CADAC
QUICK START

VOLUME I

Release 3.1
June 2000

Prepared For:
Air Force Research Laboratory (AFRL/MNG)
Eglin Air Force Base, Florida 32542

Prepared By:
TYBRIN Corporation
1030 Titan Court
Ft. Walton Beach, FL 32547

June 2000 - Release 3.1 document created. Documents revised to include references and revisions to PC programs KPLOT, PITA, GLOBE, DrawOLE and CADX were updated to reflect modifications and clarifications of their functions. References to the preprocessing utilities DFHEAD, CADIN and INPUT are also updated to reflect their modifications and clarifications of their functions.

Sept 1998 - Release 3.0 document created. Documents revised to include references and revisions to new PC programs KPLOT, PITA, CHKINT and CONVRT. References to programs SWEEP, CONTOUR, ELLIPSE, QPRINT, CADIN, INPUT, MCAP, WinDRAW, DrawOLE and CADX were updated to reflect modifications and clarifications of their functions. The real-time CADAC capability is fully implemented and documented.
KPLOT now includes 2DIM, PITA, GLOBE, WinDRAW and DrawOLE. SWEEP includes CONTOUR, ELLIPSE, QPRINT and MCAP.
Release of CADAC CD-ROM.

July 1997 - Release 2.1 document created. Contour program modified to fix reported problems with the Color box. Program Sweep modified to allow user entered sigma values. Final version of SWEEP 5 methodology fully implemented. CADIN modified to include additional standard (executive level) variables and their definitions.

May 1997 - Release 2.0 document created. Documents revised to include references and revisions to PC programs SWEEP, ELLIPSE, CONTOUR and WinDraw. References to programs CADAC, CADIN, QPRINT, and to MCAP were updated to reflect modifications and clarifications to their functions. Various editorial changes were implemented to correct reported errors. Programs SASP and SWEEP were combined into one program (SWEEP) to simplify the program series execution. Other programs QPRINT, MCAP, CONTOUR, ELLIPSE and WinDraw are executed from within the main SWEEP program but also can be executed separately. New SWEEP5 methodology was added to the CADAC executive.

October 1996 - Release 1.1 document created. Documents revised to include references to new PC programs SASP, SWEEP, TCON, and INPUT. References to programs CADAC, CADIN, QPRINT and to file HEAD.ASC were updated to reflect modifications and clarifications to their functions. Various editorial changes were implemented to correct reported errors. Disk file packing list and install procedures have been modified for better use of disk space. The use of ZIP compressed files has been initiated

March 1995 - Release 1.0 document created.

Program CADAC, Computer Aided Design of Aerospace Concepts, provides an environment for the development of general purpose, digital computer simulations of time phased dynamic systems. It manages input and output, generates stochastic noise sources, controls all state variable integration and provides post-processing data analysis and display. CADAC has proven its adaptability to many simulation tasks: air-to-ground weapons, air-to-air missiles, ground-to-space and space-to-ground vehicles, and airplanes. The CADAC environment is suitable for 3DOF, 5DOF, and 6DOF simulations. It supports deterministic and Monte Carlo runs. Output can be listed or plotted. This version is a revision of CADAC for Personal Computers (July 1998).

The structure of CADAC originated with Litton Industries in the mid 1960's. Since this time, several organizations have adopted this simulation environment: DIMODS (Rockwell), MAVERICK (Hughes), MODIGSI (GBU-15 SPO), ENDOSIM (Army Materiel Command) and several others. CADAC was first employed at USAF/AFMC/ASC during its third generation of development in 1978. Current users include ASC/XR; AFRL/MNG; SWC; NAWC, China Lake, CA; DRA, Farnborough, UK; IABG, Munich, GE and ONERA, France. A large library of subsystem Modules exists from previous applications for adaptation to future simulations.

HARDWARE REQUIREMENT

CADAC is hosted on an IBM compatible PC with a minimum of 16 MB of RAM (32 MB recommended) and 25 MB of free disk space and WINDOWS 95/98 or NT operating system installed. The advanced graphics utilities are best displayed on a 1024x768 resolution display device with font size set to “small”.

COMMERCIAL SOFTWARE REQUIREMENT

The preferred compiler is the Digital Visual FORTRAN for Windows 95 or NT (a complete FORTRAN development tool with language sensitive editor). Other compilers may require minor modifications of the CADX30.FOR executive routine.

RECOMMENDED SUBDIRECTORY SETUP

On your drive create a directory CADX and a subdirectory TEST. Copy all FORTRAN files into directory CADX with the exception of MODULE.FOR, DUMMY.FOR, INPUT.ASC, and HEAD.ASC, which go into subdirectory TEST. In the CADX directory convert the source code into executable files. For the test case build a project in subdirectory TEST. The advanced CADAC utility programs provide their own setup programs and will create directories as needed by the utility program.

RUNNING THE TEST CASE

If you use Digital visual FORTRAN, create the project CADAC, working from the subdirectory TEST. The project consists of source code CADX.FOR, UTL.FOR, DUMMY.FOR and MODULE.FOR. Run CADIN.EXE to convert the free-format INPUT.ASC into the fixed-format input file CADIN.ASC. Now run CADAC.EXE and watch the time phased trajectory data scroll by in the DOS window. Run QPRINT to look at other variable listings and KPLOT to trace trajectories.

WHAT'S NEW – Release 3.1

CADX- The CADAC executive routine has been modified: CADAC checks to ensure that the user has correctly set up a SWEEP or single run execution. The MINIT variable as a SWEEP run designation was also eliminated. A new utilities file has been generated, UTL3.FOR.

CADIN- The program has been modified to allow full length comment records.

KPLOT- A new log and trajectory file search is now included for all programs associated with all the KPLOT programs. This capability allows for the automatic opening of a log or trajectory file within the local directory. A preferences menu has also been added to the KPLOT interface and the DrawOLE graphics engine. This preferences option allows the user to define the default value for many graphics options. The following upgrades have been made to each program:

- **2DIM**: Modifications were made to correct problems encountered with version 3.0.
- **PITA**: A user entered scaling option was added to the interactive input screen. The user enters X, Y and Z minimums and maximums for the desired plot.
- **GLOBE**: Modifications were made to the terrain display option to simultaneously display the color code and terrain.
- **BIVAR**: Modifications were made to correct problems encountered with version 3.0.

INPUT – The program has been modified to allow full length comment records.

The CADAC environment is composed of program files, input files, utility files and output files. Program files describe the aerospace vehicle in Fortran 77 code; input files assign numerical values to parameters, sequence the simulation events and define the output; and utility files assist the user in the development of the simulation and provide tools for the output data analysis. The output files record the deterministic trajectories and stochastic information. Program version numbers may change to indicate a program revision.

PROGRAM FILES:

CADX30.FOR:	Executive routine: integration, input, output.
DUMMY.FOR:	Dummy return subroutines for unused modules.
MODULE.FOR:	Simulation subroutines: initialization and code of subsystems.
UTL3.FOR:	Utility subroutines: matrix manipulations, table look-up.

INPUT FILES:

CADIN.ASC:	Input data file for CADAC; fixed-format input file.
HEAD.ASC:	Output specs: selected variables scrolled to screen and written to output.
ICON.ICN:	File of icons for display by WinDRAW.
INPUT.ASC:	Free-formatted input data file: module calling sequence, input parameters, staging criteria. Must be converted by CADIN

UTILITIES:

AHEAD3.EXE:	Generates alphabetical listing of HEAD.ASC.
CADIN3.EXE:	Converts free-format INPUT.ASC into fixed-format CADIN.ASC.
CHKINT12.EXE	Checks for duplicate state variable C locations.
CONVRT24.EXE:	Creates a real-time CADAC application.
DFHEAD3.EXE:	Defines variable names in HEAD.ASC from source code MODULE.FOR.
DFMOD3.EXE:	Defines remaining variables in source code from HEAD.ASC variables.
EQMAP3.EXE:	Creates equivalence cross-referencing map.
FRLOC3.EXE:	Generates list of unused C locations.
INPUT3.EXE:	Converts fixed-formatted CADIN.ASC into free-format INPUT.ASC.
MCAP35.EXE:	Averages Monte Carlo results (included in SWEEP).
MKHEAD3.EXE:	Makes HEAD.ASC: checks for illegal duplications and dimensioning.
KPLOT20.EXE:	Plots TRAJ.BIN or TRAJ.ASC in two and three dim and displays STAT.BIN or STAT.ASC stochastic data.
QPRINT35.EXE:	Displays TRAJ.BIN, TRAJ.ASC, STAT.BIN and STAT.ASC output in columns and generates ASCII files (included in SWEEP).
SWEEP35.EXE:	Controlling program for the SWEEP series providing statistical analysis and smoothing functions for SWEEP formatted data.
WINDRAW.EXE:	Customized scientific plotting program (included in KPLOT).

OUTPUT FILES:

CONTOUR.WDR	Output from CONTOUR to be used as input for drawing program WinDRAW. Created by user during CONTOUR session.
CSAVE.ASC:	Saved C-array values at a point on the trajectory for re-initialization.
ERROR.ASC:	Records invalid statements in INPUT.ASC that prevent CADIN.EXE from producing a valid CADIN.ASC file.
IMPACT.ASC:	Impact points in air-to-ground cases.
INIT.ASC or INIT.BIN	Real-time CADAC initialization file for target track data in binary or ASCII form
RANVAR.ASC:	Actual values of random variables.
STAT.BIN or STAT.ASC:	Statistical data at points on the trajectory in binary or ASCII.
SWEEP.WDR:	Output from SWEEP series to be used as input file for drawing program WinDRAW.
TABOUT.ASC:	Tabular data displayed on the screen or written to this file.
TRACK.ASC or TRACK.BIN	Real-time CADAC target track time history data in binary or ASCII form
TRAJ.BIN or TRAJ.ASC:	Time history data of trajectory in binary or ASCII format.
WINDRAW.WDR	Output from WinDRAW.

ENVIRONMENTAL FILES:

*.HLP:	Help files for CHKINT, CONTOUR, ELLIPSE, MCAP, KPLOT, QPRINT, SWEEP and WinDraw.
*.INI:	Start up file for CHKINT, CONTOUR, ELLIPSE, MCAP, KPLOT, QPRINT, SWEEP and WinDraw.
*.OCX:	Programming required files automatically installed on the users' computer.
*.LOG:	Saves results of user interactive sessions for later reuse.

The Advanced graphics utilities are installed from your hard drive after the installation file is downloaded from an FTP site.

WEB INSTALLATION

For files received from a web site, the user will begin with a single file stored in a self-extracting zip format (*.EXE). The self-extracting zip files should be downloaded to a temporary directory (i.e. \WINDOWS\TEMP). After the program has been expanded the user can execute the program named SETUP.EXE. This program will begin installing the proper files on the hard drive. The install program will create all necessary directories. Some windows *.DLL and *.OLE files will be installed onto the computer system (see file list). The original zipped file should be retained for archive proposes; the expanded programs in the temporary directory can be .

CD-ROM INSTALLATION

The data residing on the CADAC web site is duplicated on the CADAC CD-ROM with a few exceptions. The CD-ROM directory follows:

CADAC STUDIO (Version 3.1)

- CADAC\DOC\ Documentation in 4 volumes
- CADAC\CADX\ Executive and utility FORTRAN programs; test case
- CADAC\CHKINT\ Integration variable checking program, installation required
- CADAC\KPLOT\ Plotting programs: 2-dim, 3-dim, globe, statistical, installation required
- CADAC\SWEEP\ Footprint and launch envelop generation programs, installation required
- CADAC\REALTIME\ Converter program for CADAC real-time code generation

CADAC SIMULATIONS

- CADAC\GHAME3\ 3 DoF NASA hypersonic vehicle
- CADAC\ROCKET3\ 3 DoF three stage rocket
- CADAC\AIM5\ 5 DoF simple short range air-to-air
- CADAC\CRUISE5\ 5 DoF generic cruise missile with GPS, and terminal sensor
- CADAC\SRAAM5\ 5 DoF generic short range air-to-air missile
- CADAC\FALCON6\ 6 DoF Falcon aircraft simulation without flight control
- CADAC\GHAME6\ 6 DoF NASA hypersonic vehicle with flight control
- CADAC\SRAAM6\ 6 DoF version of SRAAM5

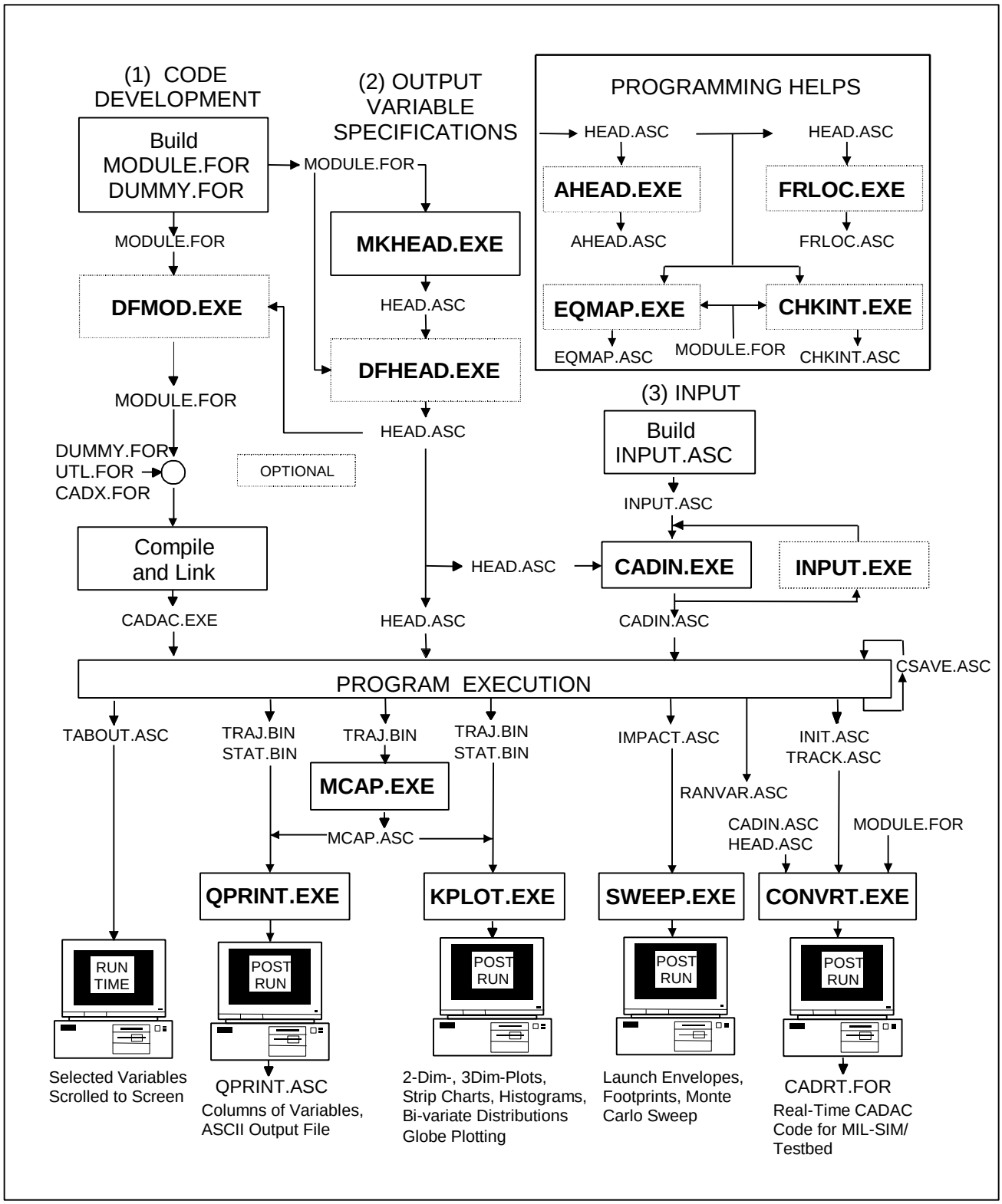
DATA

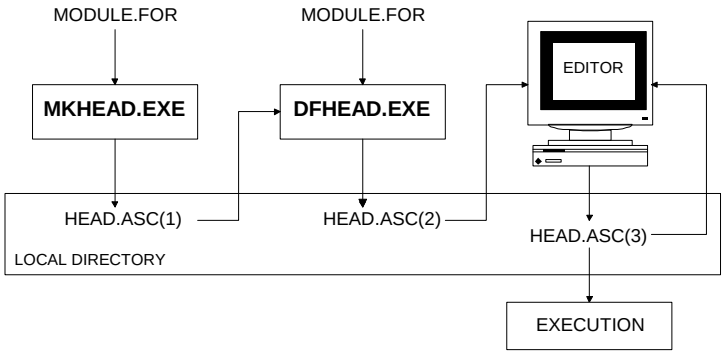
- CADAC\SSTO3\ Single stage to orbit vehicle, drag polar and rocket propulsion for 3 DoF simulation
- CADAC\AGM5\ Air-to-ground generic missile, trimmed aerodynamics for 5 DoF simulation
- CADAC\FALCON5\ Falcon aircraft, trimmed aerodynamics and turbojet propulsion for 5 DoF simulation
- CADAC\AGM6\ Air-to-ground generic missile, aerodynamics for 6 DoF simulation

BULLETIN

- CADAC\PRIMER\ Introduction to running CADAC

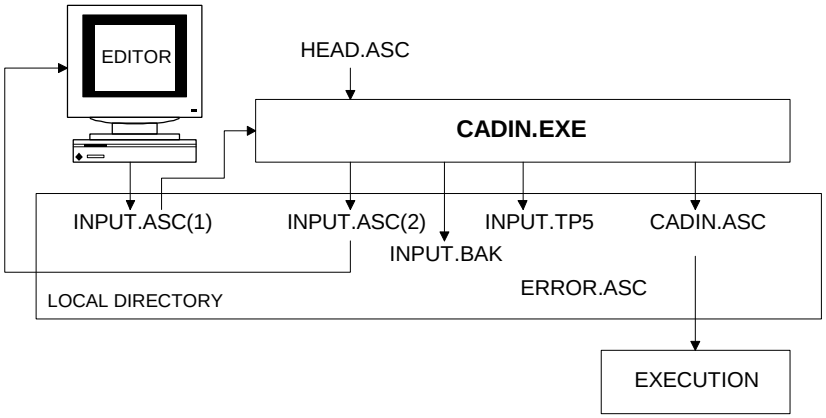
The application directories (KPLOT, SWEEP and CHKINT) on the CD-ROM contain the installation files for each program. Program installation begins by executing the set-up file (SETUP.EXE) located in the application directory.


(1) CODE DEVELOPMENT
Build MODULE.FOR DUMMY.FOR
MODULE.FOR
DFMOD.EXE
MODULE.FOR
DUMMY.FOR
UTL.FOR
CADX.FOR
Compile and Link
CADAC.EXE
(2) OUTPUT VARIABLE SPECIFICATIONS
MODULE.FOR
MKHEAD.EXE
HEAD.ASC
DFHEAD.EXE
HEAD.ASC
OPTIONAL
HEAD.ASC
HEAD.ASC
PROGRAMMING HELPS
HEAD.ASC
HEAD.ASC
AHEAD.EXE
FRLOC.EXE
AHEAD.ASC
FRLOC.ASC
EQMAP.EXE
CHKINT.EXE
EQMAP.ASC
MODULE.FOR
CHKINT.ASC
(3) INPUT
Build INPUT.ASC
INPUT.ASC
CADIN.EXE
INPUT.EXE
CADIN.ASC
CSAVE.ASC
PROGRAM EXECUTION
TABOUT.ASC
TRAJ.BIN STAT.BIN
TRAJ.BIN
MCAP.EXE
TRAJ.BIN STAT.BIN
MCAP.ASC
IMPACT.ASC
RANVAR.ASC
INIT.ASC TRACK.ASC
CADIN.ASC HEAD.ASC
MODULE.FOR
QPRINT.EXE
KPLOT.EXE
SWEEP.EXE
CONVRT.EXE
RUN TIME
POST RUN
POST RUN
POST RUN
POST RUN
Selected Variables Scrolled to Screen
QPRINT.ASC
Columns of Variables, ASCII Output File
2-Dim-, 3Dim-Plots, Strip Charts, Histograms, Bi-variate Distributions Globe Plotting
Launch Envelopes, Footprints, Monte Carlo Sweep
CADRT.FOR
Real-Time CADAC Code for MIL-SIM/ Testbed



BUILDING THE HEAD.ASC FILE

MODULE.FOR	Complete set of modules of the source code
HEAD.ASC(1)	Raw file with numerically sequenced equivalence variables, error check
HEAD.ASC(2)	=HEAD.ASC(1) with definitions of variables taken from MODULE.FOR
HEAD.ASC(3)	=HEAD.ASC(2) with option list, scroll list and variables written to TRAJ.BIN



BUILDING THE CADIN.ASC FILE

INPUT.ASC(1)	Free-format input file built with Editor, consisting of input variables and values
INPUT.ASC(2)	=INPUT.ASC(1) with definitions of variables extracted from HEAD.ASC
INPUT.BAK	=INPUT.ASC(2) for archiving
CADIN.ASC	Fixed format input file for CADAC execution
INPUT.TP5	=CADIN.ASC for archiving, see note for other possible file names
HEAD.ASC	Complete header file with all variables defined
ERROR.ASC	Composite of error messages

Note: If a different free-format input file name is used, INPUT will everywhere be replaced by it

DEVELOPMENT OF CADAC SIMULATIONS

To develop other CADAC programs rewrite the modules of subdirectory TEST and make them part of a new subdirectory. The MODULE.FOR file is developed first by programming individual modules: A1.FOR, A2.FOR, etc. and removing all FORTRAN errors followed by copying them to MODULE.FOR. Then the DUMMY.FOR is created to provide RETURN statements for all CADX.FOR module calls for which there are no subroutines in MODULE.FOR.

The output variable specifications for TABOUT.ASC, TRAJ.BIN, and STAT.BIN are annotated on HEAD.ASC, which is created using MKHEAD.EXE. If the equivalence of variables in the modules are documented, the HEAD.ASC file may also be documented using DFHEAD.EXE, and in turn, additional documentation can be inserted into MODULE.FOR with DFMOD.EXE.

The input file is created in free-format and called INPUT.ASC. It is converted into a fixed-format FORTRAN file CADIN.ASC with the CADIN.EXE. Program INPUT.EXE can be used to convert a fixed-format file back into a free-format file. Simultaneously, the variables of INPUT.ASC are documented from the HEAD.ASC definitions.

The other utilities AHEAD.EXE, FRLOC.EXE, EQMAP.EXE and CHKINT.EXE are useful for error checking and documentation. Single, multiple, and Monte Carlo runs may be executed. TRAJ.BIN contains the time phased trajectory data and STAT.BIN contains the statistical raw data at program stages and at impact. Programs QPRINT and KPLOT can process and display these files.

USING ADVANCED FEATURES

Several program features or capabilities may be considered of an advanced nature and are available for use. These features are:

VECTOR INTEGRATION: State vectors can be integrated as an entity without breaking them up into scalar components.

WEATHER: Atmospheric conditions, like temperature, density, pressure and wind can be specified as tabular functions of altitude using the keyword WEATHER in the INPUT.ASC file.

STAGING: Modes of trajectories, like midcourse or terminal guidance, can be sequenced in sections called stages. They are initiated by IF statements in the INPUT.ASC file. The trajectory is staged if one variable of the global C-array is less or greater than a numerical value or another variable. Two conditions may be combined with the logic OR to form staging criteria.

MULTI-RUNS: Several trajectories may be combined. For instance, if the sensitivity of a seeker parameter is to be investigated, new parameter values are scheduled in separate group runs and loaded into the global C-array at the appropriate stage with the keywords LOAD and STAGE.

RE-INITIALIZING: To save execution time, the state of the trajectory can be saved at a certain event, say seeker acquisition, and the following group runs are reinitialized at this point. The keyword SAVE will write the global C-array to the file CSAVE.ASC.

SWEEP RUNS: This feature is used to automate the calculation of launch envelopes and footprints. The launch position or target location is swept through a polar grid defined by the keywords SWEEP, MODE, LIMIT, RANGE, and ANGLE. The collection of trajectory output is written to the IMPACT.ASC file. The SWEEP graphics utility programs provide methodologies to analyze and display the results.

SINGLE MONTE CARLO RUNS: Stochastic runs are evoked by the keyword MONTE followed by the number of desired runs. The noise sources, like wind gusts, INS errors and seeker noise, are defined by the keywords GAUSS, UNIF, EXPO, or RAYLE. The output file RANVAR.ASC saves the random value and it can be used to rerun a particular trajectory realization. The MCAP

program averages the trajectory parameters and calculates means, standard deviations and correlation coefficients. Histograms and error ellipses are displayed by the KPLOT program.

SWEEP MONTE CARLO RUNS: Sweep runs can also be executed as a family of Monte Carlo runs. Just introduce the Keyword MONTE with its replication number into a sweep run setup.

REAL-TIME CADAC: The Batch CADAC simulation may be converted via the CONVRT.EXE program into a real-time capable code package which could become part of a man-in-the-loop simulation.

TEST CASE: SINGLE STAGE TO ORBIT VEHICLE	CAD1.9

The example that is included with this CADAC-PC, is a 3 DOF point mass simulation of a Single Stage to Orbit (SSTO) vehicle, released from a Super Boeing 747, and propelled by a throttleable LOH rocket. The equations are taken from Vinh, Nguyen "Optimal Trajectories in Atmospheric Flight", Elsevier, 1981, pp.50-58. Refer to the Module D1 in the MODULE.FOR file for the specific form of the equations of motion.

The test case INPUT.ASC simulates the release at 12km altitude above Cape Canaveral and a climb to orbital conditions, which are reached at burnout. The state variables of the six first order differential equations are given below. The trajectory is controlled by angle-of-attack, throttle, and bank angle. In this test case the bank angle is zero throughout the flight. It is instructive to modify the input, by changing the initial conditions, the end conditions, the alpha profile, the throttling ratio, and even the bank angle.