Appendix E

TRAP STRUCTURE CHARTS

TRAP has a clearly defined structure with a definite processing order. This carries through the entire engagement model from data input to the way in which each vehicle subsystem is modeled.

These structure charts have been simplified to some extent; multiple calls to the same subroutine are not shown. However, all calls are shown in the order in which they first occur. Some of the lowest level subroutines are not shown in the main call-tree; this usually applies to the data input utilities. However, these are included at the end of the structure chart where their relationship is shown to a higher level subroutine that is included in the main call-tree.

TRAP STRUCTURE CHARTS

```
TRAP     Main Program
          BLNKCHAR    Packs all character arrays with blanks prior to initialization.
          SCENAR      Read simulation times, scenario, launch a/c and target a/c data.
                      PRSCEN   Parses out the variables in the SCENAR file (UNIT 3).
                                  RSTOR        Processes all real data.
                                  ISTOR        Processes all integer data.
                                  CSTOR        Processes all character data.
                                  LSTOR        Processes all logical data.
                      STARG   Reads target data.
                                  TGINPT   Target tables read routine, TGTBLE file (UNIT 18).
                                           TBLRD        Table read - calls shown on separate chart.
                                  CHKTTL      Check for proper heading titles.
                                  PRSTGT   Parses out all values in STARG file (UNIT 2).
                                              RSTOR        Processes all real data.
                      SACFT   Reads launch aircraft data.
                                  CHKTTL       Check for proper heading titles.
                                  PRSAC   Parses out all values in SACFT file (UNIT 4).
                                              RSTOR        Processes all real data.
                                  ACINPT   Launch aircraft tables read routine, ACTBLE file (UNIT 17).
                                              TBLRD        Table read - calls shown on separate chart.
                                  PRSRAD   Parses out all values in SRADAR file (UNIT 36).
                                              CSTOR        Processes all character data.
                                              RSTOR        Processes all real data.
                                              ISTOR        Processes all integer data.
                                  TUSTIN       Driver for Tustin coefficient initialization,
                                                 calls shown on separate chart.
            BURST   Print page burst.
                        LJUST        Left justifies to first non-blank character
            SMISSL       Read missile data - calls shown on separate chart.
            SUSER   Loads input for user-defined variables from SUSER file (UNIT 28).
                        PRSUSR   Parses out all values in SUSER file (UNIT 28).
                                  RSTOR        Processes all real data.
                                  CSTOR        Processes all character data.
            LEADSU   Intercept launch aimpoint (calcs missile lead angle).
                        ATMOS        Air properties at current altitude.
            AIMISS       Calculate elevation and azimuth heading angles of launch aircraft (aims launch aircraft
                          at target aircraft).
            RDPRNT       Print initialization - reads print control files from PRINTC file (UNIT 21).
            PRINTI       Uses input variables indicated for output and sets up proper links to common blocks
                          for access during execution.
            RCNSTR   Performance reconstruction w/wo error analysis.
                        INTLCM   Initializes the complex and starts all processes.
                                    RCNINP   Reads all inputs for performance reconstruction.
                                             ERRTRA
                                             MTLMTS       Checks initial parameter estimates to limits and specs.
                                    LDCMPX   Randomly selects rest of vertices that make up initial
                                              complex "amoeba".
                                             GGUBS        IMSL random number generator.
                                    USRSTR       User routine for search restrictions.
                                    RNFLYT   Call missile flyout.
                                             FLYOUT       Calls shown on separate chart.
                                    CMPCNT       Computes centroid of all vertices.
                                    MVTXHF       Moves vertex halfway towards centroid of others.
                                    GTGDFL   Keeps moving the vertex half the distance to the centroid.
                                              RNFLYT   Call missile flyout.
                                                          FLYOUT       Calls shown on separate chart.
                                              MVTXHF       Moves vertex halfway towards centroid of others.
                        PFMRCN   Perform reconstruction.
                                  FDWVTX   Searches vertices and returns worst one.
                                              OBJFNC       Evaluates function of a vertex.
                                  CMPCNT       Computes centroid of all vertices.
                                  MVTXAP       Move vertex to the other side of the centroid.
                                  USRSTR       User routine for search restrictions.
                                  MVTXHF       Moves vertex halfway towards centroid of others.
                                  GTGDFL   Keeps moving the vertex half the distance to the centroid.
                                              RNFLYT   Call missile flyout.
                                                          FLYOUT       Calls shown on separate chart.
                                              MVTXHF       Moves vertex halfway towards centroid of others.
                                  TSTFTR   Tests for termination of reconstruction.
                                              FNLVLS   Sets final estimates.
                                                          USRSTR   User routine for search restrictions.
                                  FNLVLS   Sets final estimates.
                                              USRSTR  User routine for search restrictions.
                                  RNFLYT   Call missile flyout.
                                              FLYOUT       Calls shown on separate chart.
                                  OBJFNC       Evaluates function of a vertex.
            STKDRN       Single or stacked flyouts - calls shown on separate chart.
   TRAP   Main Program
            STKDRN   Single or stacked flyouts - Calls shown on separate chart.
                        FLYOUT   Single or non-automated stacked cases, flyouts, engagements.
                                  Calls shown on separate chart
                        LEADSU   Intercept launch aimpoint (calcs missile lead angle).
                                  ATMOS        Air properties at current altitude.
                        AIMISS       Calculates elev and az heading angles for launch aircraft
                                    (aims launch AC at target).
                        PRSCEN   Parses out the variables in the SCENAR file (UNIT 3).
                                  RSTOR        Processes all real data.
                                  ISTOR        Processes all integer data.
                                  CSTOR        Processes all character data.
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                    LSTOR        Processes all logical data.
          RDCONG    Constant "g" flyouts - loads inputs from CONSTG file (UNIT 30).
                    CHKTTL       Check for proper heading titles.
                    PRSCON   Parses out all values in CONSTG file (UNIT 30).
                                 RSTOR        Processes all real data.
          FLYCG   Automatic controller for missile constant "g" flyouts.
                    FLYOUT   Single or non-automated stacked cases, flyouts, engagements.
                                 Calls shown on separate chart.
          RDLARB    Launch zone by boundary method - loads input from LARBND file (UNIT 29).
                    CHKTTL       Check for proper heading titles.
                    PRSLRB   Parses out all values in LARBND file (UNIT 29).
                                 CSTOR        Processes all character data.
                                 RSTOR        Processes all real data.
          BNLARB    Top level control for the launch envelope boundary automated binary search.
                    BFNDRNG   Find a boundary point.
                                BOUND        Computes initial launch AC position - see calls below.
                                FLYOUT       Calls shown on separate chart.
                                BNSRCH   Binary search for next range.
                                             ATMOS        Air properties at current altitude.
                    PRTBND       Prints successful flyouts - Calls shown below.
                    BFNDTAN   Smooths an envelope boundary between points of least capability.
                                 BFNDRNG   Find a boundary point.
                                              BOUND   Computes initial launch AC position.
                                                       Calls shown below.
                                              FLYOUT       Calls shown on separate chart.
                                              BNSRCH   Binary search for next range.
                                                        ATMOS        Air properties at current
                                                                      altitude.
                                 PRTBND      Prints successful flyouts - Calls shown below.
          LARBND    Launch envelope boundary automated search.
                    FNDRNG       See calls below.
                    PRTBND        Prints successful flyouts - Calls shown below.
                    FNDTAN   Smooths an envelope boundary between points of least capability.
                                 FNDRNG   Find a boundary point.
                                              BOUND   Computes initial launch AC position.
                                                       Calls shown below.
                                              FLYOUT       Calls shown on separate chart.
                                              NXTRNG   What shot taken next.
                                                        ATMOS        Air properties at current
                                                                      altitude.
                                 PRTBND       Prints successful flyouts - Calls shown below.
          RDLARG    Loads input that controls launch envelope runs from LARGRD file (UNIT 31).
                    CHKTTL       Check for proper heading titles.
                    PRSLRG   Parses out all values in LARGRD file (UNIT 31).
                                 RSTOR        Processes all real data.
          LARGRD    Top level control routine for generating a launch range grid in the horizontal
                     plane.
                    LEADSU   Intercept launch aimpoint (calcs missile lead angle).
                               ATMOS        Air properties at current altitude.
                    AIMISS       Calculates elev and az heading angles for launch aircraft
                                  (aims launch AC at target).
                    FLYOUT       Calls shown on separate chart.
          RDAR    Loads input that controls altitude-range runs from ALTRNG file (UNIT 41).
                     CHKTTL       Check for proper heading titles.
                     PRSAR     Parses out all the values in the ALTRNG (UNIT 41) data file.
                                  CSTOR        Processes all character data.
                                  ISTOR        Processes all integer data.
                                  LSTOR        Processes all logical data.
                                  RSTOR        Processes all real data.
PRTBND    Prints successful flyouts
          BOUND   Binary search for next range.
                 LEADSU   Intercept launch aimpoint (calcs missile lead angle).
                            ATMOS        Air properties at current altitude.
                 AIMISS      Calculates elev and az heading angles for launch aircraft
                            (aims launch AC at target).
          FLYOUT      Calls shown on separate chart.
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TRAP   Main Program
         SMISSL     Top level read routine for all missile data.
                      CHKTTL       Checks for proper input file heading titles.
                      SAERO   Load missile aero-related single parameter data, SAERO file (UNIT 22).
                               PRSAER   Parses out the missile areo variables in the SAERO file (UNIT 22).
                                           CSTOR        Processes all character data.
                                           RSTOR        Processes all real data.
                               ATINPT   Missile aero tables read routine, AEROTBLE file (UNIT 12).
                                            TBLRD        Calls shown on separate chart.
                      SSEEK   Load missile seeker single parameter data, SSEEK file (UNIT 23).
                               PRSEEK   Parses out the missile seeker variables in the SSEEK file (UNIT 23).
                                           CSTOR        Processes all character data.
                                           RSTOR        Processes all real data.
                                           ISTOR        Processes all integer data.
                               TUSTIN       Driver for Tustin coefficient initialization - Calls shown below.
                               TUSTC0       Initialize Tustin Integrator.
                               FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                      SEMIT   Loads single parameter emitter data from SEMIT file (UNIT 38).
                               CHKTTL  Checks for proper input file heading titles.
                               PRSEMT   Parses all of the data in the SEMIT file (UNIT 38).
                                           RSTOR        Processes all real data.
                                           CSTOR        Processes all character data.
                               FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                      SILLUM   Loads single parameter illuminator data from SILLUM file (UNIT 39).
                               CHKTTL       Checks for proper input file heading titles.
                               PRSILM   Parses out all of the data in the SILLUM file (UNIT 39).
                                           CSTOR        Processes all character data.
                                           RSTOR        Processes all real data.
                               FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                      PDINPT   Set table titles and input unit numbers for illuminator and receiver power.
                                degradation tables, then calls table read routine TBLRD.
                               TBLRD        Calls shown on separate chart.
                      SGUID   Loads missile guidance single parameter data, SGUID file (UNIT 24).
                               PRSGUI   Parses out the missile guidance variables in the SGUID file (UNIT 24).
                                           CSTOR        Processes all character data.
                                           RSTOR        Processes all real data.
                               TUSTC2       Initialize Tustin 1st order lead - 1st order lag.
                               TUSTIN       Driver for Tustin coefficient initialization - Calls shown below.
                      SAUTOP   Loads missile autopilot single parameter data, SAUTOP file (UNIT 25).
                               PRSAUT Parses out the missile autopilot variables in the SAUTOP file (UNIT 25).
                                           LSTOR        Processes all logical data.
                                           CSTOR        Processes all character data.
                                           RSTOR        Processes all real data.
                               TUSTIN       Driver for Tustin coefficient initialization - Calls shown below.
                               TUSTC0       Initialize Tustin Integrator.
                               SGINPT Missile autopilot and sensor tables read routine, SGTBLE file (UNIT 16).
                                            TBLRD        Calls shown on separate chart.
                      SMASS   Loads missile mass properties single parameter data, SMASS file (UNIT 26).
                               PRSMAS   Parses out the missile mass property variables in the SMASS
                                            file (UNIT 26).
                                           LSTOR        Processes all logical data.
                                           RSTOR        Processes all real data.
                               MPINPT   Missile mass property tables read routine, MPTBLE file (UNIT 13).
                                            TBLRD        Calls shown on separate chart.
                      SPROP   Loads missile propulsion single parameter data, SPROP file (UNIT 27).
                               PRSPRO Parses out the missile propulsion variables in the SPROP file (UNIT 27).
                                           CSTOR        Processes all character data
                                           RSTOR        Processes all real data
                               PPINPT   Missile propulsion tables read routine, PPTBLE file (UNIT 15).
                                            TBLRD        Calls shown on separate chart.
                      SOBSRV   Driver to load preprogrammed guidance table data.
                                THINPT   Time history data tables read routine, THIST file (UNIT 14).
                                             TBLRD        Calls shown on separate chart.

TUSTIN   Driver for Tustin coefficient initialization
         TUSTC4       Initialize Tustin 1st order lead - 2nd order lag.
         TUSTC2       Initialize Tustin 1st order lead - 1st order lag.
         TUSTC1       Initialize Tustin 1st order lag.
         TUSTC3       Initialize Tustin 2nd order lag.
         TUSTC0       Initialize Tustin integrator.
         TUSTCS       Initialize Tustin differentiator.
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TBLRD   Main table read driver

         USRTTL       Assigns a table type to a user-defined title.
         TBTTL        Assigns a title type depending upon contents of title card.
         TBSKIP       Skips input data to new header card after an error has occured.
         TBRDVR   Reads variable names for user title.
                     GTINTR       Extracts integers from a line of text.

         ATSTVR   Stores missile aero table data in common.
         MPSTVR ¥  Stores missile mass property table variables.
         THSTVR ¥  Stores time history table variables in common.
         PPSTVR ¥  Stores missile propulsion table variables in common.
         SGSTVR ¥  Stores sensor/guidance table variables in common.
         ACSTVR ¥  Stores launch aircraft table data in common.
         TGSTVR ¥  Stores target table variables in common.
         PDSTVR ¥  Stores antenna power degradation table variables in common.
                     TBCKVR       Checks variables for invalid values.
                     USRSTV   Stores variables in user common.
                               TBCKVR       Checks variables for invalid values.

         ATRDTA   Controls reading of missile aero tables.
         MPRDTA ¥  Controls reading of missile mass property tables.
         THRDTA ¥  Controls reading of time history tables.
         PPRDTA ¥  Controls reading of missile propulsion tables.
         SGRDTA ¥  Controls reading of missile sensor/guidance tables.
         ACRDTA ¥  Controls reading of launch aircraft tables.
         TGRDTA ¥  Controls reading of target tables.
         PDRDTA ¥  Controls reading of antenna pdf tables.
                     TBDIM   Determines dimension of table and gets proper data values from file.
                               TBDTRD   Read data from file and set error flags if necessary.
                                           TBCKLN       Weeds out bad characters and leaves valid numerics.
                                           GTFFMT       Reads in free format values from a character string.
                               ERRTRA
         ATOUT   Send message to debug file about missile aero data.
         MPOUT ¥  Send message to debug file about missile mass property data.
         THOUT ¥  Send message to debug file about time history data.
         PPOUT ¥  Send message to debug file about propulsion table data.
         SGOUT ¥  Send message to debug file about missile sensor/guidance data.
         ACOUT ¥  Send message to debug file about launch aircraft data.
         TGOUT ¥  Send message to debug file about target data.
         PDOUT ¥  Send message to debug file about antenna pdf data.
                      TTLMSG       Writes data title message to debug file.
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```
FLYOUT   Single flyout driver routine
         ACINIT   Initialize AC.
                     ATMOS        Air properties at current altitude.
                     VEHTRF       Transforms body-to-reference.
                     TAB1DD       1-D table lookup and interpolation.
                     TAB2DD       2-D table lookup and interpolation.
                     MTMUL2       3 x 3 matrix multiplication
                     EULERA       Form direction cosine matrix from Euler angles.
         TGINIT   Initialize target.
                     ATMOS        Air properties at current altitude.
                     VEHTRF       Transforms body-to-reference.
                     TAB1DD       1-D table lookup and interpolation.
                     TAB2DD       2-D table lookup and interpolation.
                     MTMUL2       3 x 3 matrix multiplication
                     EULERA       Form direction cosine matrix from Euler angles.
         AIINIT   Initialize AI radar.
                     MTMUL1       Matrix-vector multiplication 3x3,3x1.
                     MTMUL2       3 x 3 matrix multiplication.
         MSINIT       Missile parameter initialization.
run
loop
    …ÕÕ
    ∫    GEOM   Calculates all relative ranges and velocities.
    ∫                MTMUL3       3 x 1 vector cross product.
    ∫                VEHTRF       Transforms body-to-reference.
    ∫    POLICY       User generated routine - sets program flags.
    ∫    FLYTGT   Top level control for target aircraft.
    ∫                Calls shown on separate chart.
    ∫    FLYAC   Top level control for launch aircraft.
    ∫                Calls shown on separate chart.
    ∫    RADAR   Top level control for AI radar.
    ∫                Calls shown on separate chart.
    ∫    LNCHML   Initializes all missile variables at missile launch time.
    ∫                EULERA       Form direction cosine matrix from Euler angles.
    ∫                MTMUL2       3 x 3 matrix multiplication
    ∫                VEHTRF       Transforms body-to-reference.
    ∫                GDINIT       Initializes guidance variables.
    ∫                APINIT       Initializes autopilot variables.
    ∫                SKINIT   Initialized missile seeker variables.
    ∫                             Calls shown on separate chart.
    ∫    THSTRY       Writes the values of any user-specified variables to a file for either printing or plotting.
    ∫    FLYMSL   Missile top level control.
    ∫                Calls shown on separate chart.
    ∫    RCDOBS       Records events in the flyout to be used as simulated observations in a reconstruction.
    ∫    GETTC        Determines whether a current flight or engagement should terminate.
    ∫    AVGDV        Computes average delta velocity during a flight.
    ∫    PCA          Computes the point of closest approach of the missile to the target at termination time.
    ∫    TRMPRT       Prints out the final conditions from an intercept.
    ∫    MXFPLE       Keeps track of FPOLE during a launch zone run and reports the maximum FPOLE range
    ∫                  and launch range.
    ∫    TSTATE   Top level integration routine for target states.
    ∫                CAINTG       Constant acceleration point mass integration.
    ∫                TRINTG       Adams-Bashforth 2nd order trapezoidal predictor integration.
    ∫                UPDAT1   Transformation matrix integration (constant rate).
    ∫                             MTMUL2       3 x 3 matrix multiplication.
    ∫                MTMUL2       3 x 3 matrix multiplication.
    ∫                EULERA       Extract Euler angles from X-form matrix.
    ∫    ASTATE   Top level integration routine for launch aircraft states.
    ∫                CAINTG       Constant acceleration point mass integration.
    ∫                TRINTG       Adams-Bashforth 2nd order trapezoidal predictor integration.
    ∫                UPDAT1   Transformation matrix integration (constant rate).
    ∫                             MTMUL2       3 x 3 matrix multiplication.
    ∫                MTMUL2       3 x 3 matrix multiplication.
    ∫                EULERA       Extract Euler angles from X-form matrix.
    »Õ   MSTATE   Top level integration routine for missile states.
                     TRINTG       Adams-Bashforth 2nd order trapezoidal predictor integration.
                     MTMUL1       Matrix-vector multiplication 3x3,3x1.
                     UPDAT2   Transformation matrix integration (constant rate).
                              MTMUL2       3 x 3 matrix multiplication.
                     UPDAT1   Transformation matrix integration (constant rate).
                              MTMUL2       3 x 3 matrix multiplication.
                     EULERA       Extract Euler angles from X-form matrix.
                     MTMUL2       3 x 3 matrix multiplication.
                     VEHTRF       Transforms body-to-reference.
                     MTMUL4       3 x 3 matrix, matrix transpose multiplication
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```
FLYOUT   Single flyout driver routine
         FLYTGT  Top level control for target aircraft.
                     ATMOS        Air properties at current altitude.
                     PROPTG   Target propulsion.
                                 TAB3DD       3-D thrust table lookup.
                     MASSTG       Target mass properties.
                     JAMMER   Initialize ground or airborne jammer beam pattern orientation.
                                 FORMDC   Form direction cosine matrix from Euler angles.
                                          MTMUL2       3 x 3 matrix multiplication.
                                 MTMUL2       3 x 3 matrix multiplication.
                     GUIDTG   Calls appropriate routine to generate target guidance commands.
                                 TGNALT       Straight and level with angle of attack.
                                 THEADG   Turn to a given heading.
                                          TGNALT       Straight and level with angle of attack.
                                 TGNGEE       Constant "g" maneuver.
                                 TSTURN   S-turn.
                                          THEADG   Turn to a given heading.
                                                       TGNALT      Straight and level with angle of attack.
                                 TLDRAG   Level drag.
                                          THEADG   Turn to a given heading.
                                                       TGNALT      Straight and level with angle of attack.
                                 TDDRAG   Decending drag.
                                          TGNGEE       Constant "g" maneuver.
                                 TLBEAM   Level beam.
                                          THEADG   Turn to a given heading.
                                                       TGNALT      Straight and level with angle of attack.
                                 TSLICE   Level slice.
                                          THEADG   Turn to a given heading.
                                                       TGNALT      Straight and level with angle of attack.
                                 TOFFST   Offset maneuver at msl launch.
                                          THEADG   Turn to a given heading.
                                                       TGNALT      Straight and level with angle of attack.
                                 TACCEL   Target acceleration maneuver.
                                          TGNALT       Straight and level with angle of attack.
                                 TGPURS       Target pursuit of launch aircraft.
                                 TTKOFF   Target takeoff maneuver sequence.
                                          TGNALT       Straight and level with angle of attack.
                                          THEADG   Turn to a given heading.
                                                       TGNALT      Straight and level with angle of attack.
                                 TLANDG   Target landing maneuver sequence.
                                           THEADG   Turn to a given heading.
                                                       TGNALT      Straight and level with angle of attack.
                                           TACCEL   Target acceleration maneuver.
                                                        TGNALT      Straight and level with angle of attack.
                     AEROTG   Aero coefficients for target aircraft.
                                 TAB1DD       1-D table lookup and interpolation.
                                 TAB2DD       2-D table lookup and interpolation.
                     TARGEQ       Determine acceleration and angular rates.
      FLYAC   Top level control for launch aircraft.
                      ATMOS        Air properties at current altitude.
                      PROPAC   Launch aircraft propulsion.
                               TAB3DD       3-D thrust table lookup.
                      MASSAC       Launch aircraft mass properties.
                      GUIDAC   Calls appropriate routine to generate launch aircraft guidance commands.
                               ACNALT       Straight and level with angle of attack.
                               AHEADG   Turn to a given heading.
                                          ACNALT       Straight and level with angle of attack.
                               ACNGEE       Constant "g" maneuver.
                               ACPURS       Launch aircraft pursuit of target.
                               AOFFST   Offset maneuver at msl launch.
                                          AHEADG   Turn to a given heading.
                                                       ACNALT      Straight and level with angle of attack.
                      AEROAC   Aero coefficients for launch aircraft.
                               TAB1DD       1-D table lookup and interpolation.
                               TAB2DD       2-D table lookup and interpolation.
                      ACFTEQ       Determine acceleration and angular rates.
```

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FLYOUT   Single flyout driver routine
         FLYMSL   Top level control for missile.
                      ATMOS        Air properties at current altitude.
                      PROPLM   Propulsion.
                               TAB1DD       1-D table lookup and interpolation.
                               TAB2DD       2-D table lookup and interpolation.
                               CHKSTG       Returns a valid stage number for a particular table.
                               TAB3DD       3-D table lookup and interpolation.
                      MASSPM   Mass properties.
                               THSTRY       Writes the values of any user-specified variables to a file
                                             for either printing or plotting.
                               TAB1DD       1-D table lookup and interpolation.
                      VEHTRC       Transforms from body axes to radar coordinates.
                      SEEKER   Various missile seeker models.
                               Calls shown on separate chart.
                      GUIDM   Calls appropriate routine to generate missile guidance commands.
                               Calls shown on separate chart.
                      CONSYS   Flight control system (controller and autopilot).
                               Calls shown on separate chart.
                      AEROM   Aero coefficients.
                               AERO3P   3-DOF pitch (other than point mass).
                               AERO3Y ¥  3-DOF yaw (other than point mass).
                                          TAB3DD       3-D table lookup and interpolation.
                                          TAB2DD       2-D table lookup and interpolation.
                                          TAB1DD       1-D table lookup and interpolation.
                               AERO5   5-DOF pitch and yaw (bottled up roll).
                                          AERO3P   3-DOF pitch (other than point mass).
                                          AERO3Y ¥  3-DOF yaw (other than point mass).
                                                     TAB3DD       3-D table lookup and interpolation.
                                                     TAB2DD       2-D table lookup and interpolation.
                                                     TAB1DD       1-D table lookup and interpolation.
                               AERO6   6-DOF pitch and yaw.
                                          AERO3P   3-DOF pitch (other than point mass).
                                          AERO3Y ¥  3-DOF yaw (other than point mass).
                                                     TAB3DD      3-D table lookup and interpolation.
                                                     TAB2DD      2-D table lookup and interpolation.
                                                     TAB1DD      1-D table lookup and interpolation.
                                          TAB1DD       1-D table lookup and interpolation.
                                          TAB2DD       2-D table lookup and interpolation.
                               AEROPM   Point mass aero.
                                          TAB2DD       2-D table lookup and interpolation.
                                          TAB1DD       1-D table lookup and interpolation.
                                          AERPMP   Modified point mass pitch (non-linear).
                                          AERPMY ¥  Modified point mass yaw (non-linear).
                                                     CHKSTG      Returns a valid stage number for a particular
                                                                 table.
                                                     TAB2DD      2-D table lookup and interpolation.
                                                     TAB3DD      3-D table lookup and interpolation.
                                                     TAB1DD      1-D table lookup and interpolation.
                                          TAB3DD       3-D table lookup and interpolation.
                               AERDRG   Axial force.
                                          CHKSTG       Returns a valid stage number for a particular table.
                                          TAB2DD       2-D table lookup and interpolation.
                                          TAB3DD       3-D table lookup and interpolation.
                                          TAB1DD       1-D table lookup and interpolation.
                               TAB2DD       2-D table lookup and interpolation.
                               TAB1DD       1-D table lookup and interpolation.
                      PMISEQ   Point mass, non-TVC, missile acceleration and angular rates.
                               MTMUL2       3 x 3 matrix multiplication.
                               EULERA       Extract Euler angles from X-form matrix.
                      MISLEQ       3-5-6 DOF, non-TVC, missile acceleration and angular rates.
                      TVCMSQ       3-5-6 DOF TVC missile acceleration and angular rates.
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FLYMSL   Top-level control for missile
         GUIDM   Missile guidance commands.
                     PKL   Pseudo kinematic link.
                                 ROTATE       Angular rotation transform.
                                 TRINTG       Adams-Bashforth 2nd order trapezoidal predictor integration.
                     PKLPNP   PKL proportional nav Pitch.
                     PNAVRP ¥  Pro-nav rate Pitch.
                     PNAVAP ¥  Pro-nav acceleration Pitch.
                     PURSTP ¥  Pursuit Pitch.
                                 TUSTN        Runtime Tustin filter routine.
                     PPPTCH   Preprogrammed guidance - follow splined alt-time profile, Pitch.
                                 RDPTCH   Read next command, Pitch.
                                           CHKSTG      Returns a valid stage number for a particular table.
                                           TAB2DD      2-D table lookup and interpolation.
                     CONALT   Constant Alt.
                     CONANP ¥  Constant angle Pitch.
                     PKLPNY ¥  PKL proportional nav Yaw.
                     PNAVRY ¥  Pro-nav rate Yaw.
                     PNAVAY ¥  Pro-nav acceleration Yaw.
                     PURSTY ¥  Pursuit Yaw.
                                 TUSTN        Runtime Tustin filter routine.
                     PPYAW   Preprogrammed guidance - follow splined alt-time profile, Yaw.
                                 RDYAW   Read next command, Yaw.
                                           CHKSTG      Returns a valid stage number for a particular table.
                                           TAB2DD      2-D table lookup and interpolation.
                     CONANY   Constant angle Yaw.
                              TUSTN        Runtime Tustin filter routine.

         SEEKER   Missile seeker.
                      SKINIT   Seeker initialization.
                               MTMUL1       Matrix-vector multiplication 3x3,3x1.
                               MTMUL2       3 x 3 matrix multiplication.
                               MTMUL3       3 x 1 vector cross product.
                               ANTENI   Establish the single and sum channel beam PDF.
                                           Calls shown on separate sheet.
                               ABCOEF   Absorbtion coefficients for radar wavelengths.
                                           GLLINT       Linear interpolation of log scale.
                               FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                               FORMDC   Form direction cosine matrix from Euler angles.
                                            MTMUL2       3 x 3 matrix multiplication.
                      MTMUL3       3 x 1 vector cross product.
                      MTMUL1       Matrix-vector multiplication 3x3,3x1.
                      MTMUL2       3 x 3 matrix multiplication.
                      TUSTN        Runtime Tustin filter routine.
                      FOVCHK       Field of view checks.
                      TRCKER   Signal strength check, sets LOS errors.
                               IRSNR   IR sensor SNR calculations.
                                           TAB1DD       1-D table lookup and interpolation.
                                           TAB2DD       2-D table lookup and interpolation.
                                           TAB3DD       3-D table lookup and interpolation.
                               MSLRDR   Detailed missile radar receiver model.
                                            Calls shown on separate sheet.
                      SGDSIG   Guidance signal output.
                               TUSTN        Runtime Tustin filter routine.
                      SKRPLT   Seeker stabilization platform model.
                                MTMUL1       Matrix-vector multiplication 3x3,3x1.
                                TUSTN        Runtime Tustin filter routine.
```

```
FLYOUT   Single flyout driver routine
         FLYMSL   Top level control for missile.
                      SEEKER   TRAP-type missile seeker.
                                SKINIT   Seeker initialization.
                                            ANTENI      Establish the single and sum channel beam PDF.


ANTENI   Establish the single and sum channel beam PDF
         OPTION   Determines what antenna parameter input option selected by user.
                     FNVALF       Decides if input string is valid illum function.
         APTRCK       Aperture area/diameter consistency checks.
         LAMBCK       Wavelength/frequency consistency checks.
         OP1OR2   User provides (1) nothing or (2) wavelength/frequency and aperture.
                     INTILF       Preliminary initialization of antenna PDF parameters.
                     FNUTHT       Function to convert an angle normalized by u = sin(theta)*dia/lambda to radians.
                     FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
         OPT3   User provides (2) and main beam.
                     INTILF       Preliminary initialization of antenna PDF parameters.
                     FNUTHT       Function to convert an angle normalized by u = sin(theta)*dia/lambda to radians.
                     FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
         OPT4   User provides lambda/f, aperture, and single beam gain and beamwidth.
                     FNUPRM       Function to normalize an angle by u = sin(theta)*dia/lambda.
                     INTILF       Preliminary initialization of antenna PDF parameters.
                     SLLEST   Returns min-max physically realizable sidelobe levels for given BW.
                                 FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                     ETAEST   Returns reasonable min-max aperture efficiency for given sidelobe level.
                                 FNRADB       Function to convert from a power ratio to dB, 10 LOG(RATIO).
                     FNPAT   Finds closest illumination function to data given.
                                 FNRADB       Function to convert from a power ratio to dB, 10 LOG(RATIO).
                     FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                     FNUTHT       Function to convert an angle normalized by u = sin(theta)*dia/lambda to radians.
         OPT5   User provides lambda/f, aperture, and sum channel gain and beamwidth.
                     FNUPRM       Function to normalize an angle by u = sin(theta)*dia/lambda.
                     FNUTHT       Function to convert an angle normalized by u = sin(theta)*dia/lambda to radians.
                     INTILF       Preliminary initialization of antenna PDF parameters.
                     SLLEST   Returns min-max physically realizable sidelobe levels for given BW.
                                 FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                     ETAEST   Returns reasonable min-max aperture efficiency for given sidelobe level.
                                 FNRADB       Function to convert from a power ratio to dB, 10 LOG(RATIO).
                     FNPAT   Finds closest illumination function to data given.
                                 FNRADB       Function to convert from a power ratio to dB, 10 LOG(RATIO).
                     FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
         OPT6   User provides lambda/f, aperture, and single beam first sidelobe level.
                     FNUPRM       Function to normalize an angle by u = sin(theta)*dia/lambda.
                     INTILF       Preliminary initialization of antenna PDF parameters.
                     SLLEST   Returns min-max physically realizable sidelobe levels for given BW.
                                 FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                     FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                     FNRADB       Function to convert from a power ratio to dB, 10 LOG(RATIO).
                     BTAETA   Gain, beamwidth, first sidelobe level checks for realism.
                                 FNRADB       Function to convert from a power ratio to dB, 10 LOG(RATIO).
                     FNPAT   Finds closest illumination function to data given.
                                 FNRADB       Function to convert from a power ratio to dB, 10 LOG(RATIO).
                     FNUTHT       Function to convert an angle normalized by u = sin(theta)*dia/lambda to radians.
         OPT7   User provides (2) and illumination function desired.
                     INTILF       Preliminary initialization of antenna PDF parameters.
                     FNUTHT       Function to convert an angle normalized by u = sin(theta)*dia/lambda to radians.
                     FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
         OPT8   User provides lambda/f, aperture, and single beam antenna gain pattern.
                     CHKSTG       Returns a valid stage number for a particular table.
                     TAB1DD       1-D table lookup and interpolation.
                     RELM1D       Find table pointers.
                     WELM1D       Find table pointers.
                     INTILF       Preliminary initialization of antenna PDF parameters.
                     TBPARM   Determine single channel antenna parameters.
                                 FNANG   Returns an angle which corresponds to the PDF level.
                                          TAB1DD      1-D table lookup and interpolation.
                                          FNBSCT   Bisection to find an "x" corresponding to a "y" value.
                                                      TAB1DD       1-D table lookup and interpolation.
                                 FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                                 FNUPRM       Function to normalize an angle by u = sin(theta)*dia/lambda.
                                 PDPARM   Scans PDF table for null angle, first sidelobe angle,
                                            first sidelobe level.
                                          FNDBRA      Function to convert from dB to a power ratio, 10**(dB/10).
                                          RELM1D      Find table pointers.
                     FNUTHT       Function to convert an angle normalized by u = sin(theta)*dia/lambda to radians.
                     ETAEST   Returns reasonable min-max aperture efficiency for given sidelobe level.
                                 FNRADB       Function to convert from a power ratio to dB, 10 LOG(RATIO).
                     SLLEST   Returns min-max physically realizable sidelobe levels for given BW.
                                  FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
         OPT9  User provides lambda/f, aperture, and sum channel antenna gain pattern.
                     OPT8         Calls shown above.
                     TAB1DD       1-D table lookup and interpolation.
                     CHKSTG       Returns a valid stage number for a particular table.
                     RELM1D       Find table pointers.
                     WELM1D       Find table pointers.
                     FNANG   Returns an angle which corresponds to the PDF level.
                                 FNBSCT   Bisection to find an "x" corresponding to a "y" value.
                                          TAB1DD       1-D table lookup and interpolation.
                                 TAB1DD       1-D table lookup and interpolation.
                     FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
                     OPT5   User provides lambda/f, aperture, and sum channel gain and beamwidth.
```

```
                        Calls shown above.
SUMMRY   Print out a summary of antenna parameters.
             FNRADB       Function to convert from a power ratio to dB, 10 LOG(RATIO).
```

```
FLYOUT   Single flyout driver routine
         FLYMSL   Top level control for missile.
                      SEEKER   TRAP-type missile seeker.
                                TRCKER   Signal strength check, sets LOS errors.
                                            MSLRDR         Detailed missile radar receiver model.



MSLRDR   Detailed missile radar receiver model
         PDFAC   Determines power degradation factor from aspect and beam pattern.
                     MTMUL1       Matrix-vector multiplication 3x3,3x1.
                     TAB1DD       1-D table lookup and interpolation.
                     MTMUL2       3 x 3 matrix multiplication
                     TAB2DD       2-D table lookup and interpolation.
         POLZEM   Determines polarization effects for emitter-to-receiver path.
                     MTMUL3       3 x 1 vector cross product.
         RCVRCS   Monostatic/bistatic radar cross section.
                     MTMUL1       Matrix-vector multiplication 3x3,3x1.
                     CHKSTG       Returns a valid stage number for a particular table.
                     TAB3DD       3-D table lookup and interpolation.
         POLZDP   Determines polarization effects for direct illuminator-tgt-receiver path.
                     PLGEOM   Polarization offset angles for illum and rcvr (or images) wrt target RCS ref.
                               MTMUL5       Matrix transpose-vector multiplication 3x3,3x1.
                               MTMUL1       Matrix-vector multiplication 3x3,3x1.
         MULTI   Spectral multipath return, illum-tgt-grnd-rcvr and illum-grnd-tgt-rcvr paths.
                     MTMUL1       Matrix-vector multiplication 3x3,3x1.
                     PDFAC   Determines power degradation factor from aspect and beam pattern.
                                MTMUL1       Matrix-vector multiplication 3x3,3x1.
                                TAB1DD       1-D table lookup and interpolation.
                                MTMUL2       3 x 3 matrix multiplication
                                TAB2DD       2-D table lookup and interpolation.
                     PLZMEM   Determines polarization effects for emitter-to-ground-to-receiver path.
                                MTMUL3       3 x 1 vector cross product.
                                RFLECT       Specular reflection coefficient model (Fresnel coefs).
                     RCVRCS   Monostatic/bistatic radar cross section.
                                MTMUL1       Matrix-vector multiplication 3x3,3x1.
                                CHKSTG       Returns a valid stage number for a particular table.
                                TAB3DD       3-D table lookup and interpolation.
                     PLZMTG   Polarization effects, illum-to-tgt-to-grnd-to-rcvr.
                                PLGEOM   Polarization offset angles for illum and rcvr (or images)
                                          wrt target RCS ref.
                                         MTMUL5       Matrix transpose-vector multiplication 3x3,3x1.
                                         MTMUL1       Matrix-vector multiplication 3x3,3x1.
                                MTMUL3       3 x 1 vector cross product.
                                RFLECT       Specular reflection coefficient model (Fresnel coefs).
                     PLZMIG   Polarization effects, illum-to-grnd-to-tgt-to-rcvr.
                               PLGEOM   Polarization offset angles for illum and rcvr (or images)
                                         wrt target RCS ref.
                                        MTMUL5       Matrix transpose-vector multiplication 3x3,3x1.
                                        MTMUL1       Matrix-vector multiplication 3x3,3x1.
                               MTMUL3       3 x 1 vector cross product.
                               RFLECT       Specular reflection coefficient model (Fresnel coefs).
         CLUTTR   Ground clutter contribution.
                      PDFAC  Determines power degradation factor from aspect and beam pattern.
                               MTMUL1       Matrix-vector multiplication 3x3,3x1.
                               TAB1DD       1-D table lookup and interpolation.
                               MTMUL2       3 x 3 matrix multiplication.
                               TAB2DD       2-D table lookup and interpolation.
                      RFLCTC   Clutter surface reflection model (empirical).
                                FNDBRA       Function to convert from dB to a power ratio, 10**(dB/10).
```

```
FLYOUT   Single flyout driver routine
         FLYMSL   Top level control for missile.
                      CONSYS       Flight control system - top level calls to controller model
                                  and appropriate autopilot.



CONSYS   Flight control system - top-level calls to controller model and appropriate autopilot
         CNTRLP   Pitch dynamics.
         CNTRLY ¥  Yaw dynamics.
                     TAB1DD       1-D table lookup and interpolation.
                     TUSTN        Runtime Tustin filter routine.
         ROLLAP       Roll dynamics.
                                  /
                       -pitch-                              -yaw-

         FNPOSP                              FNPOSY       Fin position.
         TORQUP                              TORQUY       Torque balance.
         RATEP                            RATEY   Rate commands for body rate autopilot.
                     TUSTN                              TUSTN        Runtime Tustin filter routine.
                     TAB1DD                             TAB1DD       1-D table lookup and interpolation.
         ATCONP                            ATCONY   Body attitude/thrust vector.
                     TAB1DD                             TAB1DD       1-D table lookup and interpolation.
                     TUSTN                              TUSTN        Runtime Tustin filter routine.
                     RATEP                          RATEY   Rate commands for body rate autopilot.
                               TAB1DD                             TAB1DD       1-D table lookup and
                                                                              interpolation.
                               TUSTN                              TUSTN        Runtime Tustin filter routine.
         ACEL1P                            ACEL1Y   Accelerometer control, inner rate or accel loop.
                     TUSTN                              TUSTN        Runtime Tustin filter routine.
                     TAB1DD                             TAB1DD       1-D table lookup and interpolation.
                     RATEP                          RATEY   Rate commands for body rate autopilot.
                                 TUSTN                              TUSTN        Runtime Tustin filter routine.
                                 TAB1DD                             TAB1DD       1-D table lookup and
                                                                              interpolation.
                     ACELFP                          ACELFY   Inner loop forward accel.
                               TUSTN                              TUSTN        Runtime Tustin filter routine.
                               TAB1DD                             TAB1DD       1-D table lookup and interp.
         SYNSTP                            SYNSTY   Synthetic stability autopilot, rate feedback.
                     TUSTN                              TUSTN        Runtime Tustin filter routine.
                     TAB1DD                             TAB1DD       1-D table lookup and interp.
                     SRATEP                          SRATEY   Dual body rate feedback for syn. loop.
                               TUSTN                              TUSTN        Runtime Tustin filter routine.
                               TAB1DD                             TAB1DD       1-D table lookup and interp.
                               TRINTG                             TRINTG       Trapezoidal integrator.
         ANGLCP                            ANGLCY   Angle control autopilot, inner rate loop.
                     TUSTN                              TUSTN        Runtime Tustin filter routine.
                     TAB1DD                             TAB1DD       1-D table lookup and interpolation.
                     RATEP                          RATEY   Rate commands for body rate autopilot.
                               TUSTN                              TUSTN        Runtime Tustin filter routine.
                               TAB1DD                             TAB1DD       1-D table lookup and
                                                                               interpolation.
        Ÿ
        /Ÿ
         THRUTV   Thrust vector dynamics of TV autopilot.
                     TUSTN        Runtime Tustin filter routine.
         ACTUAT   Servo dynamics, fin position.
                      TAB2DD       2-D table lookup and interpolation.
                      TUSTN        Runtime Tustin filter routine.
```

```
FLYOUT   Single  flyout driver routine
         RADAR   Top level control for airborne radar model.
                      RADGEO   Intercept geometry calculations for AI radar.
                               MTMUL1       Matrix-vector multiplication 3x3,3x1.
                               MTMUL5       Matrix transpose-vector multiplication 3x3,3x1.
                      PACRDR   Perfect (geometric) AI radar model.
                               MTMUL2       3 x 3 matrix multiplication
                               MTMUL1       Matrix-vector multiplication 3x3,3x1.
                      TAB1DD       1-D table lookup and interpolation.
                      PPLOSS       Total system losses due to atmosphere, equipment, fade margin.
                      PCLUT   AI radar clutter calculations.
                               TAB1DD       1-D table lookup and interpolation.
                      ACSNR        AI radar S/N for single pulse.
                      PDCALC   Multiple pulse probability of detection for given S/N and FAR.
                               SWERL0       Swerling case 0 (non-fluctuating).
                               SWERL1       Swerling case 1 (scan-scan fluct'ns, many ind. scatterers).
                               SWERL2       Swerling case 2 (pulse-pulse fluct'ns, many ind. scatterers).
                               SWERL3       Swerling case 3 (scan-scan fluct'ns, one main scatterer).
                               SWERL4       Swerling case 4 (pulse-pulse fluct'ns, one main scatterer).
                      RNGTRK   AI radar split gate range tracker.
                               PHDEL
                      ANGTRK       AI radar angle track error estimate.
                      ANCNTL   AI radar angle track command.
                               TUSTN        Runtime Tustin filter routine.
                      ANTMOV   AI radar antenna motion and stablilzation.
                                UPDAT1   Transformation matrix integration (constant rate).
                                         MTMUL2       3 x 3 matrix multiplication.
                                MTMUL2       3 x 3 matrix multiplication.
```

```
Low-level routines which execute calls not shown above for brevity :

TAB1DD   1-D table lookup and interpolation
TAB2DD ¥  2-D table lookup and interpolation
TAB3DD ¥  3-D table lookup and interpolation
TAB4DD ¥
         CHKSTG       Returns a valid stage number for a particular table.
         ERRTRA
         LGRNG        Linear interpolation for all table lookups.


CSTOR    Processes all character data input
         LJUST      Left justifies to first non-blank character.
                      IFRT         Finds first non-blank character.
                      ITRM         Finds the last non-blank character in a string.


ISTOR    Processes all integer data input
         RJUST      Right justifies characters within a character string.
                      ITRM         Finds the last non-blank character in a string.


RSTOR    Processes all real data input
         RJUST      Right justifies characters within a character string.
                      ITRM         Finds the last non-blank character in a string.


Routines not in the call tree :

   LAPTCH - Generates lead angle pitch guidance commands for the missile
         Calls no other routines

LAYAW  - Generates lead angle yaw guidance commands for the missile
         Calls no other routines

LOSRNG - Calculates line-of-sight related geometry parameters
         Calls MTMUL3

TPPTCH - Three point guidance in pitch
         Calls no other routines

TPYAW  - Three point guidance in yaw
         Calls no other routines

WTAP   - Computes control surface deflections for the wing tail autopilot
         Calls no other routines
```

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