smaller coordinate system with possibly a different aspect ratio.
Successive Subdivision	This process adds surface detail where there is none available from the original data. It is employed in the CMTK perspective algorithm using a pseudo-fractal texturing function. The effect is to add a texture to the surface in perspective views.
Symbol Format file	The collection of all symbol formats which will be used to display symbology in an application using the CMTK.

Symbol	Either an individual element of a marker font or a graphic icon made up of one or more graphics primitives.
Text	A graphics primitive defined by a point and a set of ASCII characters to be displayed at that point.
tkparser	A utility program used to create the CMTK Display Configuration, Device Description, and Symbol Format binary files. This program interprets ASCII files written in the tkparser interactive command language.
Toolkit	Refers to the CMTK functionality callable from an application. The CMTK functionality is involved with displaying map data, manipulating the map display, performing geospatial analysis, and Cartographic data base interaction.
Track History	A list of the past positions of a CMTK object that is being moved around the CMTK cartographic map display.
Transformation Matrix	A 3x3 matrix to be multiplied by a point (stored as a vector) to produce a corresponding point (vector) in a different coordinate system. A 3x3 matrix will transform a two dimensional point. A transformation matrix can be as simple as an identity matrix, in which case the output is identical to the input, or any combination of translation, scaling, and rotation matrices.
Translation	A graphics transformation in which a coordinate system is moved vertically and/or horizontally.
Transverse Mercator projection	One of the map projections available through CMTK. The central meridian (each meridian 90 degrees from the central meridian) and the equator are straight lines. All other meridians and parallels are complex curves. This projection is conformal.
True North	The compass heading where lies the geographical north as opposed to magnetic North.

View Surface Coordinates	A coordinate system used to address pixels on a computer screen. The range of this coordinate system is the same as physical device coordinates (PDC), but on all systems the VSC of the lower left pixel will be (0, 0) and the VSC of the upper right pixel will be (width-1, height-1). VSC should be used in place of PDC wherever possible to allow for system portability.

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