# Small bug, Big bang

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http://jeanjacqueslevy.net/talks/23patrimoine/bogue.pdf

# JUNE 1996

# After explosion

in the swamps close to Kourou (Guyana)

# Investigation committee

J.-L. Lions, Gilles Kahn

- at second H+36, the inertial reference system (SRI) failed
- then abrupt veer of engines et explosion
- and rocket explosion

# Investigation committee

J.-L. Lions, Gilles Kahn

- failure is due to a software bug in SRI2:
  - Ariane 5 horizontal bias is 5 times larger than in Ariane 4
  - thus overflow of a variable in the embedded program of SRI2
  - SRI2 program stopped

$$\begin{array}{cr} & 9999999999999999 \\ + & 2 \\ \hline & 10000000000000001 \end{array}$$

$$\begin{array}{cr} & 1,23 \times 10^{16} \\ = & 12300000000000000 \end{array}$$

# Investigation committee

J.-L. Lions, Gilles Kahn

- failure is due to a software bug in SRI2:
  - Ariane 5 horizontal bias is 5 times larger than in Ariane 4
  - thus overflow of a variable in the embedded program of SRI2
  - SRI2 program stopped
- backup program in SRI1 took control:
  - as SR1 program is same as SRI2 program
  - it was also stopped for same reason as for SRI2
- without SRI, rocket has no longer good direction:
  - veer of engine nozzles
  - explosion

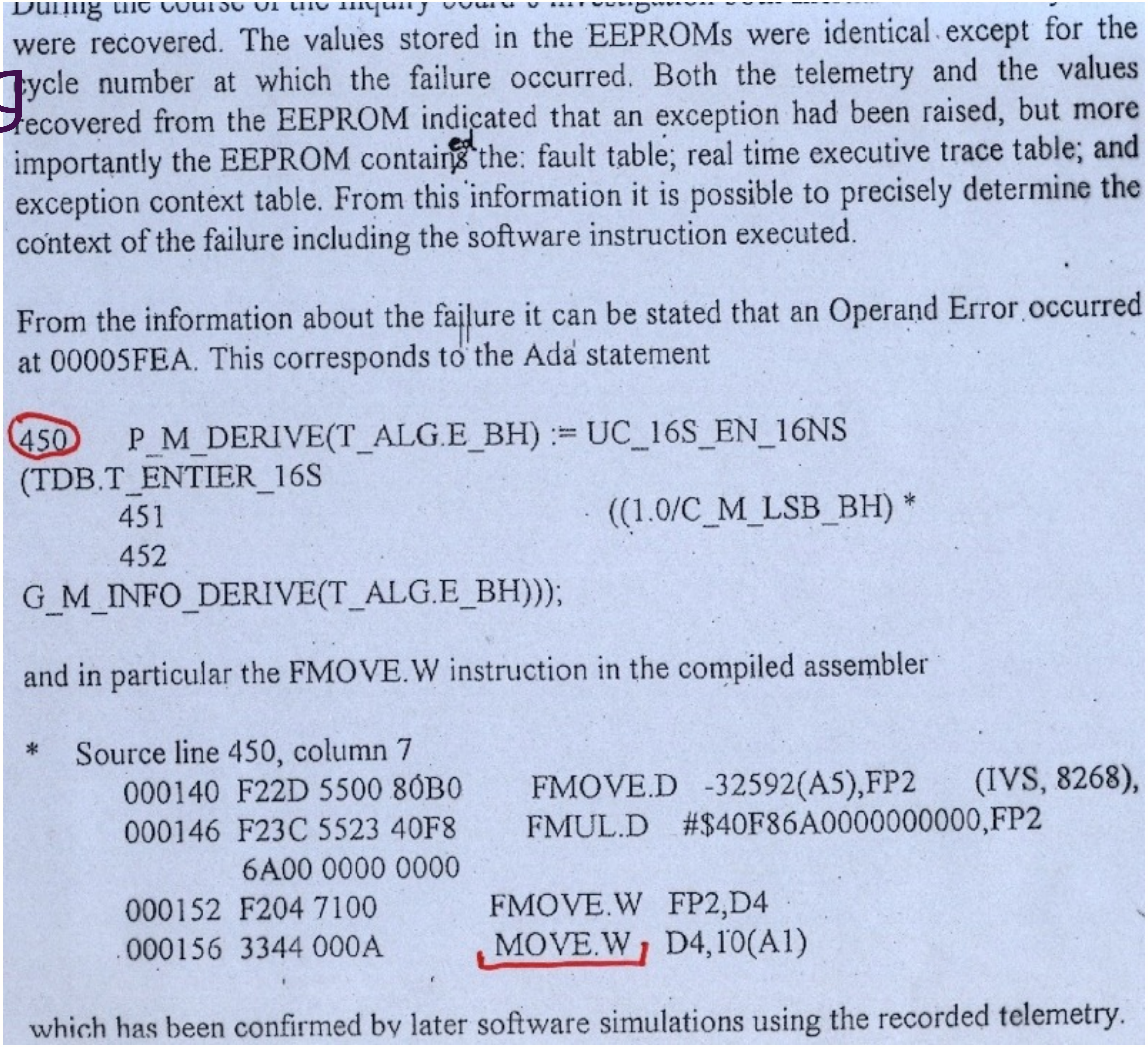
# Investigation committee

J.-L. Lions, Gilles Kahn

- the failing part of SRI program was used to re-align Ariane 4 in case of a late stop of countdown and works only until $H + 40s$
- this code was useless for Ariane 5
- but code was kept because already well tested on Ariane 4.

# Reading of PROM

Gilles Kahn,
Robert Ehrlich



During the course of the inquiry board's investigation both

were recovered. The values stored in the EEPROMs were identical except for the cycle number at which the failure occurred. Both the telemetry and the values recovered from the EEPROM indicated that an exception had been raised, but more importantly the EEPROM contai~~ns~~ed the: fault table; real time executive trace table; and exception context table. From this information it is possible to precisely determine the context of the failure including the software instruction executed.

From the information about the failure it can be stated that an Operand Error occurred at 00005FEA. This corresponds to the Ada statement

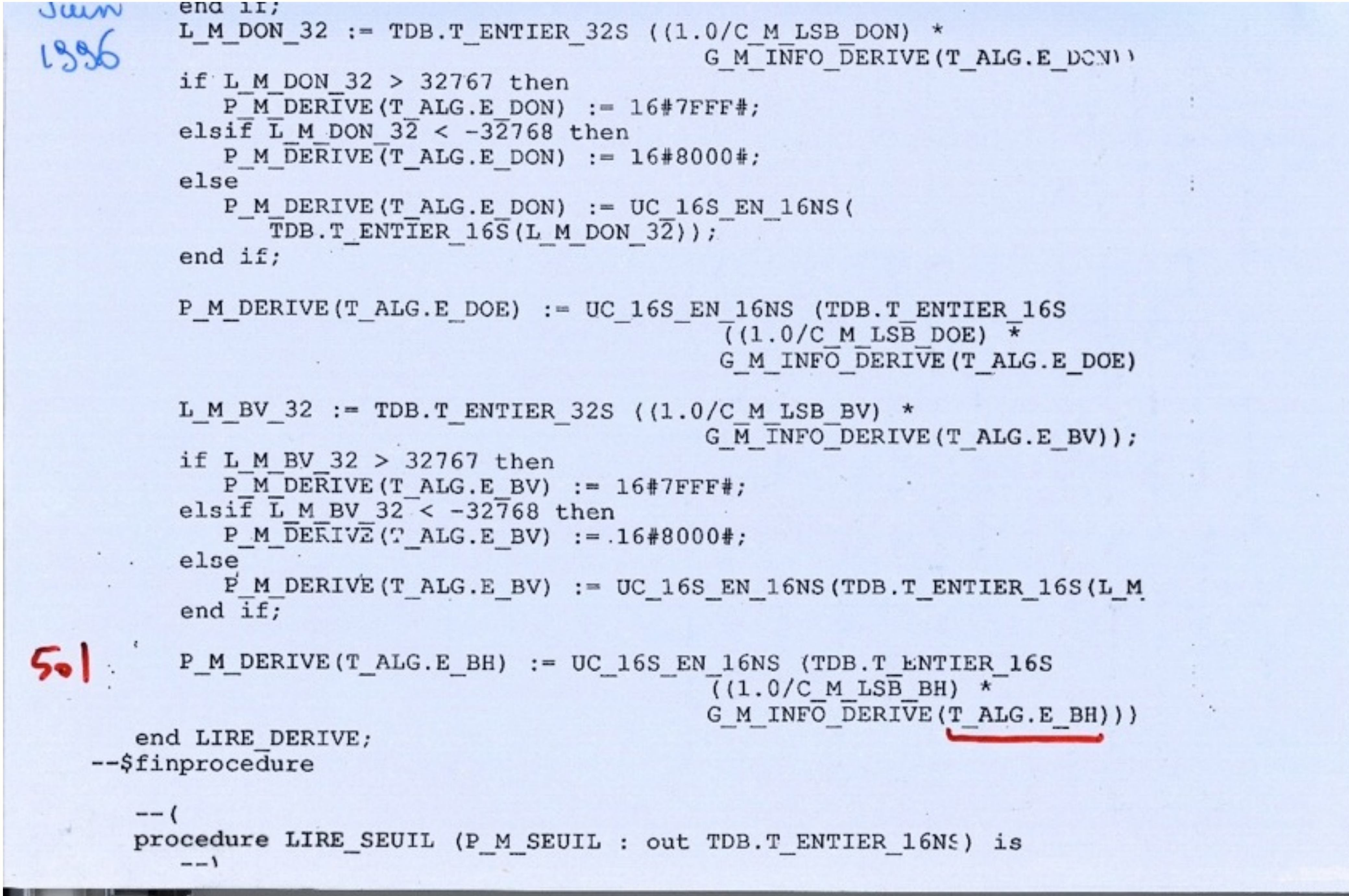
```
450     P_M_DERIVE(T_ALG.E_BH) := UC_16S_EN_16NS
(TDB.T_ENTIER_16S
        451                              ((1.0/C_M_LSB_BH) *
        452
G_M_INFO_DERIVE(T_ALG.E_BH)));
```

and in particular the FMOVE.W instruction in the compiled assembler

```
*    Source line 450, column 7
        000140  F22D 5500 80B0      FMOVE.D   -32592(A5),FP2      (IVS, 8268),
        000146  F23C 5523 40F8      FMUL.D    #$40F86A0000000000,FP2
                     6A00 0000 0000
        000152  F204 7100           FMOVE.W   FP2,D4
        000156  3344 000A           MOVE.W    D4,10(A1)
```

which has been confirmed by later software simulations using the recorded telemetry.

# The ADA code



Juin 1996

```
      end if;
      L_M_DON_32 := TDB.T_ENTIER_32S ((1.0/C_M_LSB_DON) *
                                       G_M_INFO_DERIVE(T_ALG.E_DON))
      if L_M_DON_32 > 32767 then
         P_M_DERIVE(T_ALG.E_DON) := 16#7FFF#;
      elsif L_M_DON_32 < -32768 then
         P_M_DERIVE(T_ALG.E_DON) := 16#8000#;
      else
         P_M_DERIVE(T_ALG.E_DON) := UC_16S_EN_16NS(
            TDB.T_ENTIER_16S(L_M_DON_32));
      end if;

      P_M_DERIVE(T_ALG.E_DOE) := UC_16S_EN_16NS (TDB.T_ENTIER_16S
                                        ((1.0/C_M_LSB_DOE) *
                                        G_M_INFO_DERIVE(T_ALG.E_DOE)

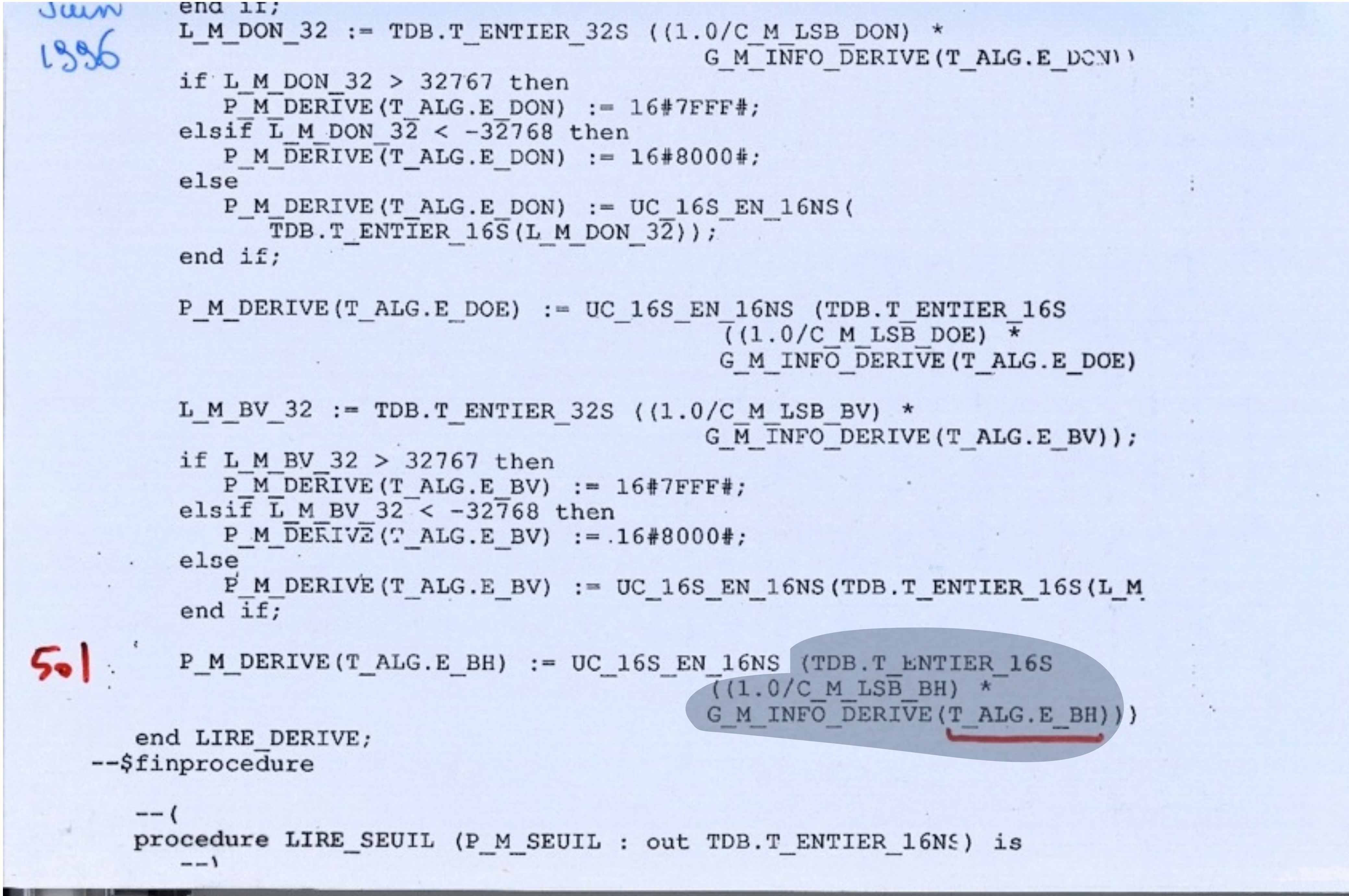
      L_M_BV_32 := TDB.T_ENTIER_32S ((1.0/C_M_LSB_BV) *
                                       G_M_INFO_DERIVE(T_ALG.E_BV));
      if L_M_BV_32 > 32767 then
         P_M_DERIVE(T_ALG.E_BV) := 16#7FFF#;
      elsif L_M_BV_32 < -32768 then
         P_M_DERIVE(T_ALG.E_BV) := 16#8000#;
      else
         P_M_DERIVE(T_ALG.E_BV) := UC_16S_EN_16NS(TDB.T_ENTIER_16S(L_M
      end if;

      P_M_DERIVE(T_ALG.E_BH) := UC_16S_EN_16NS (TDB.T_ENTIER_16S
                                       ((1.0/C_M_LSB_BH) *
                                       G_M_INFO_DERIVE(T_ALG.E_BH)))
   end LIRE_DERIVE;
--$finprocedure

   --(
   procedure LIRE_SEUIL (P_M_SEUIL : out TDB.T_ENTIER_16NS) is
     --)
```

501

# The ADA code



```
Juin     end if;
1996     L_M_DON_32 := TDB.T_ENTIER_32S ((1.0/C_M_LSB_DON) *
                                          G_M_INFO_DERIVE(T_ALG.E_DON))
         if L_M_DON_32 > 32767 then
            P_M_DERIVE(T_ALG.E_DON) := 16#7FFF#;
         elsif L_M_DON_32 < -32768 then
            P_M_DERIVE(T_ALG.E_DON) := 16#8000#;
         else
            P_M_DERIVE(T_ALG.E_DON) := UC_16S_EN_16NS(
               TDB.T_ENTIER_16S(L_M_DON_32));
         end if;

         P_M_DERIVE(T_ALG.E_DOE) := UC_16S_EN_16NS (TDB.T_ENTIER_16S
                                           ((1.0/C_M_LSB_DOE) *
                                           G_M_INFO_DERIVE(T_ALG.E_DOE)

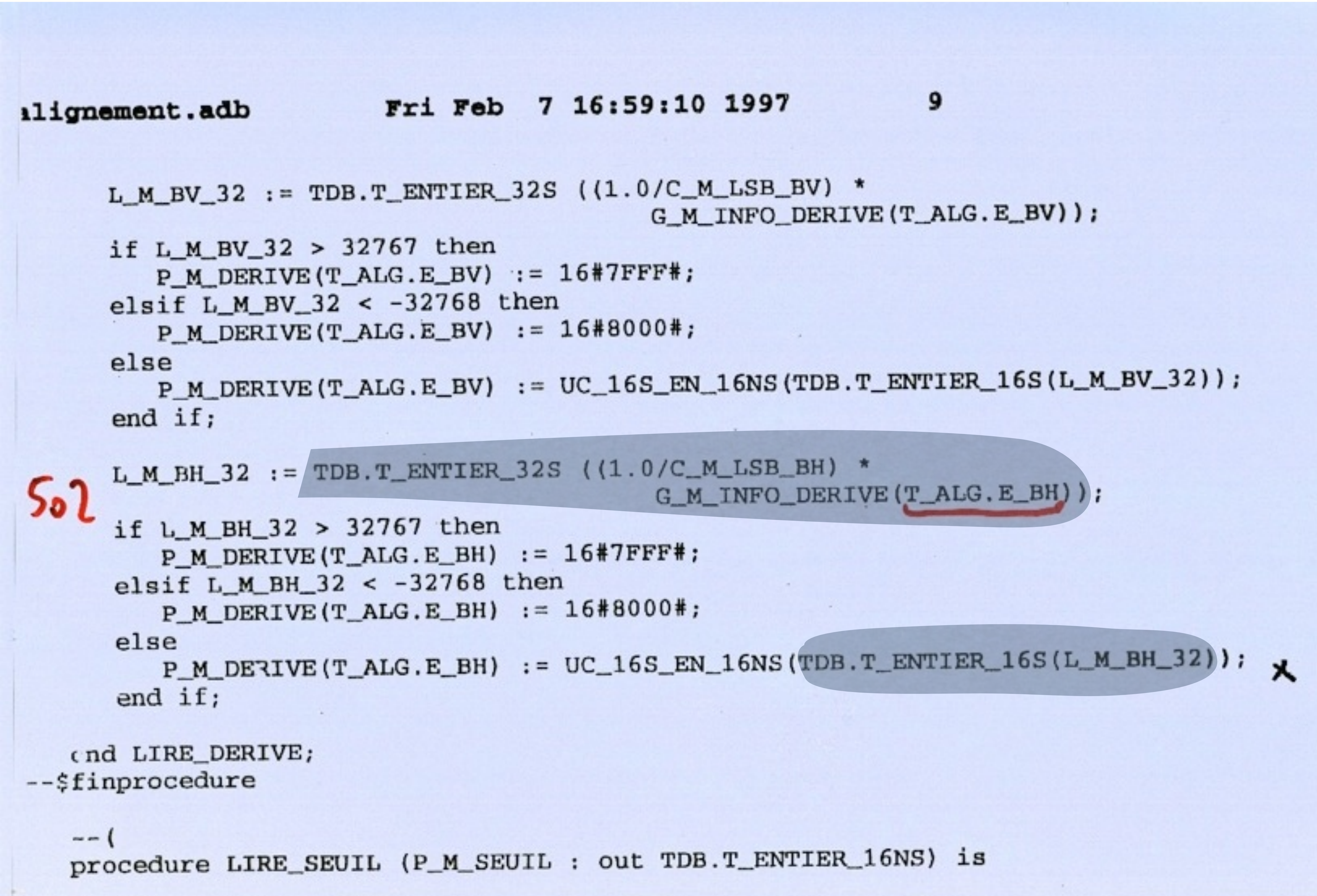
         L_M_BV_32 := TDB.T_ENTIER_32S ((1.0/C_M_LSB_BV) *
                                          G_M_INFO_DERIVE(T_ALG.E_BV));
         if L_M_BV_32 > 32767 then
            P_M_DERIVE(T_ALG.E_BV) := 16#7FFF#;
         elsif L_M_BV_32 < -32768 then
            P_M_DERIVE(T_ALG.E_BV) := 16#8000#;
         else
            P_M_DERIVE(T_ALG.E_BV) := UC_16S_EN_16NS(TDB.T_ENTIER_16S(L_M
         end if;

501      P_M_DERIVE(T_ALG.E_BH) := UC_16S_EN_16NS (TDB.T_ENTIER_16S
                                          ((1.0/C_M_LSB_BH) *
                                          G_M_INFO_DERIVE(T_ALG.E_BH)))

      end LIRE_DERIVE;
   --$finprocedure

      --(
      procedure LIRE_SEUIL (P_M_SEUIL : out TDB.T_ENTIER_16NS) is
        --)
```

# The new ADA code



```
alignement.adb          Fri Feb  7 16:59:10 1997          9

        L_M_BV_32 := TDB.T_ENTIER_32S ((1.0/C_M_LSB_BV) *
                                          G_M_INFO_DERIVE(T_ALG.E_BV));
        if L_M_BV_32 > 32767 then
            P_M_DERIVE(T_ALG.E_BV) := 16#7FFF#;
        elsif L_M_BV_32 < -32768 then
            P_M_DERIVE(T_ALG.E_BV) := 16#8000#;
        else
            P_M_DERIVE(T_ALG.E_BV) := UC_16S_EN_16NS(TDB.T_ENTIER_16S(L_M_BV_32));
        end if;

502     L_M_BH_32 := TDB.T_ENTIER_32S ((1.0/C_M_LSB_BH) *
                                          G_M_INFO_DERIVE(T_ALG.E_BH));
        if L_M_BH_32 > 32767 then
            P_M_DERIVE(T_ALG.E_BH) := 16#7FFF#;
        elsif L_M_BH_32 < -32768 then
            P_M_DERIVE(T_ALG.E_BH) := 16#8000#;
        else
            P_M_DERIVE(T_ALG.E_BH) := UC_16S_EN_16NS(TDB.T_ENTIER_16S(L_M_BH_32));
        end if;

    end LIRE_DERIVE;
--$finprocedure

    --(
    procedure LIRE_SEUIL (P_M_SEUIL : out TDB.T_ENTIER_16NS) is
```

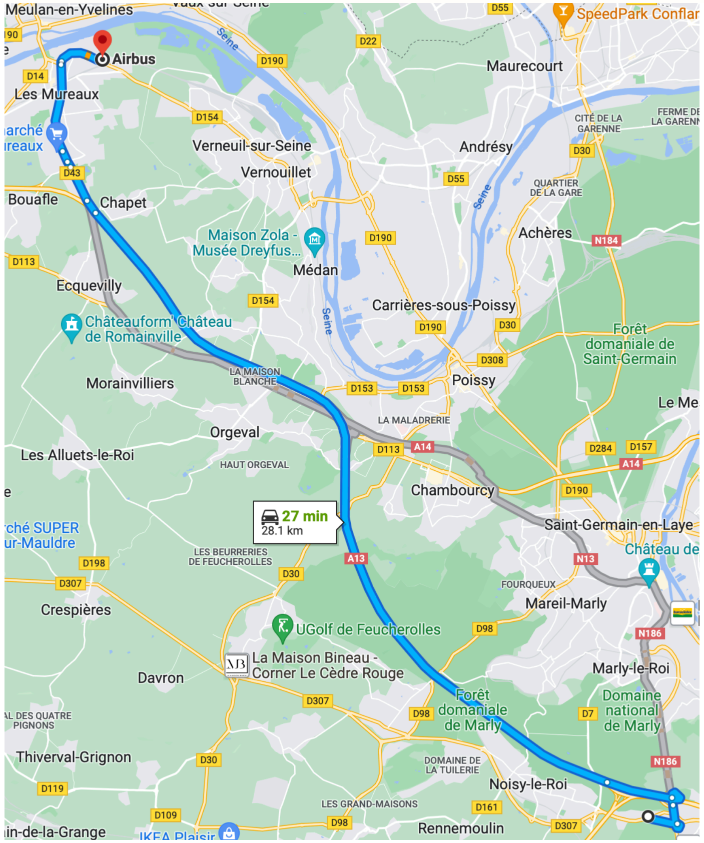
# OCTOBER 1996

Robert Ehrlich, Georges Gonthier, François Rouaix
Marcin Skubiszewski, Alain Deutsch, Damien Doligez

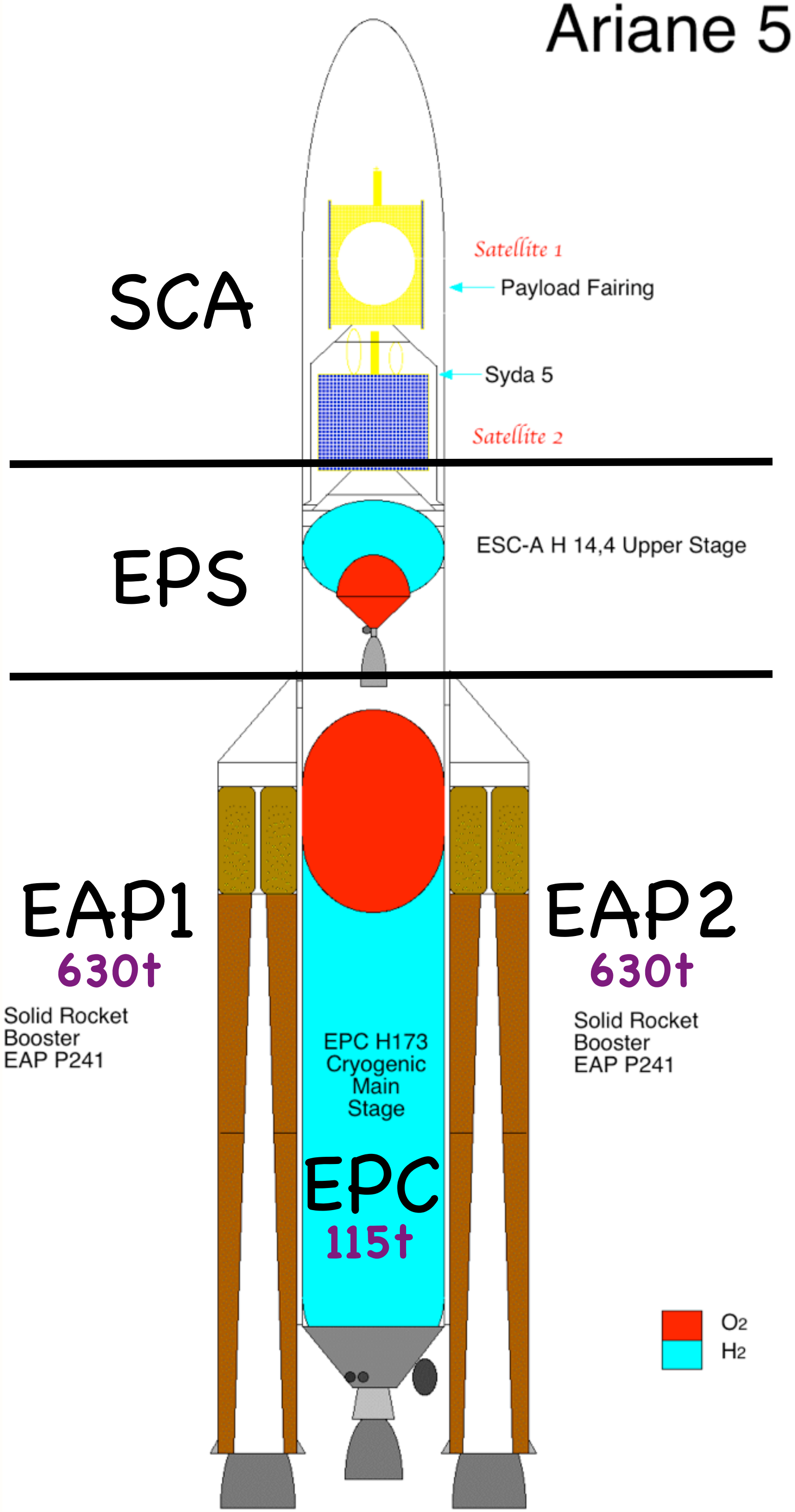
Alain Deutsch

1965 - 2006

# The  wednesday’s



# Ariane 5 ECA



SCA

Satellite 1

Payload Fairing

Syda 5

Satellite 2

EPS

ESC-A H 14,4 Upper Stage

EAP1
630t

Solid Rocket
Booster
EAP P241

EAP2
630t

Solid Rocket
Booster
EAP P241

EPC H173
Cryogenic
Main
Stage

EPC
115t

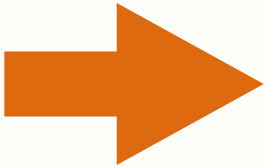
🟥 $O_2$
🟦 $H_2$

# What to do ?

- 140000 lines of ADA + assembly 68000
  - "bottom-up" analysis
  - large documentation, but rather general
- compile the code
  - to manipulate it
- 3 software modules
  - written with strict programming rules
  - multi-tasking with many shared variables

# What to do ?

- 140000 lines of ADA
  - DEC VMS + VT100’s
  - large documentation
- compile the code
  - compiler Alsys
- 3  software modules
  - written with strict coding rules
  - multi-tasking with many shared variables



tapes format
backup VMS

- 140000 lines of ADA
  - Unix + Sun 3
  - Emacs (ADA mode)
- compile the code
  - compiler GNAT (free)

```
-- ----------------------------------------------------------------------------
--
-- Project              : Ariane 5 OnBoard Software
--
-- Product              : Flight Program (LV)
--
-- Source File Name     : ACTUATORS.ADA
--
-- Source File History :
--
--          Version    Date    Version Description/Mod Number(s)    Programmer
--          --------  --------  --------------------------------    ----------
--           01.01.00  05.10.94  Initial version                      JCM,SP.
--
--           01.02.00  05.01.95  UNIT TESTS V1                        JCM,SP.
--
--           01.03.00  25.01.95   A5-FA-1811-A53: removed use of      S. Parsons
--                               COMMUNICATIONS.PUT_COMBUSTION_MESSAGE
--                               due to an incorrect and non agreed MN.
--
--                     25.01.95  A5-FA-1811-A54:                      S. Parsons
--                               EVFCVi change to FCVi due to an error
--                               in bdas
--
--           01.04.00  28-Feb-95  A5-FA-1811-A100-ASAI:                  JCM.
--                               Add of acquisitions of measures and
--                               downstream date from SRI in VARY_SPEED.
--
--                     28-Feb-95  A5-FA-1811-A95-ASAI:                   JCM.
--                               The values of the constants AZSRIN and
--                               AZSRIS must be  exchanged.
--
--           02.05.00  28.02.95  Updated to ST6.1, TA6.1, HOOD 3.1    S.Parsons,
--                              (Baseline V2.0)                        JCM.
--                       Removal of SWITCH_OFF_LVS.
--                       Incorporated Mod. note numbers :              JCM.
--                              A5-MN-1811-0039-ASAI R1
--                              A5-MN-1811-0049-ASAI R1
--                              A5-MN-1811-0050-ASAI
--                              A5-MN-1811-0054-ASAI R2
--                              A5-MN-1811-0064-ASAI R1
--
--           02.06.00  10.05.95  Updated to ST6.1, TA6.2 HOOD 3.1        OR
--                       + FMs : S042/95, S058/95 (Baseline V2.1)        JCM.
--                       Incorporated Mod. note numbers :
--                              A5-MN-1811-1143-EASM,
--                              A5-MN-1811-1146-EASM,
--                              A5-MN-1811-1149-EASM
--
--           02.07.00  29.05.95  Idem                                 JCM.
--
--           02.08.00  10.06.95  Idem                                 JCM.
--
--           02.09.00  21.07.95  BASELINE V2.1 - Correction of NCR-339-ASAI :
--                       Add of the reset of out indicators in
--                       SCA_AUTOPILOT procedure.                     JCM.
--
--           03.10.00  31.10.95  Baseline V3.3                        JCM.
```

```
--                        Implementation of A5-MN-1811-1196-EASM :
--                        Add call to COMMUNICATIONS.SET_CYCLIC_OPERATION_ON
--                        just after the begin statement of procedures
--                         VARY_SPEED and SCA_AUTOPILOT.
--
--           03.11.00  08.11.95 Baseline V-3.3 - Unit Tested (part.)     JCM
--
--           03.12.00  17.11.95  Baseline V3.4                           JCM.
--                       - Implementation of FM-S221/95 :
--                        Add call of procedure REINIT_SCA_VALVES.
--                       - Implementation of A5-MN-1811-1220-EASM (NCR-564) :
--                        remove the GET_FUEL_MASS function.
--
--           03.13.00  29.11.95  Baseline V3.4                           JCM.
--                       - Implementation of MN-2017 : Add the assignment
--                        of OLD_IOUVLV at the beginning of the SCA_AUTOPILOT
--                        algorithm.
--
--          04.14.00  12.01.96  A5-MN-1811-1234-EASM : replacement   O. Rigaud
--                              of ACTUATORS_MISSION_DATA.AZSRI[N|S]
--                              by FLIGHT_MISSION_DATA.AZSRI[N|S]
--          05.15.00  31.07.96  FM S345/96 : computation of          O. Rigaud
--                              TALLUEPS global variable according
--                              to flight phase, before SCA
--                              autopilot execution
--   OMLVN  05.16.00  16.10.96  A5-MN-1811-1274-EASM,
--                              A5-FA-1811-945-ASAI,
--                              A5-FA-1811-947-ASAI : addition of    O. Rigaud
--                              GET_PAYLOAD_RELEASE_NUMBER function
--
-- Constituent Program Units : 8
--
--      INITIALISE
--      PERFORM_ROLL
--      SCA_AUTOPILOT
--      VARY_SPEED
--      CHECK_VALVES
--      COMMAND_VALVES
--      SHORT_EPS_IGNITION_AUTHORISED
--      GET_PAYLOAD_RELEASE_NUMBER
--
--  Source File Description :
--
--     ACTUATORS shall calculate roll commands which are sent to the actuators
--     as a series of FCVi and SCA LV on/off commands. It shall also verify
--     the operation of the FCVi and SCA LVs and take the appropriate
--     recovery actions.
--     The resultant recovery actions shall be made available to the caller.
--
--     ACTUATORS shall generate roll commands for the EPC, EPS and SCA flight
--     phases. For the SCA phase it will manage the variation of the speed and
--     allow the fuel mass to be obtained.
--
-- Portability Considerations :
--
--      NONE.
--
-- Subprogram Mapping :
```

```
--
-- Source Name                 Specification Name                Fortran Model
-- -----------                 ------------------                -------------
--
--  INITIALISE               PRESENTER VALEUR INITIALES CON-      INSCAR
--                           -TROLE EN ROULIS (M22551)
--                           INITIALISER CONTROLE EN ROULIS       INSCAR
--                           (M22552)
--                           REINITIALISER PARAMETRES SCA        SCABAL
--                           (M2261)
--
--  PERFORM_ROLL             CONTROLER LE ROULIS EN PHASE        SCAROUL
--                           EPC/EPS (M22553)
--
--  SCA_AUTOPILOT            REGLER PILOTAGE SCA (M2263)         SCABAL
--
--  VARY_SPEED               CONTROLER LES VARIATIONS DE         SCABAL
--                           VITESSE (M2262)
--
--  CHECK_VALVES             COMMANDER/CONTROLER LES EV          N/A
--                           DU SCA (M22556)
--
--  COMMAND_VALVES           COMMANDER/CONTROLER LES EV          N/A
--                           DU SCA (M22556)
--
--  SHORT_EPS_IGNITION_      N/A                                 N/A
--  AUTHORISED
--
--  GET_PAYLOAD_RELEASE      N/A                                 N/A
```

```
    -- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    --
    -- FUNCTIONAL DESCRIPTION:
    --
    --   Initialises, or reinitialises, the parameters for each beginning of a
    --   new flight phase (EPC, EPS, SCAi).
    --   (see PM A5-MN-1811-0037-ASAI)
    --
    -- --
    procedure INITIALISE is separate;
    -- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

    -- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    --
    -- FUNCTIONAL DESCRIPTION:
    --
    -- Activates the roll control calculations and sends the calculated
    -- roll commands to the actuators.
    --
    -- --
    procedure PERFORM_ROLL is separate;
    -- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

    -- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    --
    -- FUNCTIONAL DESCRIPTION:
    --
    -- Performs the autopilot during the SCA phase and
    -- calculates SCA commands for the actuators.
```

```
            ACTUATORS_INTERNAL.CALCULATE_TBURN;

            if ACTUATORS_INTERNAL.FIRST then
                ACTUATORS_INTERNAL.FIRST := false;
            end if;

        end if;

        -- To update the digital message

        COMMUNICATIONS.PUT_SCA_AUTOPILOT_2_MESSAGE
           (MESSAGE =>
               (DTOUV   => ACTUATORS_INTERNAL.TBURN_TAB,
                PMASS1V => ACTUATORS_INTERNAL.PMASS,
                ANOMAL  => ACTUATORS_INTYPES.NOZZLE_FAILURE_TYPE'pos
                              (ACTUATORS_INTERNAL.ANOMAL),
                CASEI   => ACTUATORS_INTERNAL.PILOT_MODE,
                IANOM   => COMMUNICATIONS_TYPES.IANOM_TYPE
                              (ACTUATORS_INTERNAL.IANOM),
                ITEST   => ACTUATORS_INTYPES.FAILURE_TYPE'pos
                              (ACTUATORS_INTERNAL.ITEST)));

        COMMUNICATIONS.PUT_SCA_AUTOPILOT_1_MESSAGE
           (MESSAGE =>
               (STATE   => ACTUATORS_INTERNAL.STATE_VCT,
                UNBAL_2 => ACTUATORS_INTERNAL.UNBAL (2),
                UNBAL_3 => ACTUATORS_INTERNAL.UNBAL (3),
                DVFIL   => ACTUATORS_INTERNAL.DVFIL,
                QS      => ACTUATORS_INTERNAL.QS,
                RATES   => ACTUATORS_INTERNAL.ROLL_RATES));

        -- Output parameters :
        RESET_UCTM_REQUIRED := ACTUATORS_INTERNAL.RESET_UCTM_TO_REQUIRE;
        PAYLOAD_RELEASE_REQUIRED :=
           ACTUATORS_INTERNAL.RELEASE_PAYLOAD_INDICATOR;
        STOP_PROCESSING_SCA := ACTUATORS_INTERNAL.FLPASC;

        -- To reset the indicators :
        ACTUATORS_INTERNAL.RESET_UCTM_TO_REQUIRE     := false;
        ACTUATORS_INTERNAL.RELEASE_PAYLOAD_INDICATOR := false;
        ACTUATORS_INTERNAL.FLPASC                    := false;

    end SCA_AUTOPILOT;
    -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

```
        COMMUNICATIONS.SET_CYCLIC_OPERATION_ON (
            NAME => COMMUNICATIONS_TYPES.TRAJ_CONTROL_SCA_SPEED_ACTIVATED);

        -- To check variations of speed :
        -- -----------------------------
        -- Initialisation of roll component of accelerometric increment
        ACTUATORS_INTERNAL.X_ACCEL_INCREMENT :=
           SRI.GET_ACCEL_INCREMENT_IN_X_AXIS;

        -- Acquisition date
        ACTUATORS_INTERNAL.DOWNSTREAM_DATE := SRI.GET_DOWNSTREAM_DATE;
        -- SRI validity
        ACTUATORS_INTERNAL.NUMSRI          := SRI.GET_VALIDITY;

        -- Check of SRI switch :
        if ACTUATORS_INTERNAL.NUMSRI /= ACTUATORS_INTERNAL.NUMSRIP and then
           ACTUATORS_INTERNAL.NUMSRI  = FLIGHT_TYPES.BACKUP_ONLY
        then

            ACTUATORS_INTERNAL.FIRST      := true;
            ACTUATORS_INTERNAL.VXBIAS     :=
               ACTUATORS_INTERNAL.VXBIAS +
               ( ACTUATORS_INTERNAL.X_ACCEL_INCREMENT -
                 ACTUATORS_INTERNAL.VXMOLD );
            ACTUATORS_INTERNAL.COS_AZSRI  :=
               UNIVERSAL.COS (FLIGHT_MISSION_DATA.AZSRIS);
            ACTUATORS_INTERNAL.SIN_AZSRI  :=
               UNIVERSAL.SIN (FLIGHT_MISSION_DATA.AZSRIS);
            ACTUATORS_INTERNAL.NUMSRIP    := ACTUATORS_INTERNAL.NUMSRI;

        end if;

        -- Check of speed and saving of date and value if any change appeared :
        if ACTUATORS_INTERNAL.X_ACCEL_INCREMENT /= ACTUATORS_INTERNAL.VXMOLD
        then

            ACTUATORS_INTERNAL.DVSKIP := ACTUATORS_INTERNAL.DOWNSTREAM_DATE;
            ACTUATORS_INTERNAL.VXMOLD := ACTUATORS_INTERNAL.X_ACCEL_INCREMENT;

        end if;

    end VARY_SPEED;
    -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

    -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

```
    --
    -- FUNCTIONAL DESCRIPTION:
    --
    -- Performs a check on the current status of the valves.
    -- The check shall be made with respect to sent commands and recovery
    -- action shall be taken. The status of the ESs shall be indicated
    -- to the caller.
    -- The status has no meaning on each call after SCA_AUTOPILOT
    -- and therefore should not be checked.
    --
    -- FORMAL PARAMETERS:
    --
    --      Return parameter : Status of the ESs, as returned by LN2 level.
    --
    -- --
    function CHECK_VALVES
       return FLIGHT_TYPES.ELECTRO_SOLENOID_STATUS_TYPE is separate;
    -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

    -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    --
    -- FUNCTIONAL DESCRIPTION:
    --
    -- Sends the commands to open and close the actuators.
    -- These commands have been previously calculated by the roll control and
    -- sca autopilot algorithms.
    --
    -- --
    procedure COMMAND_VALVES is separate;
    -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

    -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    --
    -- FUNCTIONAL DESCRIPTION:
    --
    -- Returns the authorisation state of the short eps ignition.
    --  ST variable 'xreals'.
    --
    -- --
    function SHORT_EPS_IGNITION_AUTHORISED return BOOLEAN is

    begin

        return ACTUATORS_INTERNAL.XREALS;
```

```
    begin

        return ACTUATORS_INTERNAL.PAYLOAD_NBR;

    end GET_PAYLOAD_RELEASE_NUMBER;
    -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


end ACTUATORS;
```

```
-- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

-- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
-- FUNCTIONAL DESCRIPTION:
--
--      This function allows to calculate the quaternion error.
--
-- FORMAL PARAMETERS:
--
--      A : First quaternion
--      B : Second quaternion
--
-- DESIGN:
--
--      The error is calculate by multiplying the first quaternion by
--      the inversion of the second quaternion
--
-- [optional subprogram tags]
-- RETURN VALUE:
--
--      The quaternion error.
--
-- --
function CALC_QUATERNION_ERROR
   ( A : in FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE;
     B : in FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE )
   return FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE is

    INVERTED_QUATERNION :
       FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE := (others => 0.0);
    QUATERNION_ERROR    :
       FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE := (others => 0.0);

begin
    -- To build the negative quaternion :
    for I in 1 .. FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE'last - 1
    loop
        INVERTED_QUATERNION (I) := -(B (I));
    end loop;

    INVERTED_QUATERNION (FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE'last) :=
      B (FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE'last);

    -- Multiply the quaternions :
```

```
-- ---------------------------------------------------------------------------
--
-- Project              : Ariane 5 OnBoard Software
--
-- Product              : Flight Program (LV)
--
-- Source File Name     : ACTUATORS_UTILITIES_.ADA
--
-- Source File History :
--
--          Version     Date     Version Description/Mod Number(s)  Programmer
--          --------  --------  ---------------------------------  ----------
--          00.00.01  05.10.94  Initial version                       JCM
--
--          00.00.02  01.02.95  Update to ST 6.1, coding standards   S. Parsons
--
--          02.03.00  22.05.95  Idem                                   JCM.
--
--          02.04.00  10.06.95  Idem (Baseline V2.1).                  JCM.
--
--
-- Constituent Program Units : 5
--
-- MTXMUL_GEN
-- LIMIT
-- CALC_ANGULAR_VELOCITY
-- MULTIPLY_QUATERNIONS
-- CALC_QATERNION_ERROR
--
--  Source File Description :
--
-- This package contains some usefull operations and utilities for ACTUATORS
-- functionnalities.
--
-- Portability Considerations :
--
-- {tbs}
--
-- Subprogram Mapping :
--
-- Source Name                 Specification Name              Fortran Model
-- -----------                 ------------------              -------------
--
-- MTXMUL_GEN                  N/A                             N/A
-- LIMIT                       LIMITER SYMETRIQUEMENT LES      Unknown
--                             ENTREES(M22644)
```

```
package ACTUATORS_UTILITIES is

   -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
   -- FUNCTIONAL DESCRIPTION:
   --
   --      This function performs a matrix vector multiplication .
   --
   -- FORMAL PARAMETERS:
   --
   --      M : input matrix.
   --      V : input vector.
   --
   -- RETURN VALUE:
   --       output vector.
   --
   -- --
   generic

       type ITEM_TYPE is private;
       NULL_ITEM : ITEM_TYPE;

       type FIRST_INDEX_TYPE is range <>;
       type SECOND_INDEX_TYPE is range <>;

       type MATRIX_TYPE is array (FIRST_INDEX_TYPE, SECOND_INDEX_TYPE) of
          ITEM_TYPE;
       type IN_VECTOR_TYPE is array (SECOND_INDEX_TYPE) of ITEM_TYPE;
       type OUT_VECTOR_TYPE is array (FIRST_INDEX_TYPE) of ITEM_TYPE;

       with function "*" (X, Y : ITEM_TYPE) return ITEM_TYPE is <>;
       with function "+" (X, Y : ITEM_TYPE) return ITEM_TYPE is <>;

   function MTXMUL_GEN
      ( M : in MATRIX_TYPE;
        V : in IN_VECTOR_TYPE) return OUT_VECTOR_TYPE;
   -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


   -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
   procedure CALC_ANGULAR_VELOCITY
      (FAILURE : in ACTUATORS_INTYPES.FAILURE_TYPE);
   -- +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

    -- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    -- FUNCTIONAL DESCRIPTION:
    --
    --
    --      A : First quaternion
    --      B : Second quaternion
    --
    -- DESIGN:
    --
    --      The error is calculate by multiplying the first quaternion by
    --      the inversion of the second quaternion
    --
    -- RETURN VALUE:
    --
    --      The quaternion error.
    --
    -- --
    function CALC_QUATERNION_ERROR
      ( A : in FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE;
        B : in FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE )
       return FLIGHT_TYPES.ARRAY_1_4_FLOAT_TYPE;
   -- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

   -- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
   -- FUNCTIONAL DESCRIPTION:
   --
   -- This function allows to limit the input value (X) to the limit (LIMIT).
   --
   -- FORMAL PARAMETERS:
   --
   --      X : FLOAT input value
   --      LIMIT : Limit, has to be positive
   --
   -- RETURN VALUE:
   --
   --      clipped value of the parameter
   --
   -- --
   function LIMIT
     ( X      : in FLIGHT_TYPES.FLOAT_TYPE;
       XLIMIT : in FLIGHT_TYPES.FLOAT_TYPE )
     return FLIGHT_TYPES.FLOAT_TYPE;
   -- ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

end ACTUATORS_UTILITIES;
```

```
-- Project Name        : Ariane 5 OnBoard Software - Flight Program (LV)
--
-- Source File Name    : ACYCLIC1.ADA
--
-- Source File History :
--
--          Version    Date    Version Description/Mod Number(s)  Programmer
--          --------  --------  --------------------------------  ----------
--          00.01     25.10.94    Initial Version                  PCB
--          00.02     18.11.94    Mod Note 1041,1063               PCB
--          00.03     12.12.94    communications.process_it_bf     PCB
--          00.04     23.02.95    Mod Note 1077                    SJH
--          00.05     23.02.95    Mod Note 1077 correction         SJH
--          00.06     07.03.95    Mod Note 1076                    VT
--                                Also updated for UT purposes
--                                by creating an ACYCLIC1_INTERNAL
--                                package.
--          00.07     31.03.95    Updated in line with MN 1135.    VT
--          00.08     26.04.95    Updated in line with MN 1136.    VT
--          00.09     15.05.95    Correct header and correct       SJH
--                                Mod Note 1136.
--          00.10     19.06.95    NCR 138 incorporated             SJH
--          00.11     10.08.95    Implement the MN 1170            A. Peres
--                                and MN 1148, 1076
--          00.12     25.08.95    Add call to PHASE.SET (MN 1104)
--                                in SET_EAP_IGNITION              P. Bricker
--          00.13     29.08.95    Add OBC1 guard on IGNITE_VULCAIN
--                                and PREPARE_EAP_IGNITION (NCR 437),
--                                and add EAPs ignited guard on
--                                DISCONNECT_EPC_ES (NCR 300)      P. Bricker
--          00.14     23.11.95    Add call to
--                                PROPULSION.SWITCH_EPC_TO_FLIGHT_MODE
--                                in SET_EAP_IGNITION (NCR 568)    P. Bricker
--
--  OMLVN   00.15     05.01.96  Add call to LAUNCHER.INHIBIT_OBC_SWITCH     JCM
--                              in SET_EAP_IGNITION in order to perform
--                              OBC switch inhibition the same way on
--                              both OBCs. FM-S237/95.
--                              Operation OBC_IS now belongs to COMMUNICATIONS,
--                              according to MN-1234.
--
--
--
--
--  Source File Description :
```

```
--
--    Package body for the object ACYCLIC1
--
-- Target Dependencies :
--
--    None
--
-- Subprogram Mapping :
--
-- Source Name                Specification Name            Fortran Model
-- -----------                ------------------            -------------
--
-- ACYCLIC1.ADA
--                            M211 (Partially)                None
--
-- ----------------------------------------------------------------------------
--
--H Ada package body for object ACYCLIC1
--H Generated by HOOD Toolset at 18:48:02_on_22-09-1994

--H OBJECT ACYCLIC1 IS ACTIVE


--H REQUIRED INTERFACE
With ACYCLIC1_INTERNAL;
with TRAJECTORY_TYPES;
with COMMUNICATIONS;
with COMMUNICATIONS_TYPES;
with PROPULSION;
with ACYCLIC2;
with PHASE;
with PHASE_TYPES;
With LN1;
With LN1_TYPES;
with LAUNCHER;

Package Body ACYCLIC1 Is


   -- Renames of operation in order to improve readibility :
   function "=" (LEFT, RIGHT : COMMUNICATIONS_TYPES.OBC_TYPE) return BOOLEAN
      renames COMMUNICATIONS_TYPES."=";

-- PROVIDED OPERATIONS
```

```
    -- DESCRIPTION
    -- This procedure stops the DASDC message being sent and causes
    -- the activation of the SRI release sequence.
        RC : LN1_TYPES.RC_T;
    Begin
        -- Stop the 72 ms delay for sending the DASDC messages.
        LN1.T10_STOP_SUSPENDED_DELAY ( TASK_ID => ACYCLIC1_INTERNAL.ACYCLIC1_TASK_
                                       RC => RC);
    End ACTIVATE_SRI;


    Procedure IGNITE_VULCAIN Is
    -- DESCRIPTION
    --  Allows the Vulcain ignition sequence to be activated.
    Begin

       if COMMUNICATIONS.OBC_IS = COMMUNICATIONS_TYPES.OBC1 then
          ACYCLIC1_INTERNAL.OBCS.IGNITE_VULCAIN;
       end if;

    End IGNITE_VULCAIN;


    Procedure PREPARE_EAP_IGNITION Is
    -- DESCRIPTION
    --  Allows EAP ignition
    begin

       if COMMUNICATIONS.OBC_IS = COMMUNICATIONS_TYPES.OBC1 then
          ACYCLIC1_INTERNAL.OBCS.EAP_PRE_IGNITION;
       end if;

    End PREPARE_EAP_IGNITION;


    procedure SET_EAP_IGNITION  is
    -- DESCRIPTION
    -- This operation is to be called on the redundant OBC following
    -- the observation of the CEX closure during the EAP ignition
    -- window,
    -- or when the EAPs have been ignited in the nominal OBC.
    -- Performs also the inhibition of the OBC switch as soon
    -- as were are in flight : called by ACYCLIC2 if OBC is BC
    -- and by EXECUTIVE if OBC is RT.
    begin
```

```
          --
          ACYCLIC1_INTERNAL.ES_TO_BE_DISCONNECTED := ES;

          select
              ACYCLIC1_INTERNAL.OBCS.DISCONNECT_EPC_ES;
          else
              ACYCLIC1_INTERNAL.EPC_ES_DISCONNECTION_REQUESTED := TRUE;
          end select;

       else

          -- EAPs have not yet ignited, ACYCLIC2 performs the
          -- DISCONNECT_EPC_ES.
          ACYCLIC2.DISCONNECT_EPC_ES(ES => ES);

       end if;

   End DISCONNECT_EPC_ES;

   Procedure DISCONNECT_CASE_ES (ES : In PROPULSION_TYPES.ES_TYPE) Is
   -- DESCRIPTION
   --    Allows the CASE  electrical system disconnection sequence to be
   --    activated
   begin
       ACYCLIC1_INTERNAL.ES_TO_BE_DISCONNECTED := ES;
       select
           ACYCLIC1_INTERNAL.OBCS.DISCONNECT_CASE_ES;
       else
           ACYCLIC1_INTERNAL.CASE_ES_DISCONNECTION_REQUESTED := TRUE;
       end select;
   End DISCONNECT_CASE_ES;

   Procedure COMMUTE Is
   -- DESCRIPTION
   -- This operation should not exist????
   Begin
       ACYCLIC1_INTERNAL.OBCS.COMMUTE;
   End COMMUTE;

   Procedure COMMUTE_EPE (FAILED_AXIS : in TRAJECTORY_TYPES.JACK_AXIS_TYPE) Is
   -- DESCRIPTION
   -- This operation activates the entry point COMMUTE_EPE in
   -- task OBCS.
   Begin
```

```
     begin
        return ACYCLIC1_INTERNAL.FRAME_STARTED_IN_OBC2 ;
     end FRAME_STARTED_BY_OBC2 ;


     function EAPS_HAVE_IGNITED return BOOLEAN is
     -- DESCRIPTION
     -- This operation is to return TRUE when it has detected that
     -- the EAP booster engines have ignited
     --
     begin
        return ACYCLIC1_INTERNAL.EAPS_IGNITED ;
     end EAPS_HAVE_IGNITED ;


End ACYCLIC1;
```

```
--H Ada package specification for object ACYCLIC1
--H Generated by HOOD Toolset on 07:51:00_on_21-09-1994

--H OBJECT ACYCLIC1 IS ACTIVE
--H DESCRIPTION
--H     \fC
--H     --|-----------------------------------------------------------------
--H     --
--H     --   Project Name:   Ariane 5 OnBoard Software - PV
--H     --
--H     --   Object Name:    ACYCLIC1
--H     --
--H     --   Object History:
--H     --
--H     --   Version    Date    Version Description/Mod Number(s)  Designer
--H     --   -------  --------  --------------------------------  --------
--H     --    00.00   19.09.94  5.1.                              AJB
--H     --    00.01   15.02.95  ST6.1.1 Modifications :-          A.J.Hatwell
--H     --                      Mod Note 1076, new SET_EAP_IGNITION
--H     --                      procedure.
--H     --    00.02   26.04.95  Updated in line with MN 1136.     V.Tailor
--H     --    00.03   02.08.95  Updated as per
--H     --                      A5-MN-1811-1170-EASM              C.Jones
--H     --    00.04   04.08.95  Updated as per
--H     --                      A5-MN-1811-1076-EASM-R3
--H     --                      A5-MN-1811-1148-EASM              C.Jones
--H     --
--H     -----------------------------------------------------------------|--
--H
--H     ACYCLIC1 shall allow the SRI release sequence to be activated from the
--H     operation ACTIVATE_SRI.
--H
--H     The Vulcain may be ignited via the operation IGNITE_VULCAIN. The date of
--H     ignition shall be obtained from DATE and the sequence activated. If the
--H     sequence is successful the EAPs may then be ignited otherwise the Vulcain
--H     shall be stopped (via ACYCLIC2).
--H
--H     As described above once the Vulcain has been correctly ignited the EAP
--H     ignition sequence may be activated via the operation PREPARE_EAP_IGNITION.
--H     This operation activates the EAP pre-ignition sequence. If the EAP
--H     pre-ignition is succuessful ACYCLIC1 shall suspend until just before the
--H     EAP ignition is activated, it shall then activate the EAP ignition sequenc
--H     (via ACYCLIC2) otherwise the Vulcain stop sequence shall be activated.
--H
--H     Once the EAPs are ignited one may only disconnect the CASE or EPC electric
--H     systems via the operations DISCONNECT_CASE_ES and DISCONNECT_EPC_ES. If
```

```
--H
--H
--H     \fP
--H IMPLEMENTATION AND SYNCHRONISATION CONSTRAINTS
--H   NONE
with PROPULSION_TYPES;
with TRAJECTORY_TYPES;
package ACYCLIC1 is
    --H PROVIDES OPERATIONS

    procedure START;

    procedure ACTIVATE_SRI;
    --H LSER        -- Allows the SRI release sequence to be activated
    --

    procedure IGNITE_VULCAIN;
    --H LSER        -- Allows the ignition sequence for both the Vulcain to be
    -- activated. The EPC ignition sequence will be activated
    -- at the date of H0.
    --

    procedure PREPARE_EAP_IGNITION;
    --H LSER        -- Allows the EAP pre-ignition and ignition sequence to be
    -- activated. The pre-ignition sequence shall be activated
    -- and if it is successful the EAP ignition sequence shall
    -- be activated. In the case of the pre-ignition being
    -- unsuccessful the EAP ignition shall be aborted and the
    -- EPC stop sequence shall be activated.

    procedure DISCONNECT_EPC_ES (ES : in PROPULSION_TYPES.ES_TYPE);
    -- Allows an EPC electrical system disconnection sequence to
    -- be activated.
    --

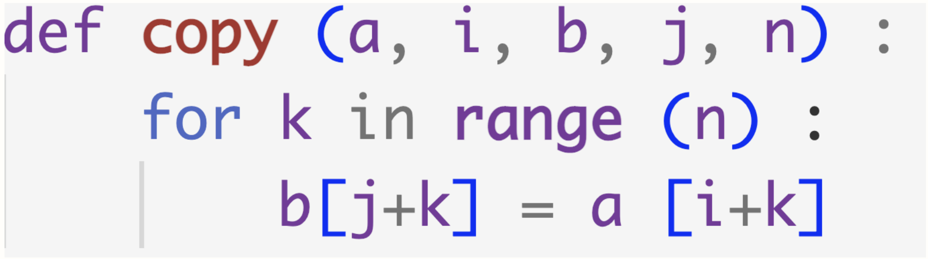
    procedure DISCONNECT_CASE_ES (ES : in PROPULSION_TYPES.ES_TYPE);
    --H LSER        -- Allows a CASE electrical system disconnection sequence to
    -- be activated.
    --

    procedure COMMUTE;
    -- Allows the commutation to be handled and the recovery
    -- sequences to be activated.

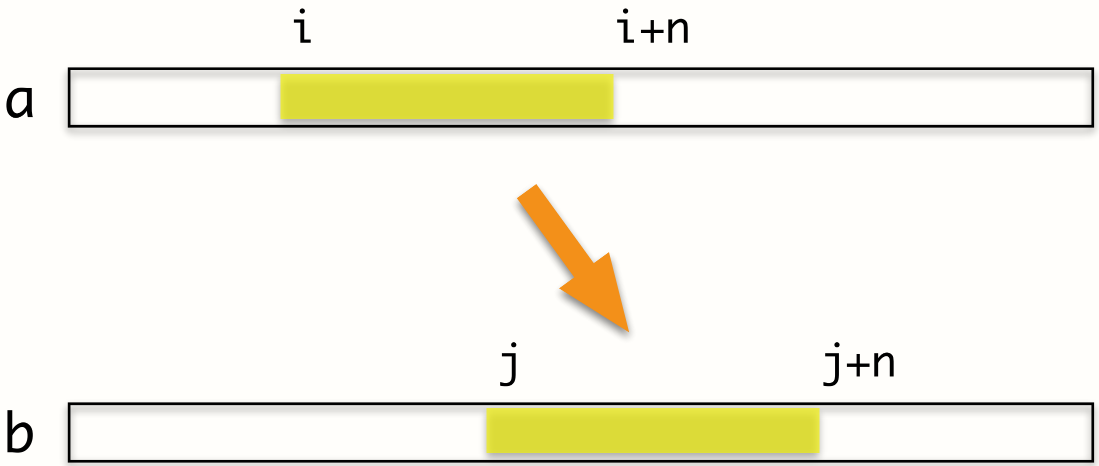
    procedure SET_EAP_IGNITION;
    -- This operation is to be called on the redundant OBC following the observati
```

# Alias detection

- is this program correct ?

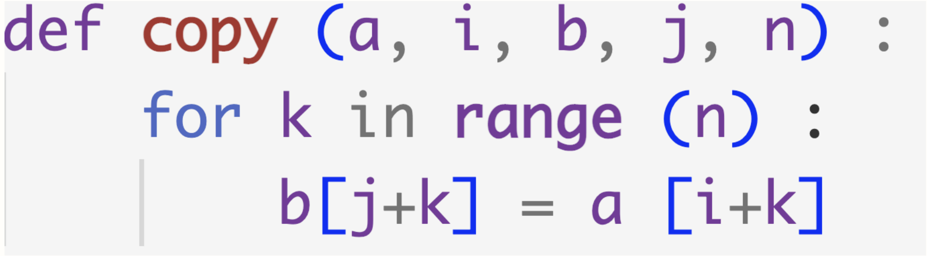


```
def copy (a, i, b, j, n) :
    for k in range (n) :
        b[j+k] = a [i+k]
```

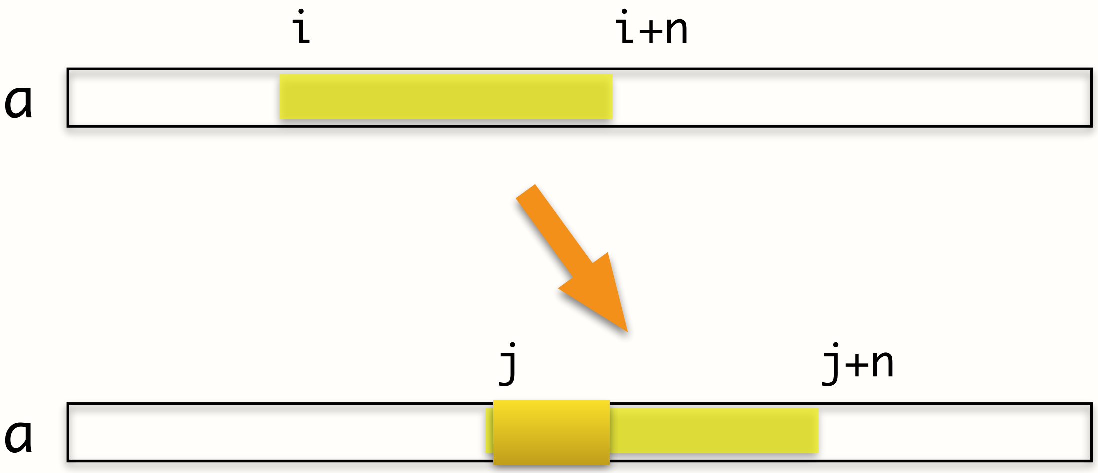


# Alias detection

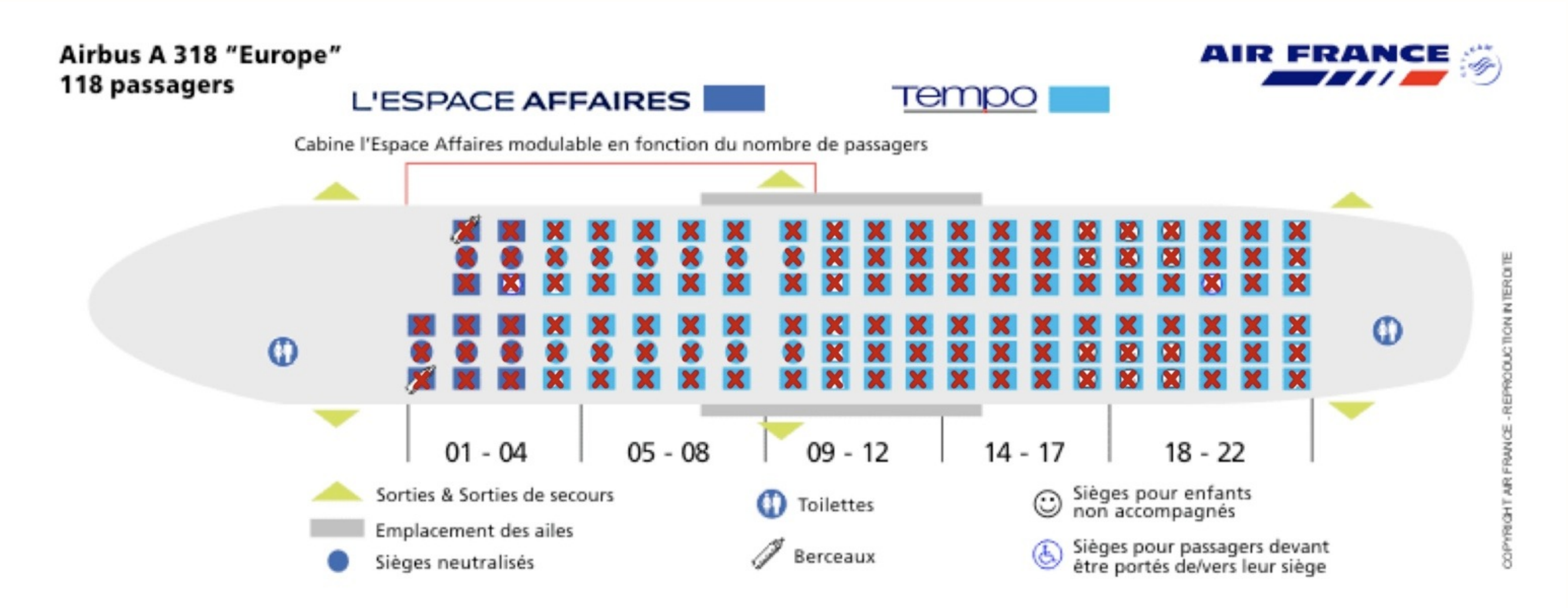
- this program is not correct when `a is b` (same address)



```
def copy (a, i, b, j, n) :
    for k in range (n) :
        b[j+k] = a [i+k]
```



# Shared variables


Airbus A 318 "Europe"
118 passagers
L'ESPACE AFFAIRES
Tempo
AIR FRANCE
Cabine l'Espace Affaires modulable en fonction du nombre de passagers
01 - 04
05 - 08
09 - 12
14 - 17
18 - 22
Sorties & Sorties de secours
Emplacement des ailes
Sièges neutralisés
Toilettes
Berceaux
Sièges pour enfants non accompagnés
Sièges pour passagers devant être portés de/vers leur siège
COPYRIGHT AIR FRANCE - REPRODUCTION INTERDITE

available seat ?

*"yes"*

I take it

available seat ?

*"yes"*

I take it

# Shared variables

- shared variables need locks for synchronisation
- shared variables badly behave when tasks run in parallel

available seat ?

*“yes”*

I take it

available seat ?

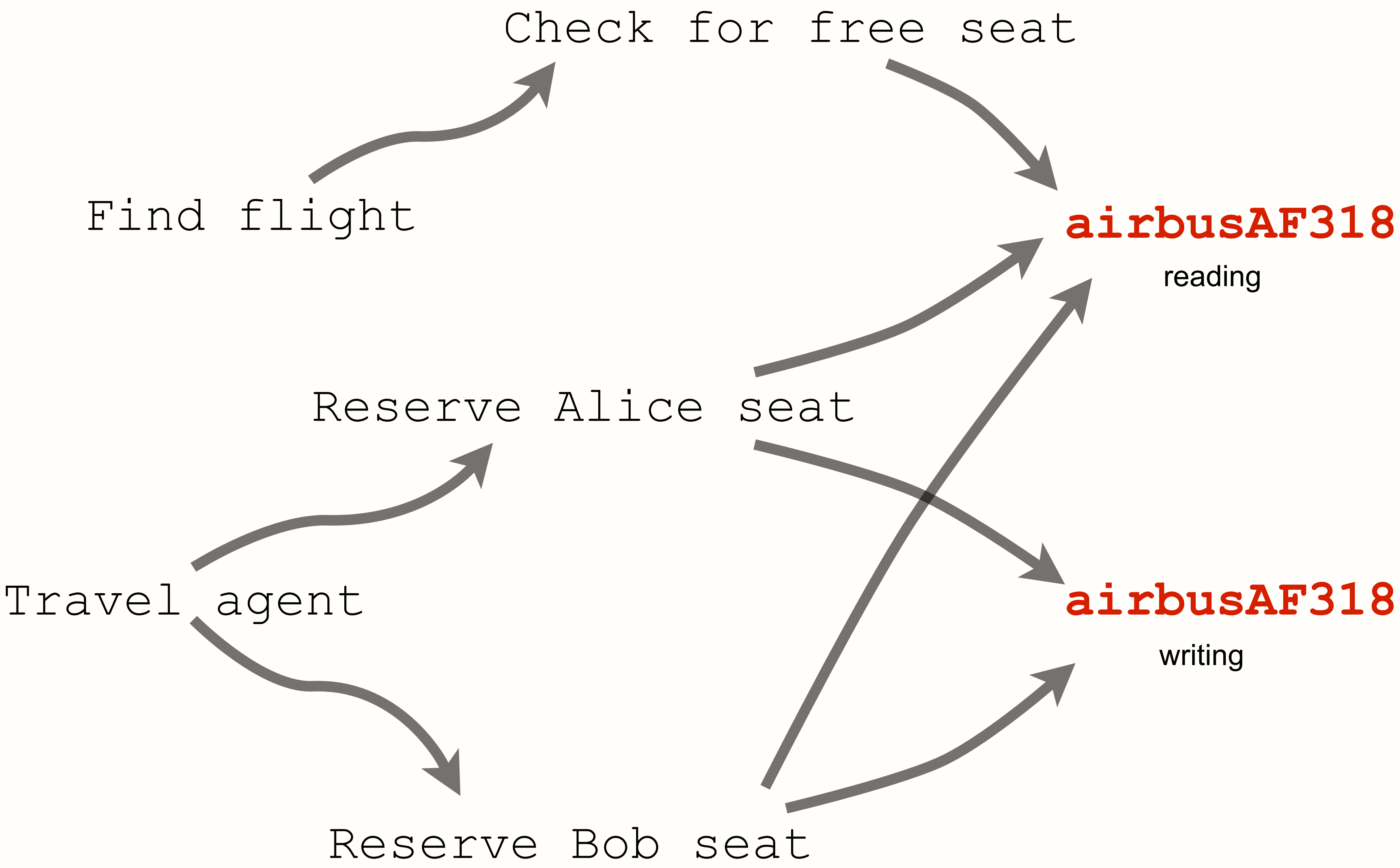
*“yes”*

I take it

# Shared variables detection

- PV (flight program) is Ada program with 5 parallel tasks
- find all shared variables !
- 80000 lines ADA + 10000 lines assembler MC68000
- with taking care of aliases

# Access to shared variables



Check for free seat

Find flight

airbusAF318

reading

Reserve Alice seat

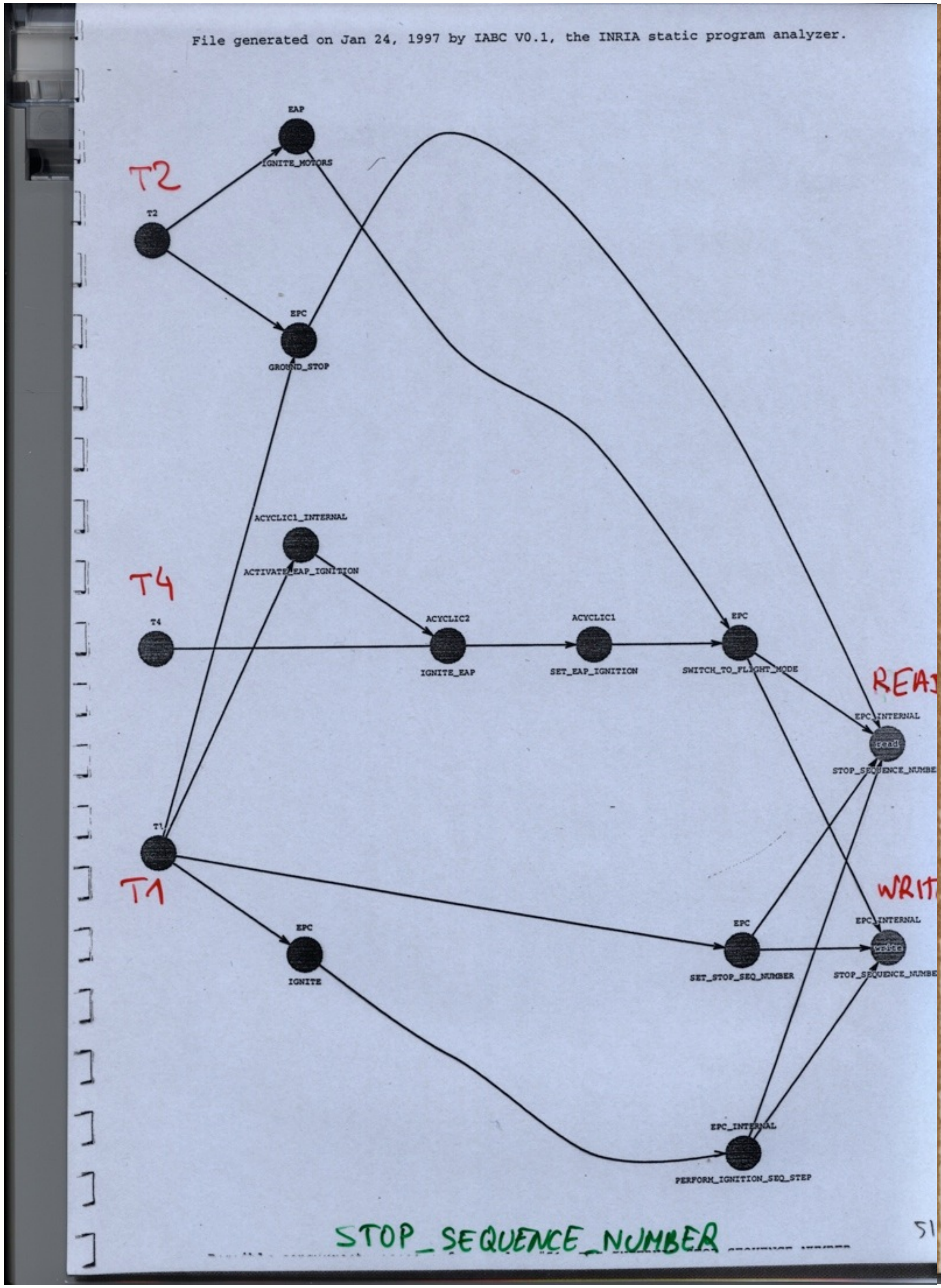
Travel agent

airbusAF318

writing

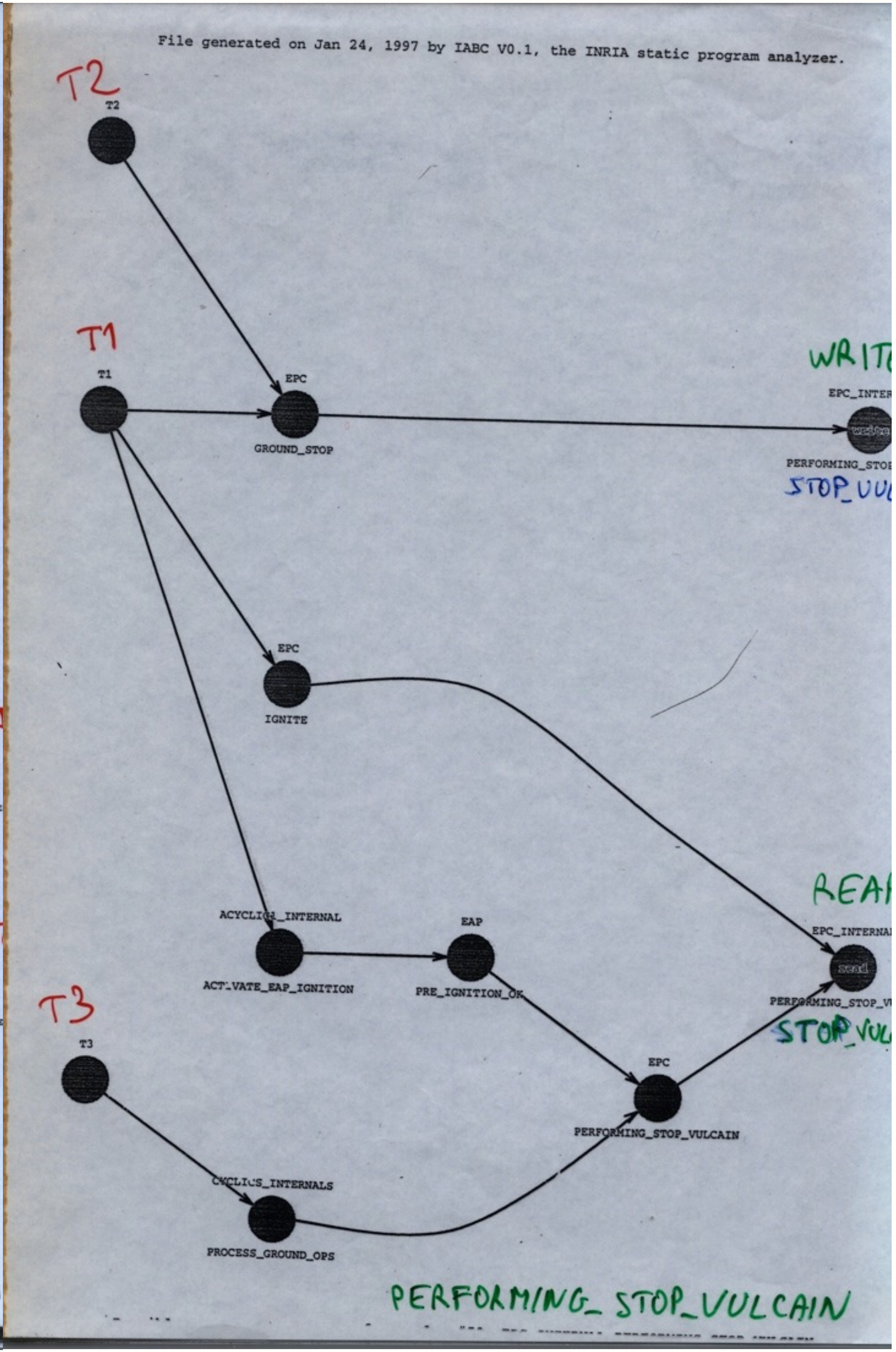
Reserve Bob seat

# Access to shared variables



File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.

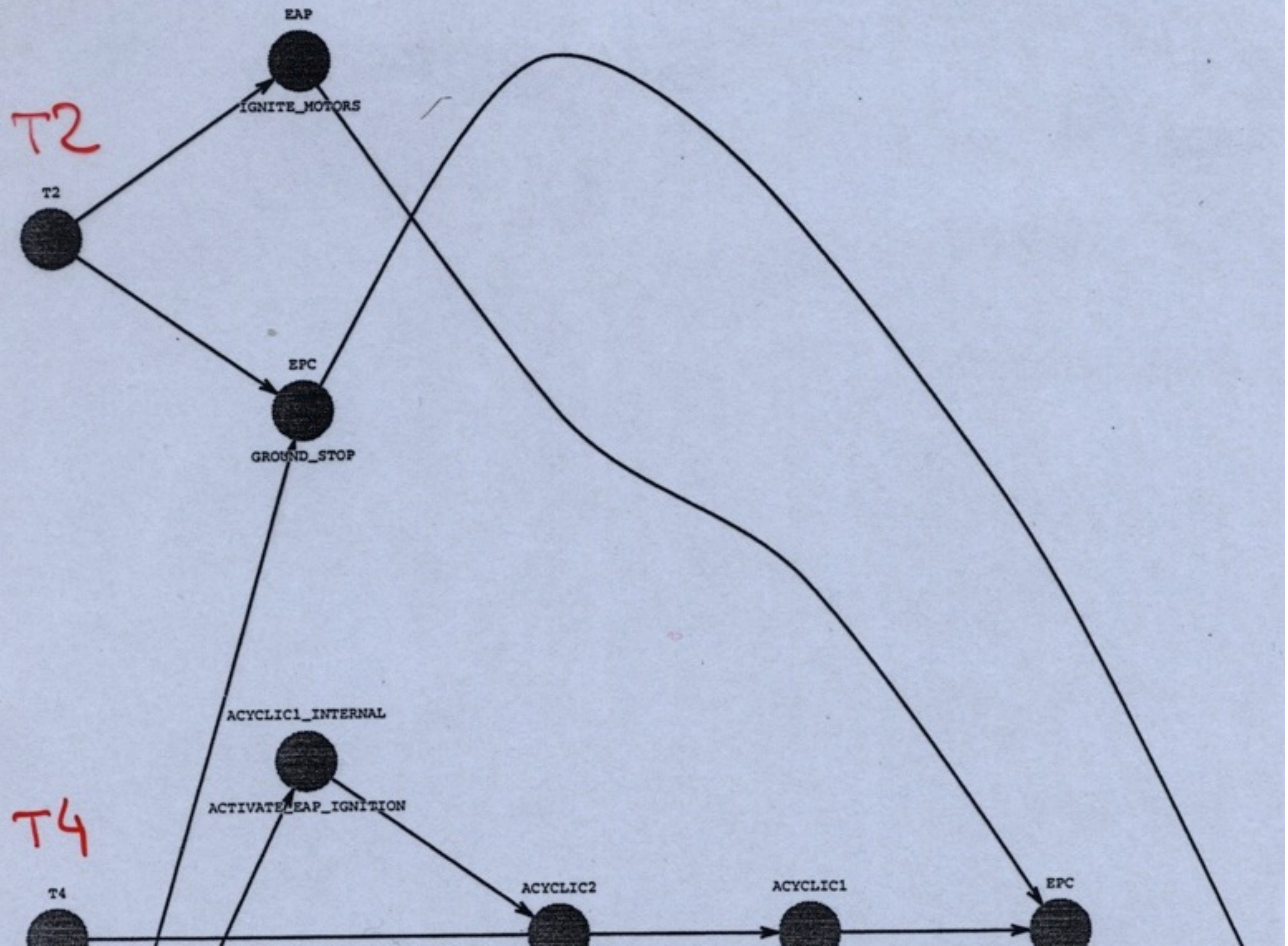
STOP_SEQUENCE_NUMBER



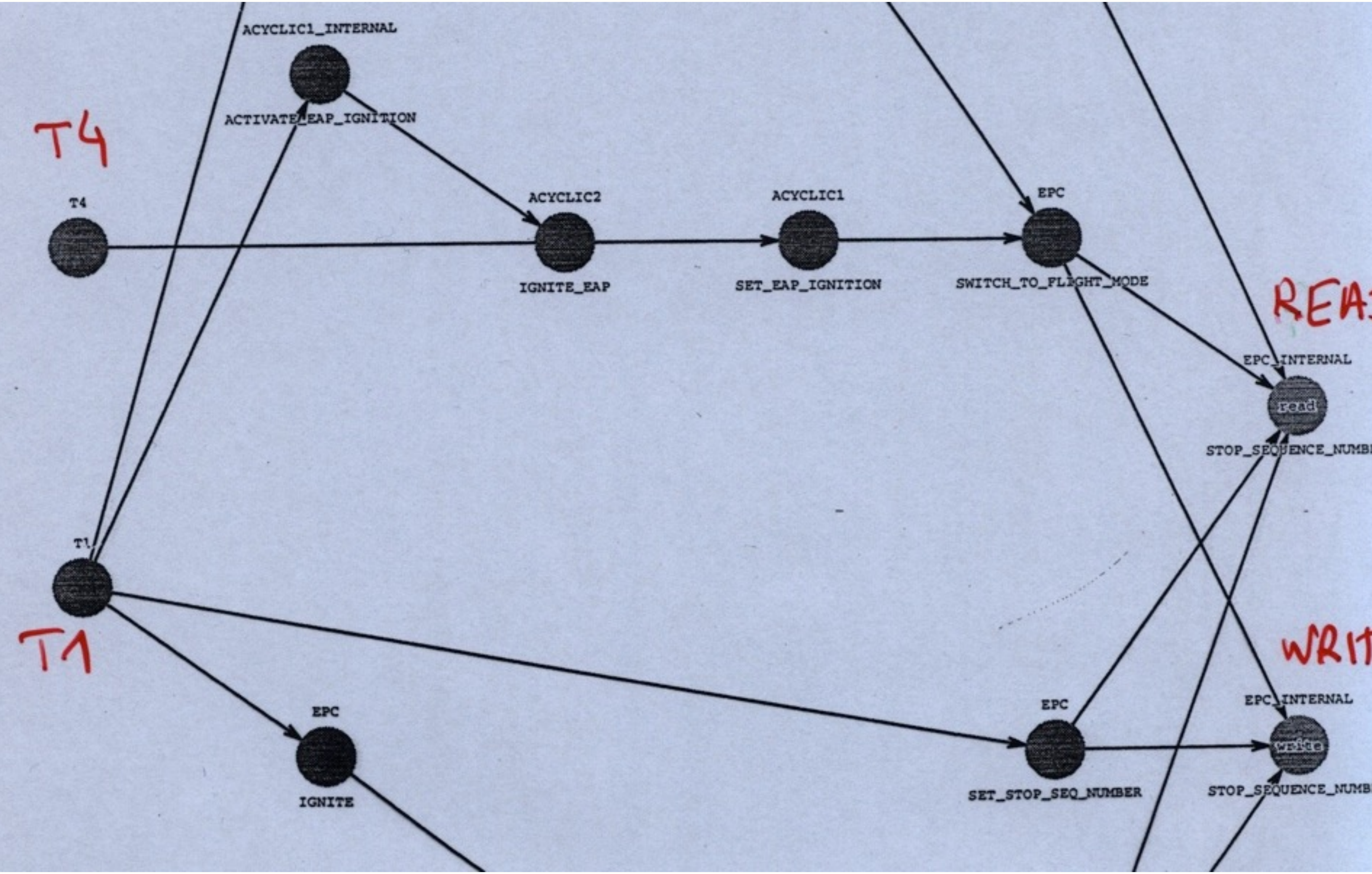
File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.

PERFORMING_STOP_VULCAIN

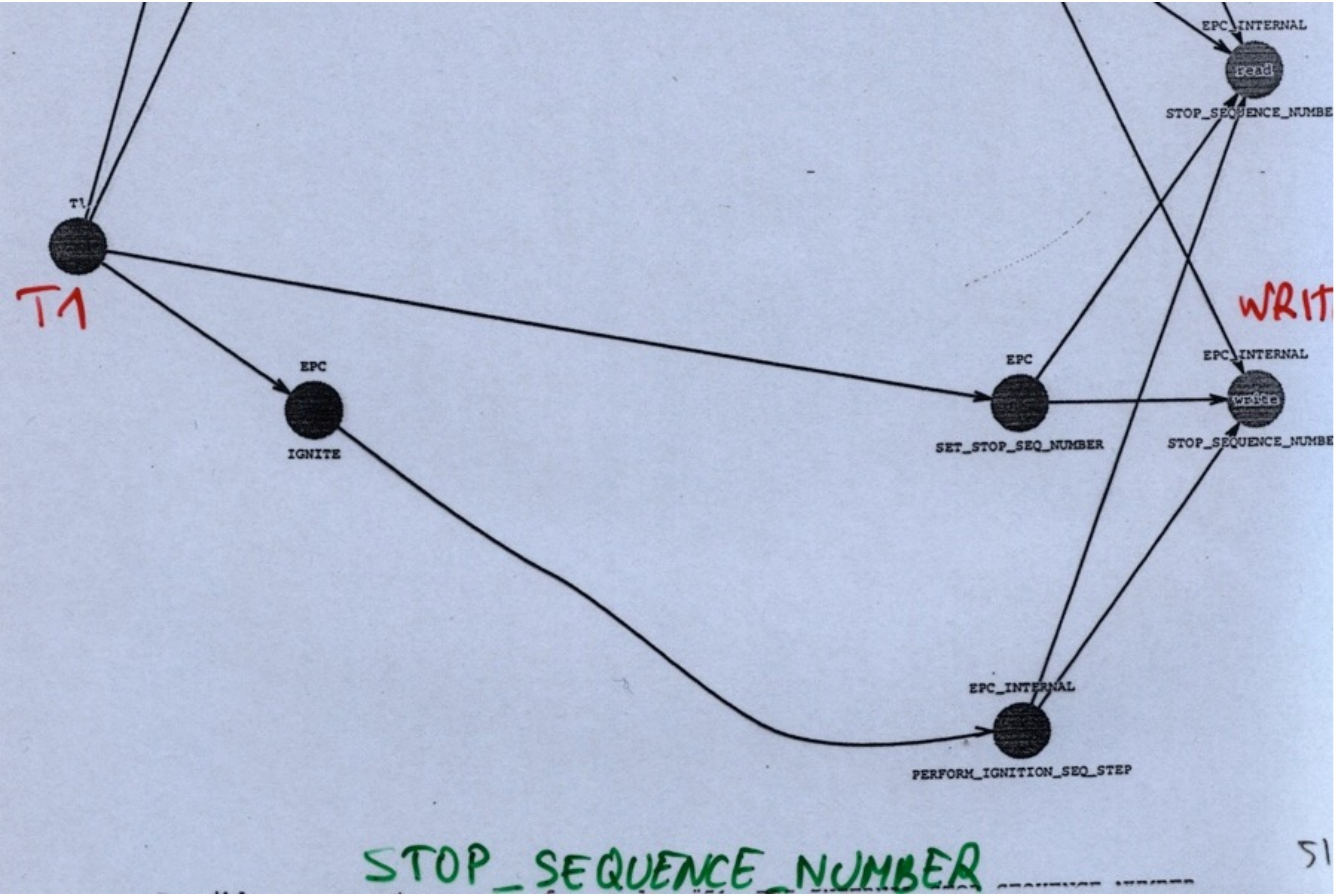
File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.



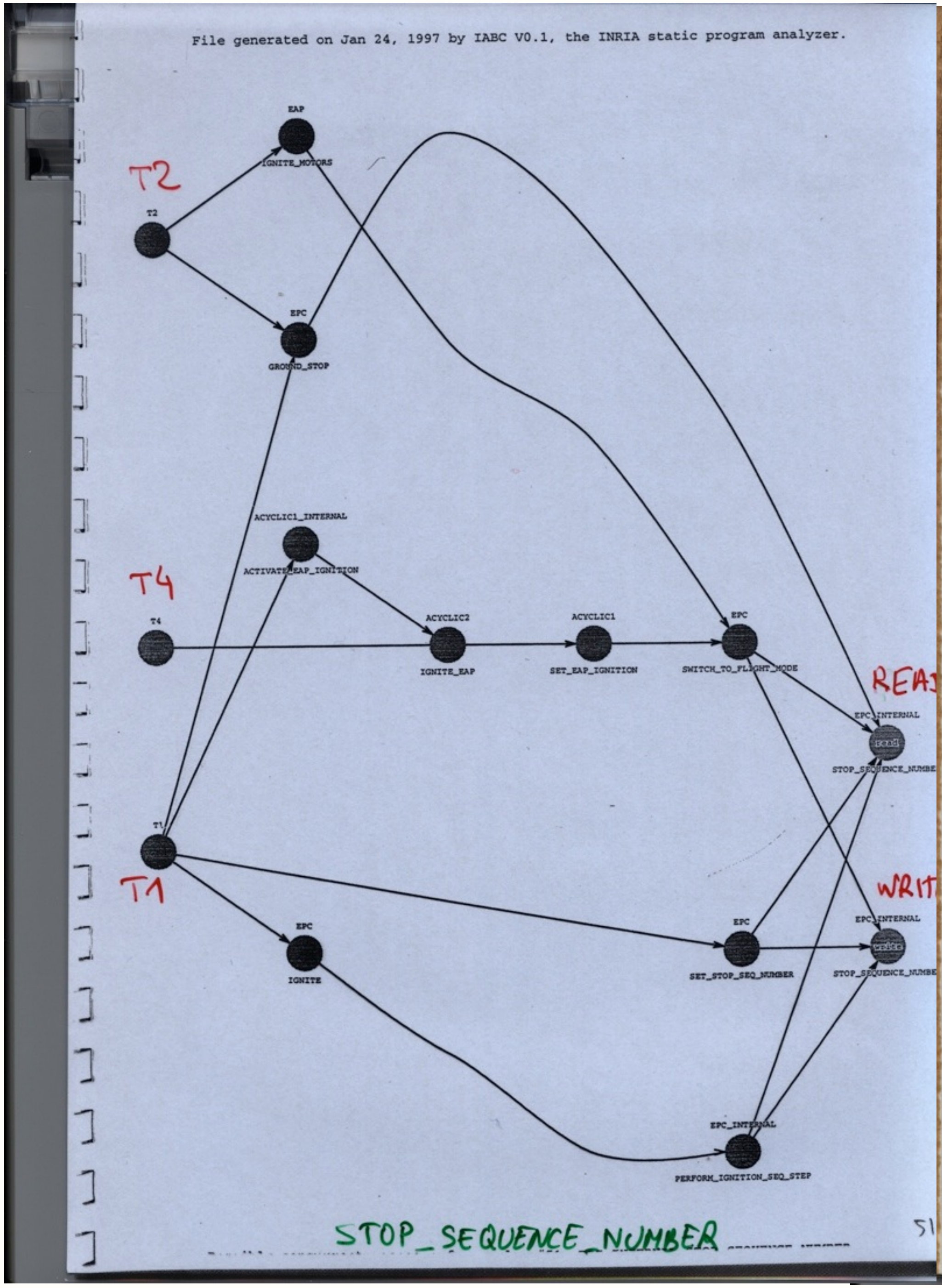
# Access to shared variables



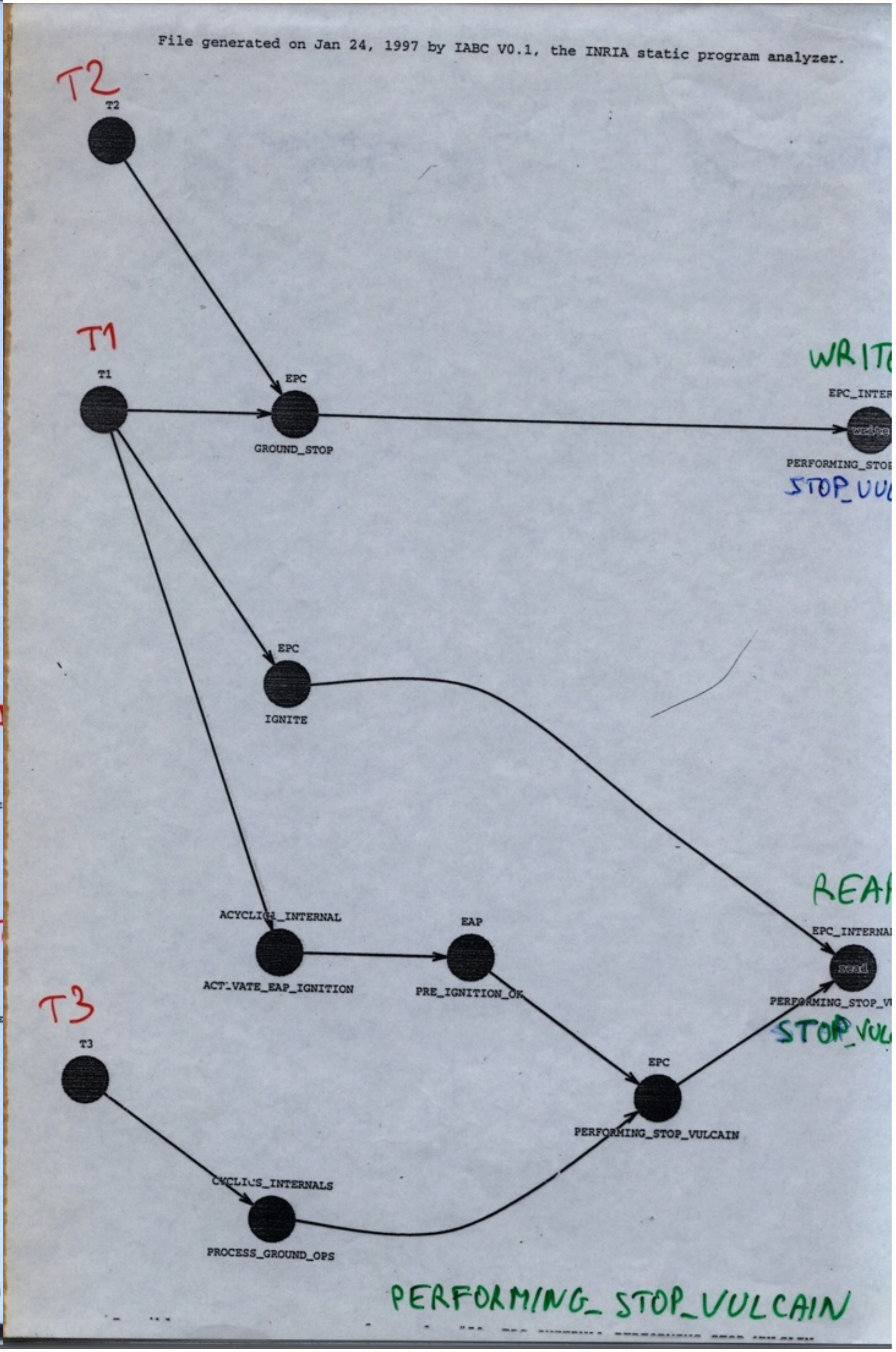
# Access to shared variables



# Access to shared variables



File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.



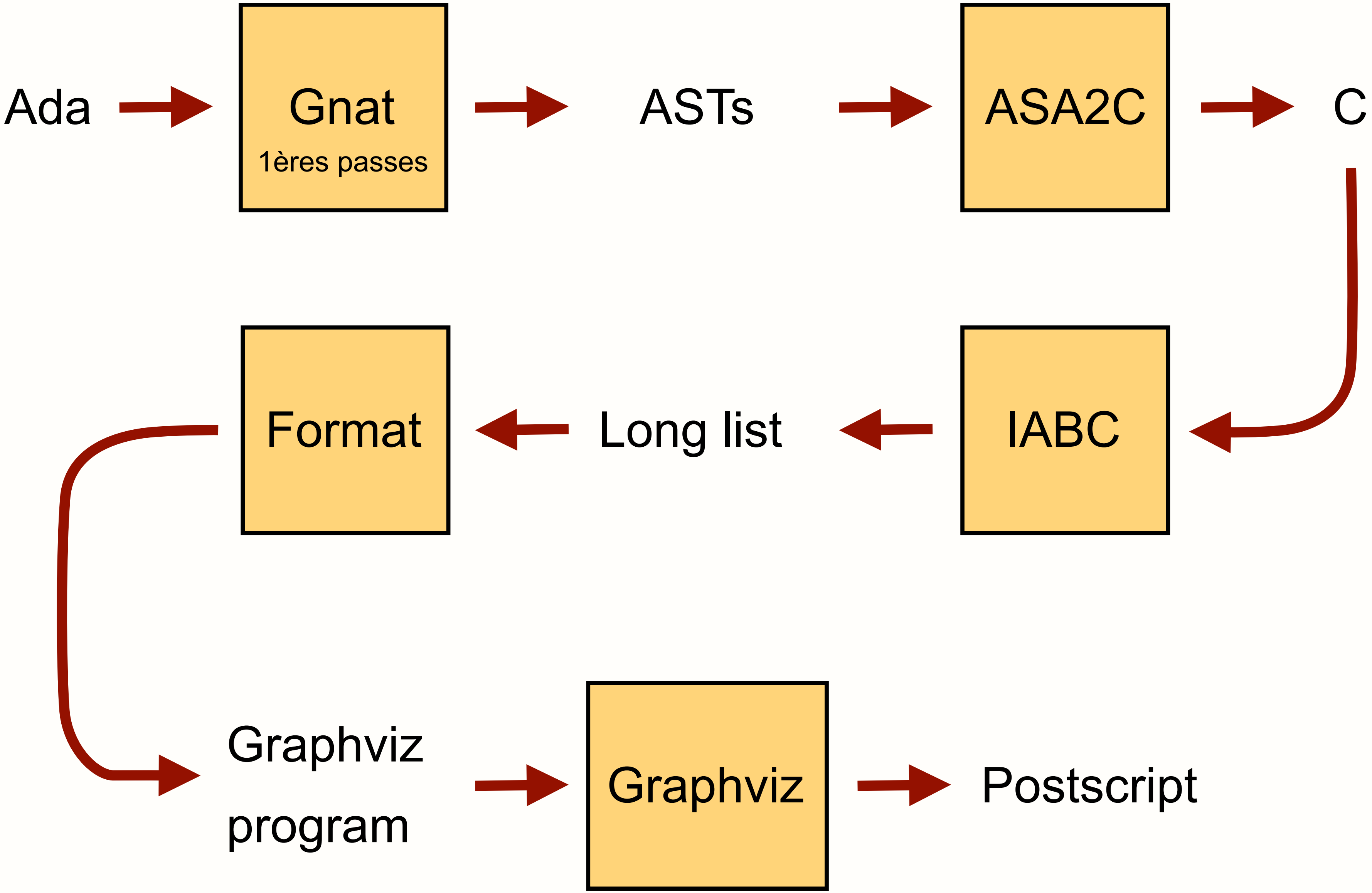
File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.

# Alias detection

- **10-year long work** of Alain Deutsch --- IABC (*INRIA Interprocedural Array Bounds Checker*)
- large community of “alias analysis”, “points-to analysis”
- **static analysis**, *abstract interpretation*
- **approximation** of the result résultat
- zero-alias guarantee

- IABC worked with **C** programs
- **efficient** program with good precision

# From Ada to C and IABC



Ada

Gnat

1ères passes

ASTs

ASA2C

C

IABC

Long list

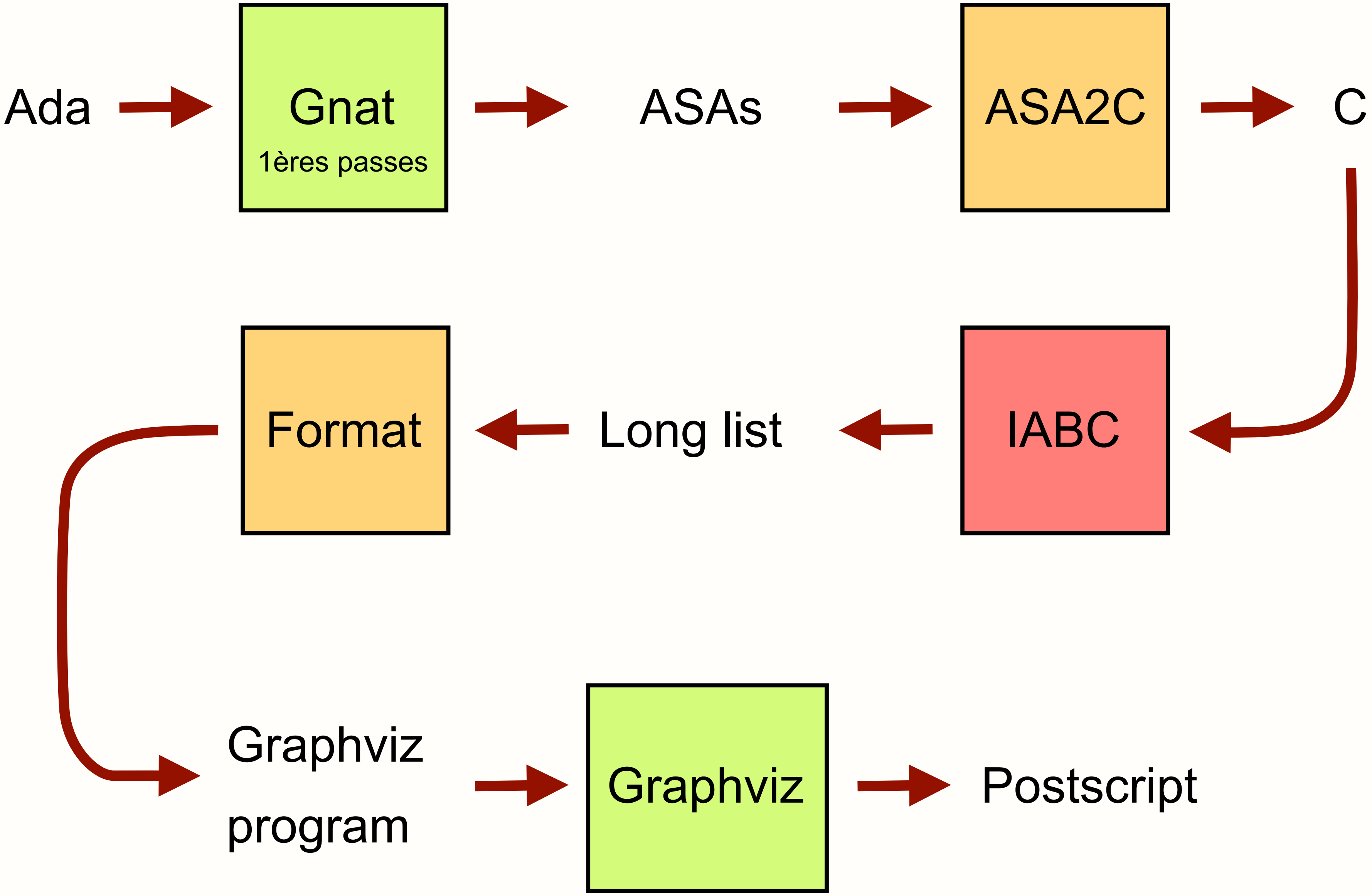
Format

Graphviz program

Graphviz

Postscript

# From Ada to C and IABC


Ada

Gnat

1ères passes

ASAs

ASA2C

C

IABC

Long list

Format

Graphviz program

Graphviz

Postscript

# Part in assembly lan

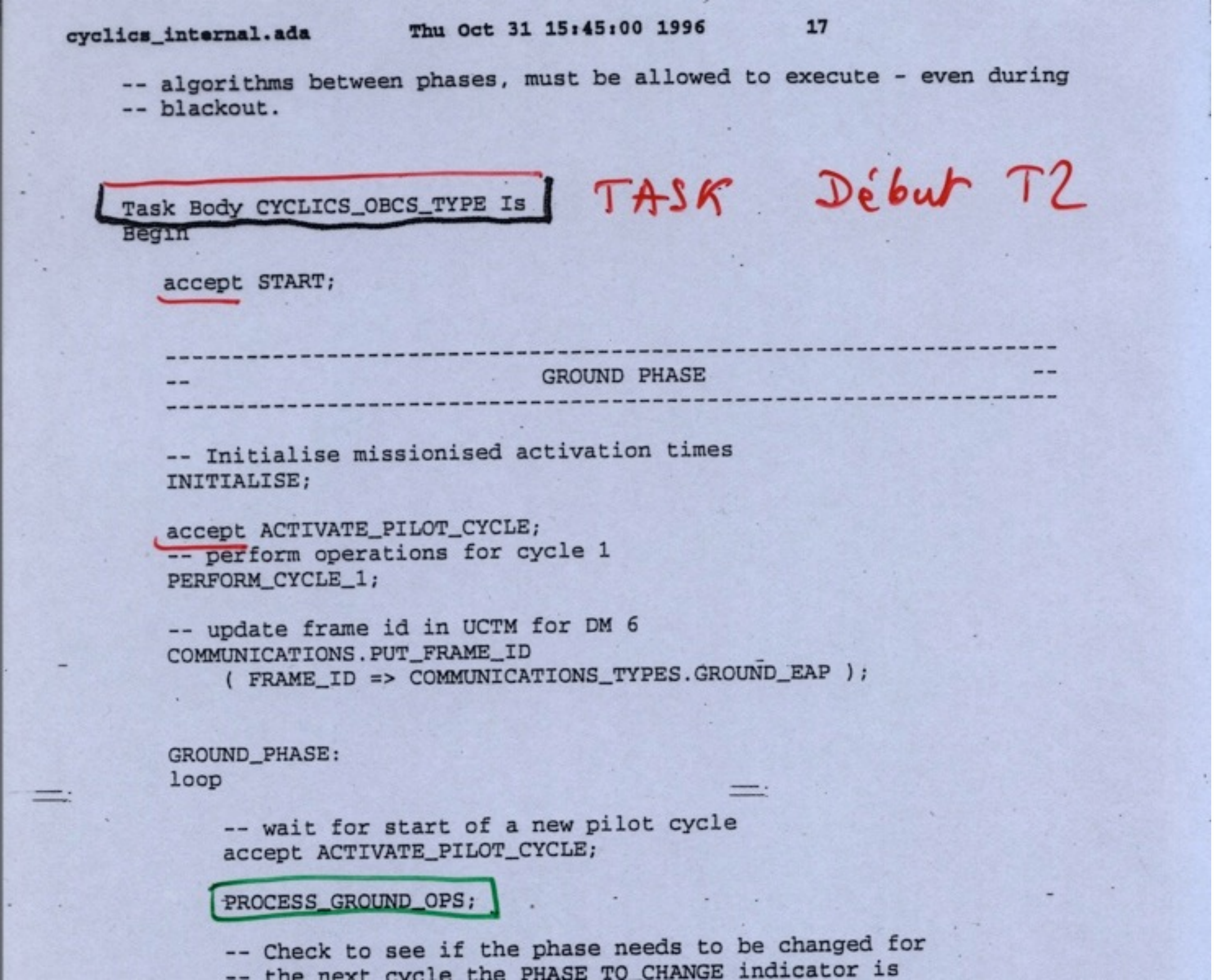
- read the documentation
- and make ADA *stubs*

# JANUARY 1997

PV

Unité échange

SRI



```
    -- algorithms between phases, must be allowed to execute - even during
    -- blackout.


    Task Body CYCLICS_OBCS_TYPE Is
    Begin

       accept START;


       ---------------------------------------------------------------------
       --                        GROUND PHASE                             --
       ---------------------------------------------------------------------

       -- Initialise missionised activation times
       INITIALISE;

       accept ACTIVATE_PILOT_CYCLE;
       -- perform operations for cycle 1
       PERFORM_CYCLE_1;

       -- update frame id in UCTM for DM 6
       COMMUNICATIONS.PUT_FRAME_ID
           ( FRAME_ID => COMMUNICATIONS_TYPES.GROUND_EAP );


       GROUND_PHASE:
       loop

           -- wait for start of a new pilot cycle
           accept ACTIVATE_PILOT_CYCLE;

           PROCESS_GROUND_OPS;

           -- Check to see if the phase needs to be changed for
           -- the next cycle the PHASE TO CHANGE indicator is
```

TASK Début T2

```
PERFORM_CYCLE_1;

-- update frame id in UCTM for DM 6
COMMUNICATIONS.PUT_FRAME_ID
    ( FRAME_ID => COMMUNICATIONS_TYPES.GROUND_EAP );


GROUND_PHASE:
loop

    -- wait for start of a new pilot cycle
    accept ACTIVATE_PILOT_CYCLE;

    PROCESS_GROUND_OPS;

    -- Check to see if the phase needs to be changed for
    -- the next cycle the PHASE_TO_CHANGE indicator is
    -- updated during the processing of the cycle. The
    -- command to change the frame is called during this
    -- processing.
    exit when PHASE_TO_CHANGE;

end loop GROUND_PHASE;


-------------------------------------------------------------------
--    EAP               EAP PHASE                                --
-------------------------------------------------------------------

-- Set launcher in flight, so that trajectory algorithms are
-- consistent between critical pilot (EXECUTIVE) and
-- other trajectory algorithms (CYCLICS).
PHASE.SET_IN_FLIGHT;


EAP_FLIGHT_PHASE:
loop
```

```
        -- wait for start of a new pilot cycle
        accept ACTIVATE_PILOT_CYCLE;

        PROCESS_EAP_OPS;

        -- Check to see if the phase needs to be changed for
        -- the next cycle the PHASE_TO_CHANGE indicator is
        -- updated during the processing of the cycle. The
        -- command to change the frame is called during this
        -- processing.
        exit when PHASE_TO_CHANGE;

    end loop EAP_FLIGHT_PHASE;


    ------------------------------------------------------------------
    --     EPC                   EPC PHASE                          --
    ------------------------------------------------------------------

    -- 3rd CYCLICS phase (while launcher is in EPC flight )
    PHASE.SET(NEW_PHASE => PHASE_TYPES.EPC_WITH_FAIRING);

    -- update frame id in UCTM for DM 6
    COMMUNICATIONS.PUT_FRAME_ID (FRAME_ID => COMMUNICATIONS_TYPES.EPC);

    -- Set up initialisation for roll control
    TRAJECTORY.INITIALISE_ACTUATORS;

    -- As this is the first call to this function, set up the earliest
    -- start time of CALCULATE_CONTROL_INTEGRAL (tleapeff + 10), 139 cycl
    -- after start of EPC.
    -- CALCULATE_CONTROL_INTEGRAL will be executed in Navigate_cycle_2.
    EPC_CONTROL_INTEGRAL_START := OVERALL_CYCLE_COUNT + 139;
```

```
PHASE.SET(NEW_PHASE => PHASE_TYPES.[illegible]);

-- update frame id in UCTM for DM 6
COMMUNICATIONS.PUT_FRAME_ID (FRAME_ID => COMMUNICATIONS_TYPES.EPC);

-- Set up initialisation for roll control
TRAJECTORY.INITIALISE_ACTUATORS;

-- As this is the first call to this function, set up the earliest
-- start time of CALCULATE_CONTROL_INTEGRAL (tleapeff + 10), 139 cycl
-- after start of EPC.
-- CALCULATE_CONTROL_INTEGRAL will be executed in Navigate_cycle_2.
EPC_CONTROL_INTEGRAL_START := OVERALL_CYCLE_COUNT + 139;

-- Set the guidance counter so that the out_atmosphere guidance
-- is resynchronised. The ST states that the start of out_atmosphere
-- guidance is started at "tleapeff".
GUIDANCE_CYCLE_COUNT := 1;

EPC_FLIGHT_PHASE:
loop

    -- wait for start of a new pilot cycle
    accept ACTIVATE_PILOT_CYCLE;

    PROCESS_EPC_OPS;

    -- Check to see if the phase needs to be changed for
    -- the next cycle the PHASE_TO_CHANGE indicator is
    -- updated during the processing of the cycle. The
    -- command to change the frame is called during this
    -- processing.
    exit when PHASE_TO_CHANGE;

end loop EPC_FLIGHT_PHASE;
```

```
-------------------------------------------------------------------
--     EPS               EPS PHASE                               --
-------------------------------------------------------------------

-- EPC flight is now complete. Further processing will depend on
-- the flight mission.
--
-- There are 2 possible missions;
-- Mission TYPE_1      and     Mission TYPE_2
--
-- EPS flight                  no initial EPS flight for this mission
-- SCA (ballistic)             SCA (ballistic)
-- EPS flight                  EPS flight
-- SCA (ballistic)             SCA (ballistic)
-- EPS flight                  EPS flight
-- SCA FIN                     SCA FIN

-- the mission type is obtained from FLIGHT_MISSION_DATA.
if FLIGHT_MISSION_DATA.MISSION_TYPE_IS = FLIGHT_TYPES.TYPE_1 then

    PHASE.SET(NEW_PHASE => PHASE_TYPES.EPS_STOPPED);

    -- update frame id in UCTM for DM 6
    COMMUNICATIONS.PUT_FRAME_ID (FRAME_ID => COMMUNICATIONS_TYPES.EPS);

    -- Reset digital message 1 and 2 with thrust estimation data.
    COMMUNICATIONS.PUT_THRUST_ESTIMATE_MESSAGE (MESSAGE => ( others => 0.0)

    TRAJECTORY.INITIALISE_EPS_PILOT;

    TRAJECTORY.INITIALISE_ACTUATORS;
    -- for a type 1, actuators initialisation for roll control
    -- is activated once, on the first EPS phase.

    EPS_FLIGHT_PHASE:
    loop
    -- update frame id in UCTM for DM 6
    COMMUNICATIONS.PUT_FRAME_ID (FRAME_ID => COMMUNICATIONS_TYPES.EPS);

    -- Reset digital message 1 and 2 with thrust estimation data.
    COMMUNICATIONS.PUT_THRUST_ESTIMATE_MESSAGE (MESSAGE => ( others => 0.0)

    TRAJECTORY.INITIALISE_EPS_PILOT;

    TRAJECTORY.INITIALISE_ACTUATORS;
    -- for a type 1, actuators initialisation for roll control
    -- is activated once, on the first EPS phase.

    EPS_FLIGHT_PHASE:
    loop

        -- wait for start of a new pilot cycle
        accept ACTIVATE_PILOT_CYCLE;

        PROCESS_EPS_OPS;

        -- Check to see if the phase needs to be changed for
        -- the next cycle the PHASE_TO_CHANGE indicator is
        -- updated during the processing of the cycle. The
        -- command to change the frame is called during this
        -- processing.
        exit when PHASE_TO_CHANGE;

    end loop EPS_FLIGHT_PHASE;

end if;  -- FLIGHT_MISSION_DATA.MISSION_TYPE_IS


-----------------------------------------------------------------
--    Ballistique          SCA PHASE                            --
-----------------------------------------------------------------
```

JJC

```
File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.

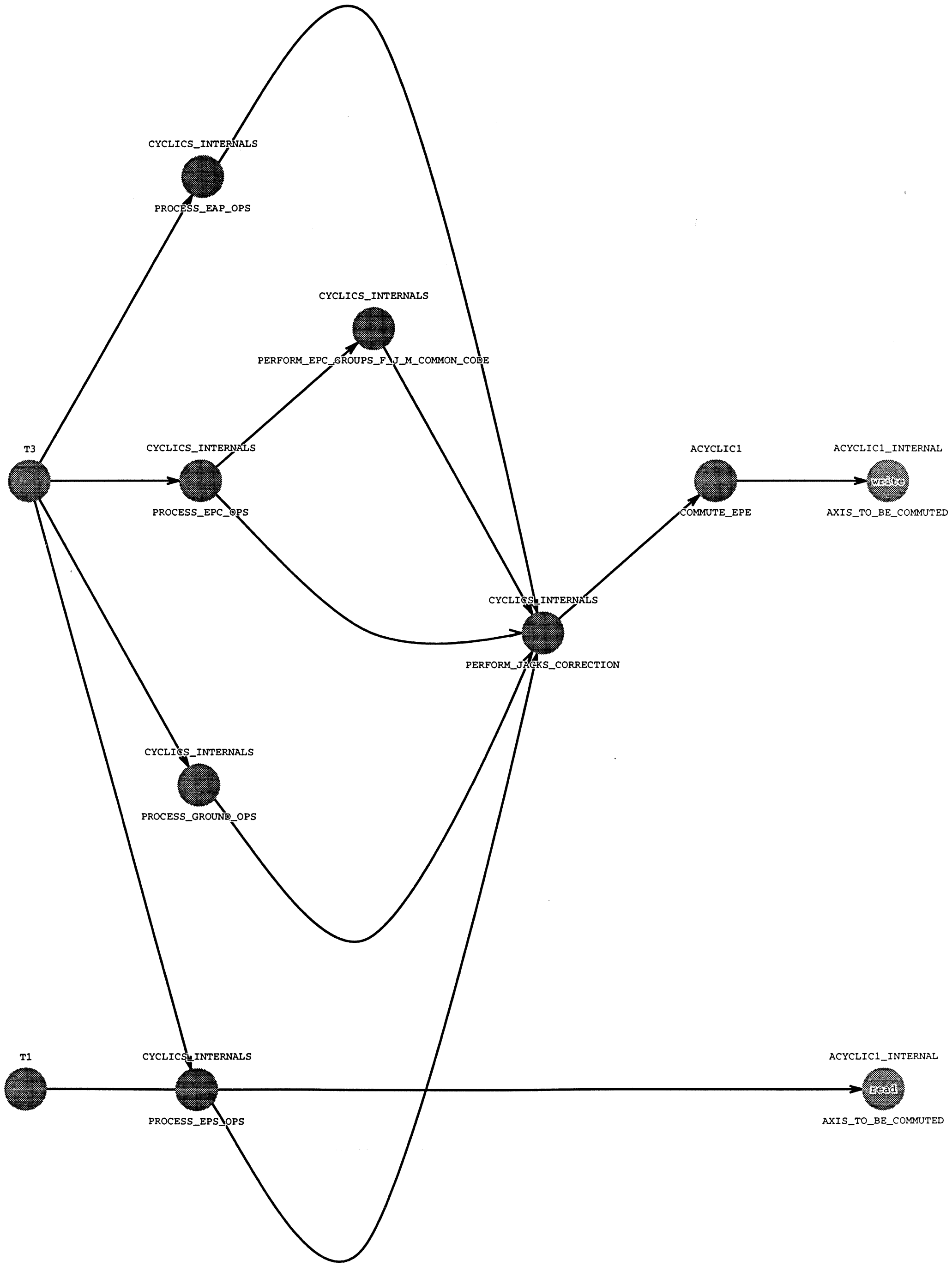

Level 0 Concurrency Analysis for scalars accessed by:
 T1) ACYCLIC1_INTERNAL.OBCS_TYPE (task), "acyclic1_internal_.ada" line 63, column 4:
        Task type OBCS_TYPE Is
        ^
 T2) ACYCLIC2_INTERNAL.OBCS_TYPE (task), "acyclic2_internal_.ada" line 69, column 4:
        Task type OBCS_TYPE Is
        ^
 T3) CYCLICS_INTERNALS.CYCLICS_OBCS_TYPE (task), "cyclics_internal_.ada" line 194, column 2:
        Task type CYCLICS_OBCS_TYPE Is
        ^
 T4) EXECUTIVE_INTERNAL.OBCS_TYPE (task), "executive_internal_.ada" line 50, column 3:    main
        task type OBCS_TYPE is
        ^
 T5) GUIDANCE_CONTROL_INTERNAL.OBCS_TYPE (task), "guidance_control_internal_.ada" line 51, column 0:
        Task type OBCS_TYPE Is
        ^

    | variable                                | type                               | reads        | writes
  1 | ACTUATORS_INTERNAL.PAYLOAD_NBR          | -32768..32767                      | {T2}         | {T3}
  2 | ACYCLIC1_INTERNAL.ACYCLIC1_TASK_ID      | 1..2147483647                      | {T3}         | {T1}
  3 | ACYCLIC1_INTERNAL.AXIS_TO_BE_COMMUTED   | u_axis..v_axis                     | {T1}         | {T3}
  4 | ACYCLIC1_INTERNAL.CASE_ES_DISCO...N_REQUESTED | false..true                  | {T1}         | {T1,T3}
  5 | ACYCLIC1_INTERNAL.COMMUTE_EPE_REQUESTED | false..true                        | {T1}         | {T1,T3}
  6 | ACYCLIC1_INTERNAL.EAPS_IGNITED          | false..true                        | {T1,T3}      | {T1,T4}
  7 | ACYCLIC1_INTERNAL.EPC_ES_DISCON...N_REQUESTED | false..true                  | {T1}         | {T1,T3}
  8 | ACYCLIC1_INTERNAL.ES_TO_BE_DISCONNECTED | es1..es2                           | {T1}         | {T3}
  9 | ACYCLIC1_INTERNAL.FRAME_STARTED_IN_OBC2 | false..true                        | {T3}         | {T1}
 10 | ACYCLIC2_EVENT_QUEUE.POP_POINTER        | event_1..event_8                   | {T2}         | {T1,T2}
 11 | ACYCLIC2_EVENT_QUEUE.PUSH_POINTER       | event_1..event_8                   | {T1}         | {T3}
 12 | ACYCLIC2_INTERNAL.DISCONNECT_ES         | false..true                        | {T2}         | {T3}
 13 | ACYCLIC2_INTERNAL.ES_TO_BE_DISCONNECTED | es1..es2                           | {T2}         | {T3}
 14 | BGY_INTERNAL.DIAL_BGY1                  | -32768..32767                      | {T3,T4}      | {T3,T4}
 15 | BGY_INTERNAL.DIAL_BGY2                  | -32768..32767                      | {T3,T4}      | {T3,T4}
 16 | BGY_INTERNAL.FIRST_PASS                 | false..true                        | {T3,T4}      | {T3,T4}
 17 | BGY_INTERNAL.ILC1                       | -32768..32767                      | {T3,T4}      | {T3,T4}
 18 | BGY_INTERNAL.ILC2                       | -32768..32767                      | {T3,T4}      | {T3,T4}
 19 | BGY_INTERNAL.ITG1                       | -32768..32767                      | {T3,T4}      | {T3,T4}
 20 | BGY_INTERNAL.ITG2                       | -32768..32767                      | {T3,T4}      | {T3,T4}
 21 | BGY_INTERNAL.MASIL1                     | no_failure..definitive_failure     | {T3,T4}      | {T3,T4}
 22 | BGY_INTERNAL.MASIL2                     | no_failure..definitive_failure     | {T3,T4}      | {T3,T4}
 23 | BGY_INTERNAL.MASIT1                     | no_failure..definitive_failure     | {T3,T4}      | {T3,T4}
 24 | BGY_INTERNAL.MASIT2                     | no_failure..definitive_failure     | {T3,T4}      | {T3,T4}
```

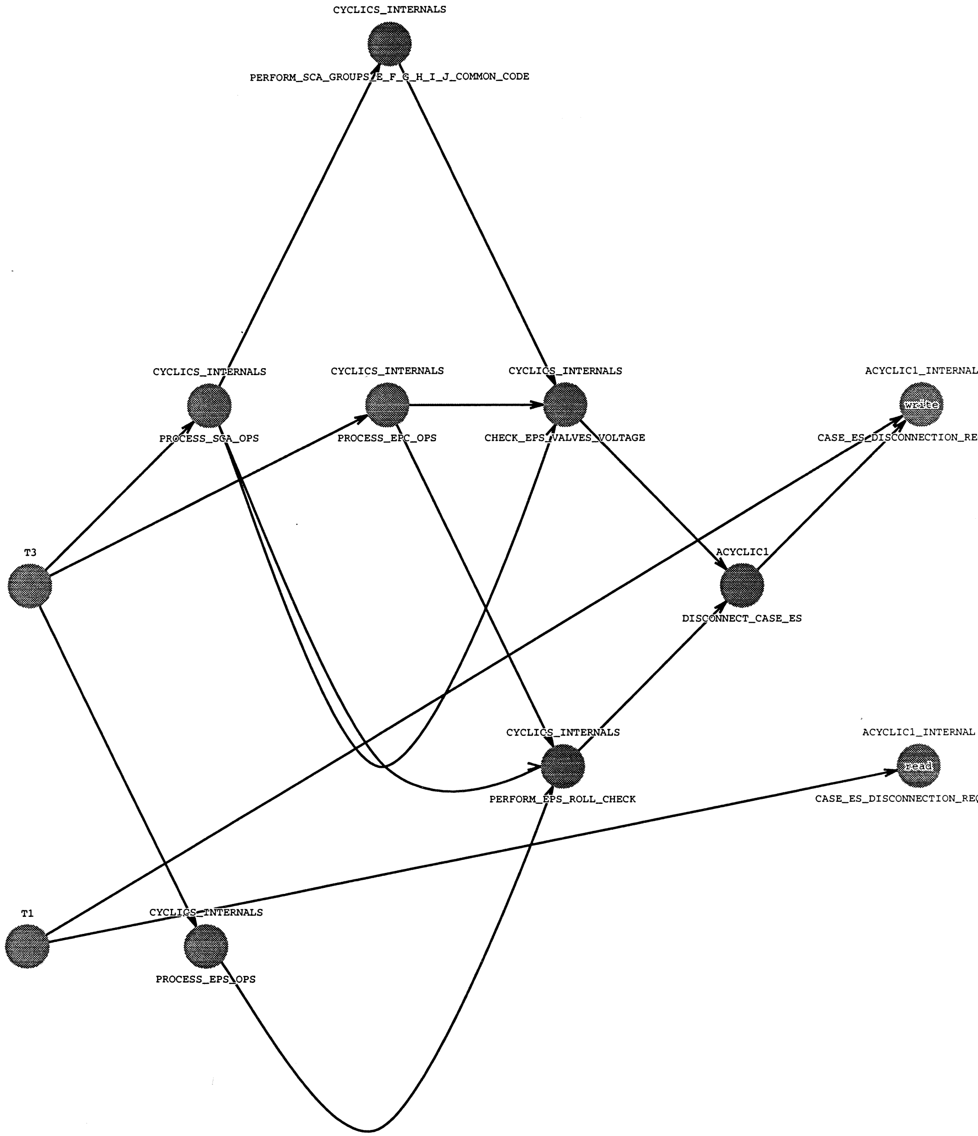
| | | | | |
|---|---|---|---|---|
| 25 | BGY_INTERNAL.NTEN1 | -32768..32767 | {T3,T4} | {T3,T4} |
| 26 | BGY_INTERNAL.NTEN2 | -32768..32767 | {T3,T4} | {T3,T4} |
| 27 | BGY_INTERNAL.PGL1 | -32768..32767 | {T3,T4} | {T3,T4} |
| 28 | BGY_INTERNAL.PGL2 | -32768..32767 | {T3,T4} | {T3,T4} |
| 29 | BGY_INTERNAL.PGT1 | -32768..32767 | {T3,T4} | {T3,T4} |
| 30 | BGY_INTERNAL.PGT2 | -32768..32767 | {T3,T4} | {T3,T4} |
| 31 | CYCLICS_INTERNALS.DOUBLE_FAILURE | false..true | {T3,T4} | {T3,T4} |
| 32 | CYCLICS_INTERNALS.EPS_PRESSURISE_FIRST_CALL | false..true | {T2} | {T3} |
| 33 | CYCLICS_INTERNALS.IN_EAP_TO_EPC_TRANSITION | false..true | {T4} | {T3} |
| 34 | CYCLICS_INTERNALS.INHIBIT_TRAJECTORY | false..true | {T3,T4} | {T3,T4} |
| 35 | CYCLICS_INTERNALS.OVERALL_CYCLE_COUNT | 1..2147483647 | {T4} | {T3} |
| 36 | CYCLICS_INTERNALS.SRI_BGY_MEASUREMENT_FAILURE | false..true | {T3,T4} | {T3,T4} |
| 37 | CYCLICS_INTERNALS.SRI_NEVER_COMMUTED | false..true | {T3,T4} | {T3,T4} |
| 38 | DATE.EPC_STOP_MOTOR_REASON | no_stop..low_level | {T3} | {T3,T5} |
| 39 | DATE.EPS_IGNITION_COUNTER | 0..3 | {T2,T5} | {T3} |
| 40 | DATE.EPS_STOP_MOTOR_REASON | no_extinction..date | {T3} | {T3,T5} |
| 41 | DATE_PAYLOAD_SETUP.ACTIVE_POINTER | 0..22 | {T2} | {T3} |
| 42 | ELECTRICAL_SYSTEM_INTERNAL.EPE_EPS_COMMUTE_OK | false..true | {T1,T2,T3} | {T1,T2,T3} |
| 43 | ELECTRICAL_SYSTEM_INTERNAL.EPH_...._COMMUTE_OK | false..true | {T1,T2,T3} | {T1,T2,T3} |
| 44 | ELECTRICAL_SYSTEM_INTERNAL.EPH_...._COMMUTE_OK | false..true | {T1,T2,T3} | {T1,T2,T3} |
| 45 | ELECTRICAL_SYSTEM_INTERNAL.EPH_EPC_COMMUTE_OK | false..true | {T1,T2,T3} | {T1,T2,T3} |
| 46 | ELECTRICAL_SYSTEM_INTERNAL.ES_C...SCONNECT_OK | false..true | {T1,T2,T3} | {T1,T2,T3} |
| 47 | ELECTRICAL_SYSTEM_INTERNAL.ES_E...SCONNECT_OK | false..true | {T1,T2} | {T1,T2} |
| 48 | EPC_INTERNAL.EPH_DISCONNECTED | false..true | {T3} | {T2} |
| 49 | EPC_INTERNAL.INHIBIT_DETECT_CORRECT | false..true | {T3} | {T1} |
| 50 | EPC_INTERNAL.PERFORMING_STOP_VULCAIN | false..true | {T1,T3} | {T1,T2} |
| 51 | EPC_INTERNAL.STOP_SEQUENCE_NUMBER | stop_sequence_0..sto...uence_3 | {T1,T2,T4} | {T1,T2,T4} |
| 52 | EPC_TANKS_INTERNAL.CONTINUE_EPC...CYCLIC_PROC | false..true | {T3} | {T1,T2} |
| 53 | EQUIP.I_AM_BC | false..true | {T1,T2,T3,T4} | {T1,T2,T4} |
| 54 | EQUIP.THE_SRI1_IS_NOMINAL | false..true | {T1,T2,T3,T4} | {T1,T3,T4} |
| 55 | EV.CAN_SWITCH_OBC | false..true | {T1,T2,T3} | {T1,T4} |
| 56 | GUIDANCE_INTERNAL.BLOC | false..true | {T3,T5} | {T3,T5} |
| 57 | GUIDANCE_INTERNAL.DTHA_FLAG | of_16_cycles..of_64_cycles | {T3,T5} | {T3,T5} |
| 58 | GUIDANCE_INTERNAL.ISEG_FLT | -32768..32767 | {T3,T5} | {T3,T5} |
| 59 | GUIDANCE_INTERNAL.KBAL | false..true | {T3} | {T5} |
| 60 | GUIDANCE_INTERNAL.KD | -32768..32767 | {T3} | {T5} |
| 61 | GUIDANCE_INTERNAL.KPANNE | false..true | {T3,T5} | {T3,T5} |
| 62 | GUIDANCE_INTERNAL.NBSEG | -32768..32767 | {T3,T5} | {T3,T5} |
| 63 | GUIDANCE_INTERNAL.NCOIF | -32768..32767 | {T3,T5} | {T3,T5} |
| 64 | GUIDANCE_INTERNAL.NCOM | -32768..32767 | {T5} | {T3,T5} |
| 65 | GUIDANCE_INTERNAL.NFIN | -32768..32767 | {T3,T5} | {T3,T5} |
| 66 | GUIDANCE_INTERNAL.NSEP | -32768..32767 | {T3,T5} | {T3,T5} |
| 67 | GUIDANCE_INTERNAL.NUMBAL | -32768..32767 | {T3,T5} | {T3,T5} |
| 68 | OBC_INTERNAL.H0R | -2147483648..2147483647 | {T3,T5} | {T4} |
| 69 | OBC_INTERNAL.INHIBIT_DASDC_MESSAGE | false..true | {T1,T3} | {T1,T2,T4} |

```
 70 | OBC_INTERNAL.MONITOR_FIRST_PASS                | false..true                     | {T1,T3}          | {T1,T3}
 71 | OBC_INTERNAL.PHASE1_TRANSITION_INHIBITED       | false..true                     | {T4}             | {T1,T2,T4}
 72 | PHASE_INTERNAL.CURRENT_PHASE                   | undefined..eps_qdp              | {T1,T2,T3,T4}    | {T1,T2,T3,T4}
 73 | PHASE_INTERNAL.ON_GROUND                       | false..true                     | {T1,T2,T4}       | {T3}
 74 | PILOT_INTERNAL.FIXED_BRAQUAGE_REQUESTED        | false..true                     | {T3,T4}          | {T3,T4}
 75 | PILOT_INTERNAL.IEPX                            | -32768..32767                   | {T4}             | {T3}
 76 | PILOT_INTERNAL.NFIEPX                          | -32768..32767                   | {T4}             | {T3}
 77 | PILOT_INTERNAL.NRAZ                            | -32768..32767                   | {T3,T4}          | {T3,T4}
 78 | SIMU_DATA.NEXT_INPUT_NB                        | 1..32                           | {T1,T2,T3,T4}    | {T1,T2,T3,T4}
 79 | SRI_INTERNAL.DIAL_AMONT_SRIN                   | -32768..32767                   | {T3,T4}          | {T3,T4}
 80 | SRI_INTERNAL.DIAL_AMONT_SRIS                   | -32768..32767                   | {T3,T4}          | {T3,T4}
 81 | SRI_INTERNAL.IALAT                             | -32768..32767                   | {T3,T4}          | {T3,T4}
 82 | SRI_INTERNAL.IHACC                             | false..true                     | {T4}             | {T3}
 83 | SRI_INTERNAL.IHATT                             | false..true                     | {T4}             | {T3}
 84 | SRI_INTERNAL.LGCFIL                            | false..true                     | {T3,T4}          | {T3,T4}
 85 | SRI_INTERNAL.NOCYN                             | -2147483648..2147483647         | {T3,T4}          | {T3,T4}
 86 | SRI_INTERNAL.NOCYNP                            | -2147483648..2147483647         | {T3,T4}          | {T3,T4}
 87 | SRI_INTERNAL.NOCYS                             | -2147483648..2147483647         | {T3,T4}          | {T3,T4}
 88 | SRI_INTERNAL.NOCYSP                            | -2147483648..2147483647         | {T3,T4}          | {T3,T4}
 89 | SRI_INTERNAL.SRI_VALIDITY                      | both_ok..backup_only            | {T3,T4}          | {T3,T4}
 90 | SRI_INTERNAL.UPSTREAM_FIRST_PASS               | false..true                     | {T3,T4}          | {T3,T4}
 91 | TIMER_INTERNAL.CURRENT_NAVIGATION_CYCLE        | cycle_1..cycle_8                | {T1,T3}          | {T1,T3}
 92 | TIMER_INTERNAL.PHASE_CYCLE_COUNTER             | 0..32767                        | {T1,T4}          | {T1,T4}
 93 | TIMER_INTERNAL.PREDICTED_AWOKEN_DATE           | -2147483648..2147483647         | {T3}             | {T1,T2,T3,T4}
 94 | TIMER_INTERNAL.SIXTEEN_CYCLE_COUNT             | cycle_1..cycle_16               | {T1,T3}          | {T1,T3}
 95 | UCTM_INTERNAL.ACTUAL_H0                        | -2147483648..2147483647         | {T1,T2,T3}       | {T4}
 96 | UCTM_INTERNAL.APP_CR_BC_ID_INDEX               | 1..2                            | {T1,T2,T3,T4}    | {T1,T2,T3,T4}
 97 | UCTM_INTERNAL.CURRENT_READ_POINTER_EVENT       | 1..8                            | {T1,T2,T3,T4}    | {T1,T2,T3,T4}
 98 | UCTM_INTERNAL.CURRENT_WRITE_POINTER_EVENT      | 1..8                            | {T1,T2,T3}       | {T1,T2,T3}
 99 | UCTM_INTERNAL.KD_DM                            | 1..25                           | {T3}             | {T3,T5}
100 | UCTM_INTERNAL.MSG_6_BC_ID_INDEX                | 1..3                            | {T1,T2,T3,T4}    | {T1,T2,T3,T4}
101 | UCTM_INTERNAL.OBC_STATE                        | initialise..applicat...bc_mode  | {T1,T2,T3,T4}    | {T1,T2,T4}
102 | UCTM_INTERNAL.TELE_IS_STOPPED                  | false..true                     | {T3}             | {T1,T2,T4}
```

File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.

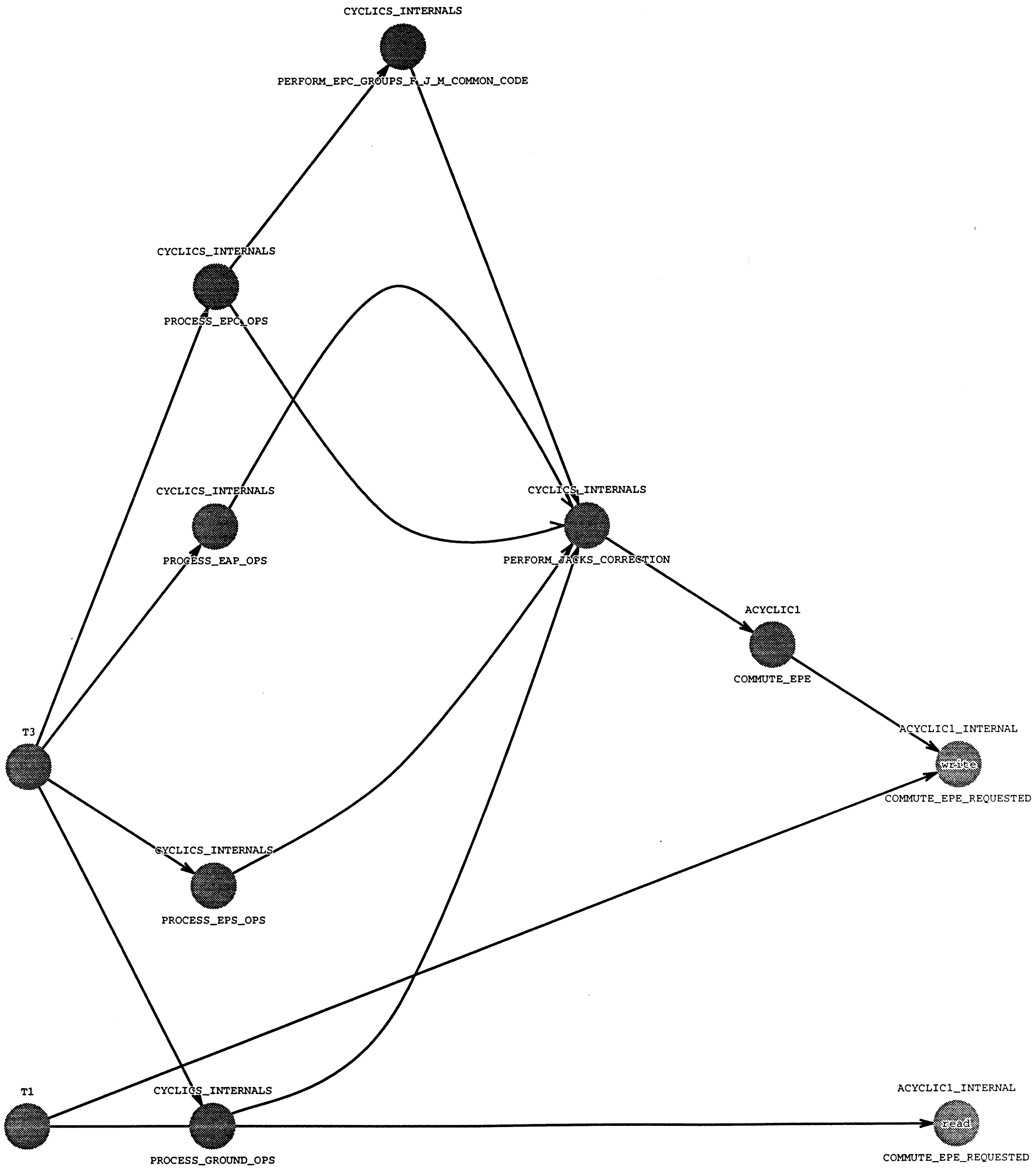


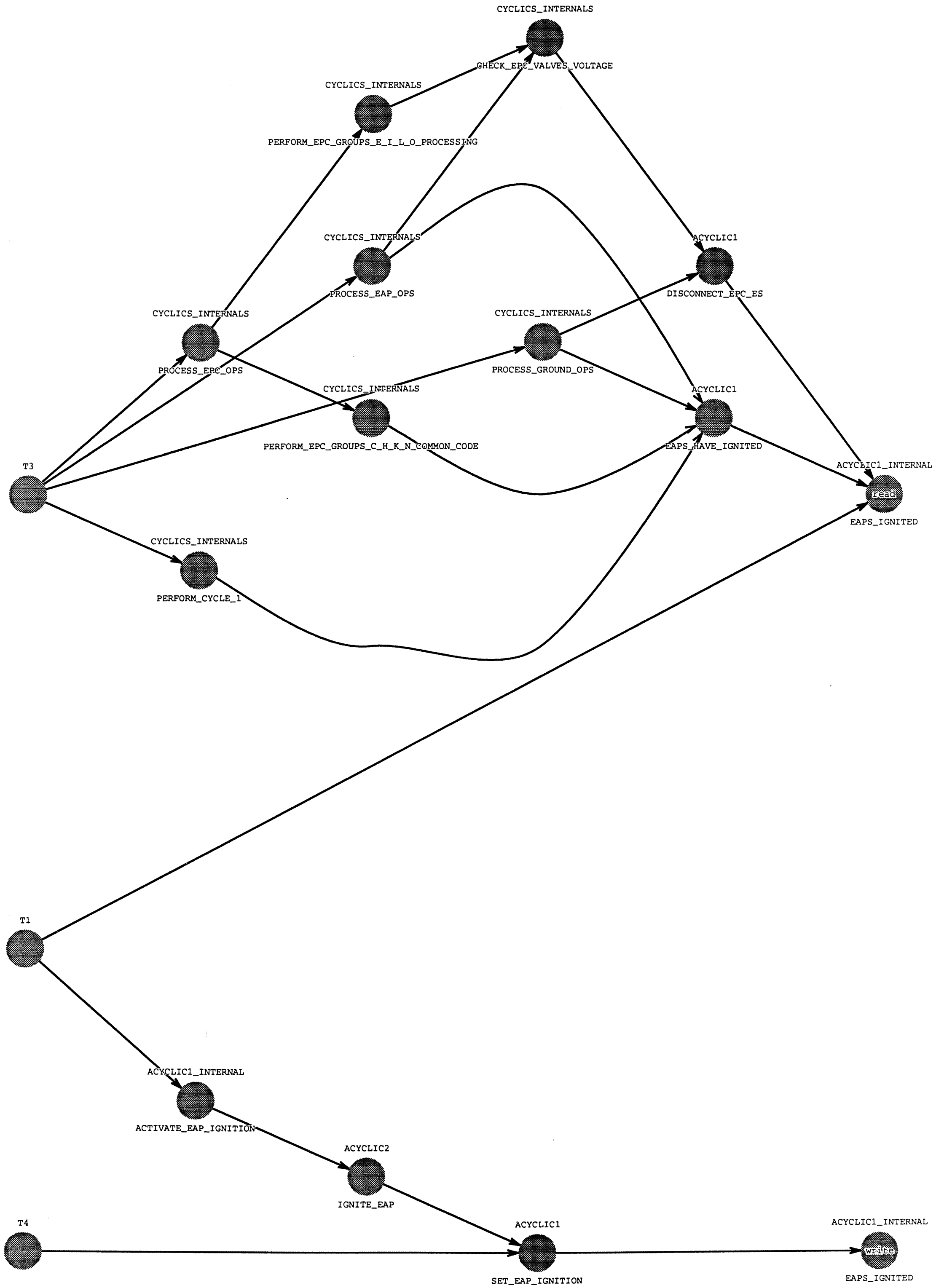
File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.

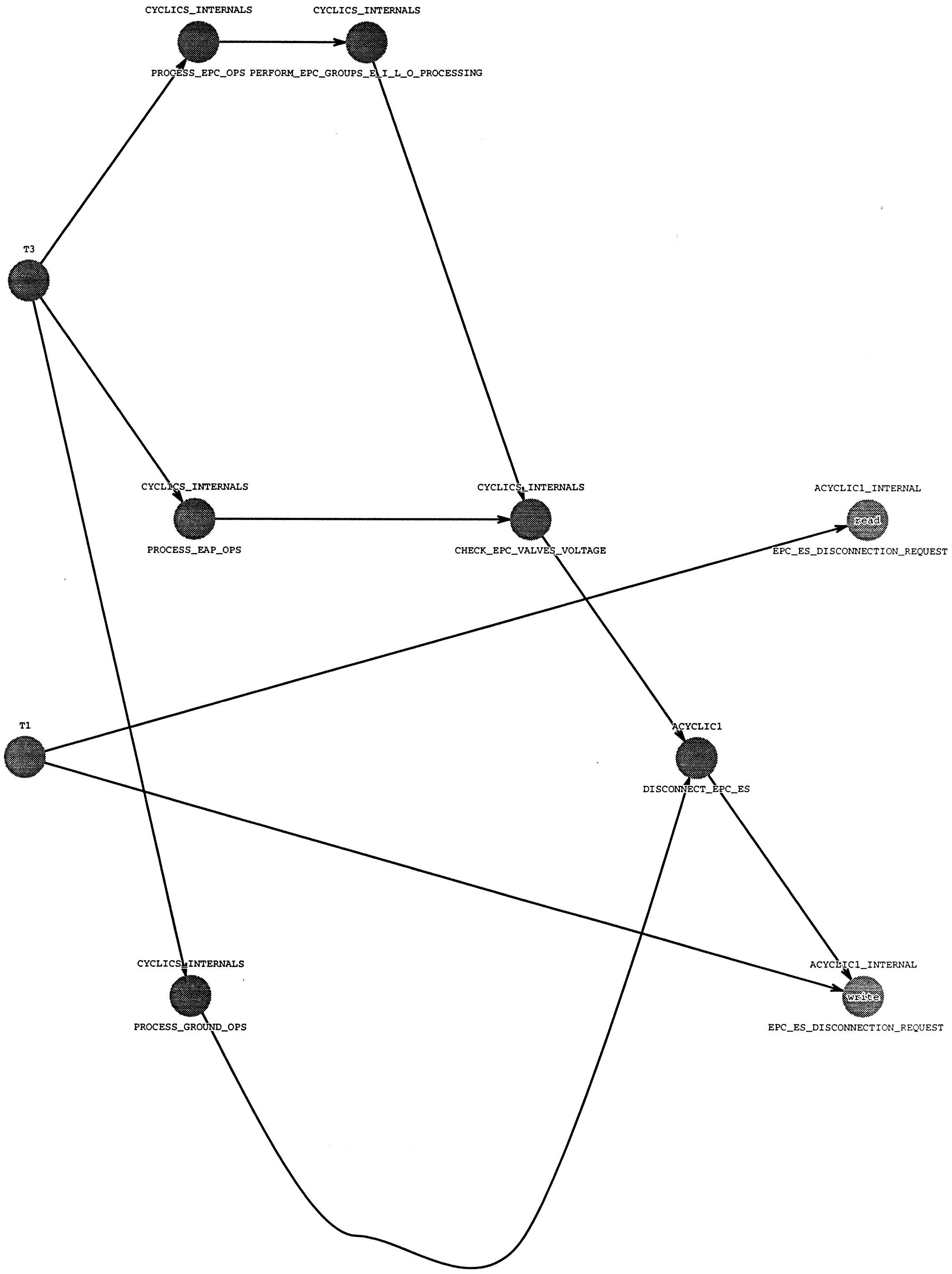


Possibly concurrent accesses for scalar #3, ACYCLIC1_INTERNAL.AXIS_TO_BE_COMMUTED

File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.




CYCLICS_INTERNALS
CHECK_EPC_VALVES_VOLTAGE
CYCLICS_INTERNALS
PERFORM_EPC_GROUPS_E_I_L_O_PROCESSING
CYCLICS_INTERNALS
PROCESS_EAP_OPS
ACYCLIC1
DISCONNECT_EPC_ES
CYCLICS_INTERNALS
PROCESS_EPC_OPS
CYCLICS_INTERNALS
PROCESS_GROUND_OPS
CYCLICS_INTERNALS
PERFORM_EPC_GROUPS_C_H_K_N_COMMON_CODE
ACYCLIC1
EAPS_HAVE_IGNITED
T3
ACYCLIC1_INTERNAL
read
EAPS_IGNITED
CYCLICS_INTERNALS
PERFORM_CYCLE_1
T1
ACYCLIC1_INTERNAL
ACTIVATE_EAP_IGNITION
ACYCLIC2
IGNITE_EAP
T4
ACYCLIC1
SET_EAP_IGNITION
ACYCLIC1_INTERNAL
write
EAPS_IGNITED


CYCLICS_INTERNALS
PROCESS_EPC_OPS
CYCLICS_INTERNALS
PERFORM_EPC_GROUPS_E_I_L_O_PROCESSING
T3
CYCLICS_INTERNALS
PROCESS_EAP_OPS
CYCLICS_INTERNALS
CHECK_EPC_VALVES_VOLTAGE
ACYCLIC1_INTERNAL
read
EPC_ES_DISCONNECTION_REQUEST
T1
ACYCLIC1
DISCONNECT_EPC_ES
CYCLICS_INTERNALS
PROCESS_GROUND_OPS
ACYCLIC1_INTERNAL
write
EPC_ES_DISCONNECTION_REQUEST

JJL

```
File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.


Level 0 Concurrency Analysis for non scalars accessed by:
 T1) ACYCLIC1_INTERNAL.OBCS_TYPE (task), "acyclic1_internal_.ada" line 63, column 4:
        Task type OBCS_TYPE Is
        ^
 T2) ACYCLIC2_INTERNAL.OBCS_TYPE (task), "acyclic2_internal_.ada" line 69, column 4:
        Task type OBCS_TYPE Is
        ^
 T3) CYCLICS_INTERNALS.CYCLICS_OBCS_TYPE (task), "cyclics_internal_.ada" line 194, column 2:
        Task type CYCLICS_OBCS_TYPE Is
        ^
 T4) EXECUTIVE_INTERNAL.OBCS_TYPE (task), "executive_internal_.ada" line 50, column 3:
        task type OBCS_TYPE is
        ^
 T5) GUIDANCE_CONTROL_INTERNAL.OBCS_TYPE (task), "guidance_control_internal_.ada" line 51, column 0:
        Task type OBCS_TYPE Is
        ^

    | variable                                  | type                                | reads         | writes
  1 | <ASM-GLOBALS>                             |                                     | {}            | {T1,T2,T3,T4}
  2 | ACYCLIC2_EVENT_QUEUE.QUEUE     sem ?      | array(event_1..event...record>      | {T1,T2}       | {T1,T2,T3}
  3 | ATTITUDE_INTERNAL.GHA_COMMANDS            | #<record>                           | {T3}          | {T3,T5}
  4 | ATTITUDE_INTERNAL.PSID                    | float                               | {T4}          | {T3}
  5 | ATTITUDE_INTERNAL.TETAD                   | float                               | {T4}          | {T3}
  6 | ATTITUDE_INTERNAL.VPSID                   | float                               | {T4}          | {T3}
  7 | ATTITUDE_INTERNAL.VTETAD                  | float                               | {T4}          | {T3}
  8 | BGY_INTERNAL.MEAN_VELOCITIES              | #<record>                           | {T3,T4}       | {T3,T4}
  9 | BGY_INTERNAL.XPIL                         | #<record>                           | {T4}          | {T3}
 10 | CYCLICS_INTERNALS.TIME_AUTOPILO...CLE_STARTED | float                           | {T3}          | {T4}
 11 | DATA_TABLES_INTERNAL.A6L                  | float                               | {T4}          | {T3}
 12 | DATA_TABLES_INTERNAL.A6T                  | float                               | {T4}          | {T3}
 13 | DATA_TABLES_INTERNAL.BF_0                 | #<record>                           | {T4}          | {T3}
 14 | DATA_TABLES_INTERNAL.BLCOMP               | float                               | {T4}          | {T3}
 15 | DATA_TABLES_INTERNAL.BMAX                 | array(1..3) of float                | {T4}          | {T3}
 16 | DATA_TABLES_INTERNAL.BPF_0                | #<record>                           | {T4}          | {T3}
 17 | DATA_TABLES_INTERNAL.GAINC                | array(1..29) of float               | {T4}          | {T3}
 18 | DATA_TABLES_INTERNAL.GAING                | array(1..29) of float               | {T4}          | {T3}
 19 | DATA_TABLES_INTERNAL.GAINK                | array(1..29) of float               | {T4}          | {T3}
 20 | DATA_TABLES_INTERNAL.GAINST               | array(1..3) of float                | {T4}          | {T3}
 21 | DATA_TABLES_INTERNAL.GICL                 | float                               | {T4}          | {T3}
 22 | DATA_TABLES_INTERNAL.GICT                 | float                               | {T4}          | {T3}
 23 | DATA_TABLES_INTERNAL.KL                   | array(1..3) of float                | {T4}          | {T3}
 24 | DATA_TABLES_INTERNAL.KT                   | array(1..3) of float                | {T4}          | {T3}
```

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25 | DATA_TABLES_INTERNAL.PF_1_2                     | #<record>                      | {T4}              | {T3}
26 | DATA_TABLES_INTERNAL.PHID                       | float                          | {T4}              | {T3}
27 | DATA_TABLES_INTERNAL.VBMAX                      | array(1..3) of float           | {T4}              | {T3}
28 | DATA_TABLES_INTERNAL.VPHID                      | float                          | {T4}              | {T3}
29 | DATA_TABLES_INTERNAL.XBVERU                     | float                          | {T4}              | {T3}
30 | DATA_TABLES_INTERNAL.XBVERV                     | float                          | {T4}              | {T3}
31 | DATE.DESCRIPTOR_TABLE                           | array(eap_start..epc...record> | {T1,T2,T3,T4,T5}  | {T2,T3,T4,T5}
32 | DATE_PAYLOAD_SETUP.LIST                         | array(1..22) of #<record>      | {T2}              | {T3}
33 | EPC_INTERNAL.AT_HR1                             | #<record>                      | {T1,T2}           | {T1,T2}
34 | EPC_INTERNAL.AT_HR2                             | #<record>                      | {T1,T2}           | {T1,T2}
35 | EPC_INTERNAL.STEP_51_DATE                       | #<record>                      | {T1,T2}           | {T1,T2}
36 | EPC_INTERNAL.STOP_SEQ1_DATE                     | #<record>                      | {T1,T2}           | {T1,T2}
37 | EPC_INTERNAL.STOP_SEQ2_DATE                     | #<record>                      | {T1,T2}           | {T1,T2}
38 | EPC_INTERNAL.STOP_SUB_SEQ_DATE                  | #<record>                      | {T1,T2}           | {T1,T2}
39 | EPC_TANKS_INTERNAL.LOX_LH2_HE_VALVE_STATE       | array(evppo1..evpe2)...record> | {T1,T3}           | {T1,T3}
40 | EQUIP.FUNCTIONAL_STATES                         | array(eq_null..eq_kb...service | {T1,T2,T3}        | {T1,T2,T3,T4}
41 | EQUIP.SEL_STATUS_WORD                           | #<record>                      | {T1,T2,T3,T4}     | {T1,T2,T3,T4}
42 | ES.AXIS_NOT_FAILED_INT                          | array(axis_u..axis_v...e..true | {T2}              | {T1,T2,T3}
43 | EV.STATE_CMD                                    | array(group_epc_1..g...e..true | {T1,T2,T3}        | {T1,T2,T3}
44 | EV.STATE_CMD_2                                  | array(group_epc_1..g...e..true | {T3}              | {T1,T2,T3}
45 | EV.STATE_COMMUTE                                | array(group_epc_1..g...e..true | {T3}              | {T1,T2,T3}
46 | GUIDANCE_INTERNAL.C_M                           | array(1..5, 1..5) of float     | {T5}              | {T3,T5}
47 | GUIDANCE_INTERNAL.COEF                          | array(1..2) of float           | {T3}              | {T5}
48 | GUIDANCE_INTERNAL.COMA                          | array(1..3) of float           | {T3,T5}           | {T3,T5}
49 | GUIDANCE_INTERNAL.COMA2                         | array(1..3) of float           | {T3,T5}           | {T3,T5}
50 | GUIDANCE_INTERNAL.COMABC                        | array(1..3) of float           | {T3,T5}           | {T3,T5}
51 | GUIDANCE_INTERNAL.COMB                          | array(1..3) of float           | {T3,T5}           | {T3,T5}
52 | GUIDANCE_INTERNAL.COMB2                         | array(1..3) of float           | {T3,T5}           | {T3,T5}
53 | GUIDANCE_INTERNAL.COMBBC                        | array(1..3) of float           | {T3,T5}           | {T3,T5}
54 | GUIDANCE_INTERNAL.COMMANDS                      | array(1..5) of array...f float | {T3}              | {T5}
55 | GUIDANCE_INTERNAL.DELTA1                        | array(1..35) of float          | {T5}              | {T3,T5}
56 | GUIDANCE_INTERNAL.DINCDT                        | float                          | {T4}              | {T3}
57 | GUIDANCE_INTERNAL.DTGHA                         | float                          | {T3,T5}           | {T3,T5}
58 | GUIDANCE_INTERNAL.DUMAX                         | array(1..35) of float          | {T5}              | {T3,T5}
59 | GUIDANCE_INTERNAL.DYMAX                         | array(1..25) of float          | {T5}              | {T3,T5}
60 | GUIDANCE_INTERNAL.INC                           | array(1..25) of -32768..32767  | {T3,T5}           | {T3,T5}
61 | GUIDANCE_INTERNAL.INCDT                         | float                          | {T4}              | {T3}
62 | GUIDANCE_INTERNAL.K1Z                           | array(1..5) of -32768..32767   | {T5}              | {T3,T5}
63 | GUIDANCE_INTERNAL.K2Z                           | array(1..5) of -32768..32767   | {T5}              | {T3,T5}
64 | GUIDANCE_INTERNAL.MBAL                          | array(0..3) of float           | {T3,T5}           | {T3,T5}
65 | GUIDANCE_INTERNAL.MCOIF                         | float                          | {T5}              | {T3}
66 | GUIDANCE_INTERNAL.ME                            | array(1..2) of float           | {T3}              | {T5}
67 | GUIDANCE_INTERNAL.METAG                         | array(1..2) of float           | {T3}              | {T5}
68 | GUIDANCE_INTERNAL.NCT                           | array(1..5) of -32768..32767   | {T3,T5}           | {T3,T5}
69 | GUIDANCE_INTERNAL.NORDRE                        | array(1..25) of -32768..32767  | {T3}              | {T5}
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| | | | | |
|---|---|---|---|---|
| 70 | GUIDANCE_INTERNAL.NORMER | float | {T3} | {T5} |
| 71 | GUIDANCE_INTERNAL.NPROP | array(1..5) of -32768..32767 | {T5} | {T3,T5} |
| 72 | GUIDANCE_INTERNAL.TACQSRIAV | float | {T3,T5} | {T3,T5} |
| 73 | GUIDANCE_INTERNAL.TALLUEPS | float | {T3,T5} | {T3,T5} |
| 74 | GUIDANCE_INTERNAL.TC | array(0..5) of float | {T3,T5} | {T3,T5} |
| 75 | GUIDANCE_INTERNAL.TCB | array(1..3, 0..5) of float | {T3} | {T5} |
| 76 | GUIDANCE_INTERNAL.TCOIFPRED | float | {T3,T5} | {T3,T5} |
| 77 | GUIDANCE_INTERNAL.TEPCCS | float | {T5} | {T3,T5} |
| 78 | GUIDANCE_INTERNAL.TEPCPRED | float | {T3,T5} | {T3,T5} |
| 79 | GUIDANCE_INTERNAL.TEPSPRED | float | {T3,T5} | {T3,T5} |
| 80 | GUIDANCE_INTERNAL.TRES | array(0..5) of float | {T3,T5} | {T3,T5} |
| 81 | GUIDANCE_INTERNAL.TVALID | float | {T3,T5} | {T3,T5} |
| 82 | GUIDANCE_INTERNAL.U1 | array(1..35) of float | {T3,T5} | {T3,T5} |
| 83 | GUIDANCE_INTERNAL.UB | array(1..3, 1..35) of float | {T3} | {T5} |
| 84 | GUIDANCE_INTERNAL.XPTSEG | array(0..5, 1..6) of float | {T3,T5} | {T3,T5} |
| 85 | GUIDANCE_INTERNAL.XPTSEGB | array(1..3, 0..5, 1....f float | {T3} | {T5} |
| 86 | JACKS_INTERNALS.JACKS_DATA | array(eap1..eps) of #<record> | {T3,T4} | {T3,T4} |
| 87 | LN1.LN1_PROCEDURE_ACTIVE | #<record> | {} | {T1,T2,T3,T4} |
| 88 | LN1.UES10_CONTROL_OBSERVER_ACTIVE | #<record> | {} | {T1,T4} |
| 89 | LN1.UES12_FAST_WRITE_ACTIVE | #<record> | {} | {T1,T2,T3,T4} |
| 90 | LN1.UES2B_CHANGE_MODE_ANSWER_ACTIVE | #<record> | {} | {T1,T2,T4} |
| 91 | LN1.UES4_WRITE_DATA_ACTIVE | #<record> | {} | {T1,T2,T3,T4} |
| 92 | LN1.UES5_READ_DATA_ACTIVE | #<record> | {} | {T1,T2,T3,T4} |
| 93 | LN1.UES6_RUN_FRAME_ACTIVE | #<record> | {} | {T1,T3,T4} |
| 94 | LN1.UES7_STOP_FRAME_ACTIVE | #<record> | {} | {T1,T2,T4} |
| 95 | LN1.UES8A_SEND_DATA_ACTIVE | #<record> | {} | {T1,T2,T3,T4} |
| 96 | LN1.UES8B_DATA_ACQUISITION_ACTIVE | #<record> | {} | {T1,T2,T3,T4} |
| 97 | LN1.UT1_RECONFIGURATION_ACTIVE | #<record> | {} | {T1,T2,T3} |
| 98 | LN1.UT7_CONTROL_HARDWARE_ACTIVE | #<record> | {} | {T1,T2,T3,T4} |
| 99 | LN2_TIME.SUSPENSION_DATE | #<record> | {T3} | {T1,T2,T3} |
| 100 | MEAS_INTERNAL.BGY_DATA | #<record> | {T3,T4} | {T3,T4} |
| 101 | MEAS_INTERNAL.SRI_UPSTREAM_DATA | #<record> | {T3,T4} | {T3,T4} |
| 102 | NAVIGATION_INTERNAL.ACCNGL | array(1..3) of float | {T5} | {T3} |
| 103 | NAVIGATION_INTERNAL.NVRELA | float | {T4} | {T3} |
| 104 | NAVIGATION_INTERNAL.TACQSRIAV | float | {T5} | {T3} |
| 105 | NAVIGATION_INTERNAL.VEQ | array(1..3) of float | {T5} | {T3} |
| 106 | NAVIGATION_INTERNAL.XEQ | array(1..3) of float | {T5} | {T3} |
| 107 | OBC_INTERNAL.H0_OBT | #<record> | {T1} | {T4} |
| 108 | OBC_INTERNAL.RELBDP | array(bdp1case..bdp2.....65535 | {T1,T3} | {T1,T3} |
| 109 | OBC_INTERNAL.VALBDP | array(bdp1case..bdp2.....65535 | {T1,T3} | {T1,T3} |
| 110 | PILOT_INTERNAL.ATTITUDE_STATE | #<record> | {T1} | {T3,T4} |
| 111 | PILOT_INTERNAL.BLC | float | {T3,T4} | {T3,T4} |
| 112 | PILOT_INTERNAL.BLCDT | float | {T3,T4} | {T3,T4} |
| 113 | PILOT_INTERNAL.BLCE | float | {T3,T4} | {T3,T4} |
| 114 | PILOT_INTERNAL.BLCEPCDT | float | {T3,T4} | {T3,T4} |

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115 | PILOT_INTERNAL.BLFDT                          | float                        | {T3,T4}        | {T3,T4}
116 | PILOT_INTERNAL.BRAQUAGE_EAP1                  | #<record>                    | {T3,T4}        | {T3,T4}
117 | PILOT_INTERNAL.BRAQUAGE_EAP2                  | #<record>                    | {T3,T4}        | {T3,T4}
118 | PILOT_INTERNAL.BRAQUAGE_EPX                   | #<record>                    | {T3,T4}        | {T3,T4}
119 | PILOT_INTERNAL.BRC                            | float                        | {T3,T4}        | {T3,T4}
120 | PILOT_INTERNAL.BRCDT                          | float                        | {T3,T4}        | {T3,T4}
121 | PILOT_INTERNAL.BTC                            | float                        | {T3,T4}        | {T3,T4}
122 | PILOT_INTERNAL.BTCDT                          | float                        | {T3,T4}        | {T3,T4}
123 | PILOT_INTERNAL.BTCE                           | float                        | {T3,T4}        | {T3,T4}
124 | PILOT_INTERNAL.BTCEPCDT                       | float                        | {T3,T4}        | {T3,T4}
125 | PILOT_INTERNAL.BTFDT                          | float                        | {T3,T4}        | {T3,T4}
126 | PILOT_INTERNAL.CLC                            | float                        | {T3,T4}        | {T3,T4}
127 | PILOT_INTERNAL.COSALP_IEPX                    | float                        | {T4}           | {T3}
128 | PILOT_INTERNAL.COSIN_PHI                      | float                        | {T3,T4}        | {T3,T4}
129 | PILOT_INTERNAL.COSIN_PSI                      | float                        | {T3,T4}        | {T3,T4}
130 | PILOT_INTERNAL.CTC                            | float                        | {T3,T4}        | {T3,T4}
131 | PILOT_INTERNAL.DTPIL                          | float                        | {T4}           | {T3}
132 | PILOT_INTERNAL.FILTERED_ATTITUDE              | #<record>                    | {T3}           | {T4}
133 | PILOT_INTERNAL.PUELEPX                        | array(0..2) of float         | {T3,T4}        | {T3,T4}
134 | PILOT_INTERNAL.PUETEPX                        | array(0..2) of float         | {T3,T4}        | {T3,T4}
135 | PILOT_INTERNAL.PYSLEPX                        | array(0..2) of float         | {T3,T4}        | {T3,T4}
136 | PILOT_INTERNAL.PYSLINT                        | float                        | {T4}           | {T3}
137 | PILOT_INTERNAL.PYSTEPX                        | array(0..2) of float         | {T3,T4}        | {T3,T4}
138 | PILOT_INTERNAL.PYSTINT                        | float                        | {T4}           | {T3}
139 | PILOT_INTERNAL.SINALP_IEPX                    | float                        | {T4}           | {T3}
140 | PILOT_INTERNAL.SINUS_PHI                      | float                        | {T3,T4}        | {T3,T4}
141 | PILOT_INTERNAL.SINUS_PSI                      | float                        | {T3,T4}        | {T3,T4}
142 | PILOT_INTERNAL.UELEPX                         | array(0..2, 1..5) of float   | {T3,T4}        | {T3,T4}
143 | PILOT_INTERNAL.UETEPX                         | array(0..2, 1..5) of float   | {T3,T4}        | {T3,T4}
144 | PILOT_INTERNAL.VPUELEPX                       | array(0..2) of float         | {T3,T4}        | {T3,T4}
145 | PILOT_INTERNAL.VPUETEPX                       | array(0..2) of float         | {T3,T4}        | {T3,T4}
146 | PILOT_INTERNAL.VPYSLEPX                       | array(0..2) of float         | {T3,T4}        | {T3,T4}
147 | PILOT_INTERNAL.VPYSLINT                       | float                        | {T4}           | {T3}
148 | PILOT_INTERNAL.VPYSTEPX                       | array(0..2) of float         | {T3,T4}        | {T3,T4}
149 | PILOT_INTERNAL.VPYSTINT                       | float                        | {T4}           | {T3}
150 | PILOT_INTERNAL.XPIL                           | array(1..29) of float        | {T3,T4}        | {T3,T4}
151 | PILOT_INTERNAL.YSLEPX                         | array(0..2, 1..5) of float   | {T3,T4}        | {T3,T4}
152 | PILOT_INTERNAL.YSLINT                         | array(1..5) of float         | {T4}           | {T3}
153 | PILOT_INTERNAL.YSTEPX                         | array(0..2, 1..5) of float   | {T3,T4}        | {T3,T4}
154 | PILOT_INTERNAL.YSTINT                         | array(1..5) of float         | {T4}           | {T3}
155 | PILOT_INTERNAL.YTETAM                         | float                        | {T3}           | {T4}
156 | SRI_INTERNAL.ALF                              | array(1..3) of float         | {T3,T4}        | {T3,T4}
157 | SRI_INTERNAL.ATTITUDE_ANGLES                  | #<record>                    | {T3,T4}        | {T3,T4}
158 | SRI_INTERNAL.ATTN_INDIC                       | array(1..3) of -32768..32767 | {T3,T4}        | {T3,T4}
159 | SRI_INTERNAL.ATTNDT                           | array(1..3) of float         | {T3,T4}        | {T3,T4}
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|---|---|---|---|---|
| 160 | SRI_INTERNAL.ATTS_INDIC | array(1..3) of -32768..32767 | {T3,T4} | {T3,T4} |
| 161 | SRI_INTERNAL.ATTSDT | array(1..3) of float | {T3,T4} | {T3,T4} |
| 162 | SRI_INTERNAL.BRC | float | {T3} | {T3,T4} |
| 163 | SRI_INTERNAL.IATT | array(1..3) of -32768..32767 | {T3,T4} | {T3,T4} |
| 164 | SRI_INTERNAL.NREJA | array(1..3) of -32768..32767 | {T3,T4} | {T3,T4} |
| 165 | SRI_INTERNAL.PHIN0 | float | {T3,T4} | {T3,T4} |
| 166 | SRI_INTERNAL.PHIN1 | float | {T3,T4} | {T3,T4} |
| 167 | SRI_INTERNAL.PHINF | float | {T3,T4} | {T3,T4} |
| 168 | SRI_INTERNAL.PHINP | float | {T3,T4} | {T3,T4} |
| 169 | SRI_INTERNAL.PHIS0 | float | {T3,T4} | {T3,T4} |
| 170 | SRI_INTERNAL.PHIS1 | float | {T3,T4} | {T3,T4} |
| 171 | SRI_INTERNAL.PHISF | float | {T3,T4} | {T3,T4} |
| 172 | SRI_INTERNAL.PHISP | float | {T3,T4} | {T3,T4} |
| 173 | SRI_INTERNAL.PREDICTED_ATTITUDE_ANGLES | #<record> | {T4} | {T3} |
| 174 | SRI_INTERNAL.PSIN0 | float | {T3,T4} | {T3,T4} |
| 175 | SRI_INTERNAL.PSIN1 | float | {T3,T4} | {T3,T4} |
| 176 | SRI_INTERNAL.PSINF | float | {T3,T4} | {T3,T4} |
| 177 | SRI_INTERNAL.PSINP | float | {T3,T4} | {T3,T4} |
| 178 | SRI_INTERNAL.PSIS0 | float | {T3,T4} | {T3,T4} |
| 179 | SRI_INTERNAL.PSIS1 | float | {T3,T4} | {T3,T4} |
| 180 | SRI_INTERNAL.PSISF | float | {T3,T4} | {T3,T4} |
| 181 | SRI_INTERNAL.PSISP | float | {T3,T4} | {T3,T4} |
| 182 | SRI_INTERNAL.TACQSRIAM | float | {T3,T4} | {T3,T4} |
| 183 | SRI_INTERNAL.TETAN0 | float | {T3,T4} | {T3,T4} |
| 184 | SRI_INTERNAL.TETAN1 | float | {T3,T4} | {T3,T4} |
| 185 | SRI_INTERNAL.TETANF | float | {T3,T4} | {T3,T4} |
| 186 | SRI_INTERNAL.TETANP | float | {T3,T4} | {T3,T4} |
| 187 | SRI_INTERNAL.TETAS0 | float | {T3,T4} | {T3,T4} |
| 188 | SRI_INTERNAL.TETAS1 | float | {T3,T4} | {T3,T4} |
| 189 | SRI_INTERNAL.TETASF | float | {T3,T4} | {T3,T4} |
| 190 | SRI_INTERNAL.TETASP | float | {T3,T4} | {T3,T4} |
| 191 | SYSTEM.ADDRESS.* | #<record> | {T1,T2,T3,T4} | {T1,T3} |
| 192 | TIMER_INTERNAL.DRIFT | float | {T1,T2,T3} | {T4} |
| 193 | TIMER_INTERNAL.REFERENCE_OBT | #<record> | {T1,T2,T3} | {T4} |
| 194 | TIMER_INTERNAL.START_OF_CURRENT_CYCLE | float | {T1,T3,T4} | {T1,T4} |
| 195 | TIMER_INTERNAL.START_OF_CYCLE_OBT | #<record> | {T3,T4} | {T1,T4} |
| 196 | TIMER_INTERNAL.START_OF_NEXT_CYCLE | float | {T1,T3,T4} | {T1,T4} |
| 197 | UCTM_INTERNAL.BGY_STATUS_DM | #<record> | {T3} | {T3,T4} |
| 198 | UCTM_INTERNAL.COEFF_DM | array(1..2) of float | {T3} | {T3,T5} |
| 199 | UCTM_INTERNAL.EAP_NOMINAL_DEFLECTION_DM | #<record> | {T3} | {T3,T4} |
| 200 | UCTM_INTERNAL.EAP_NOMINAL_PILOT_VECTOR_2_DM | #<record> | {T3} | {T3,T4} |
| 201 | UCTM_INTERNAL.EAP_QDP_DEFLECTION_DM | #<record> | {T3} | {T3,T4} |
| 202 | UCTM_INTERNAL.EAP_QDP_PILOT_VECTOR_2_DM | #<record> | {T3} | {T3,T4} |
| 203 | UCTM_INTERNAL.EPC_EPS_DEFLECTION_DM | #<record> | {T3} | {T4} |
| 204 | UCTM_INTERNAL.EPC_EPS_PILOT_VECTOR_2_DM | #<record> | {T3} | {T3,T4} |

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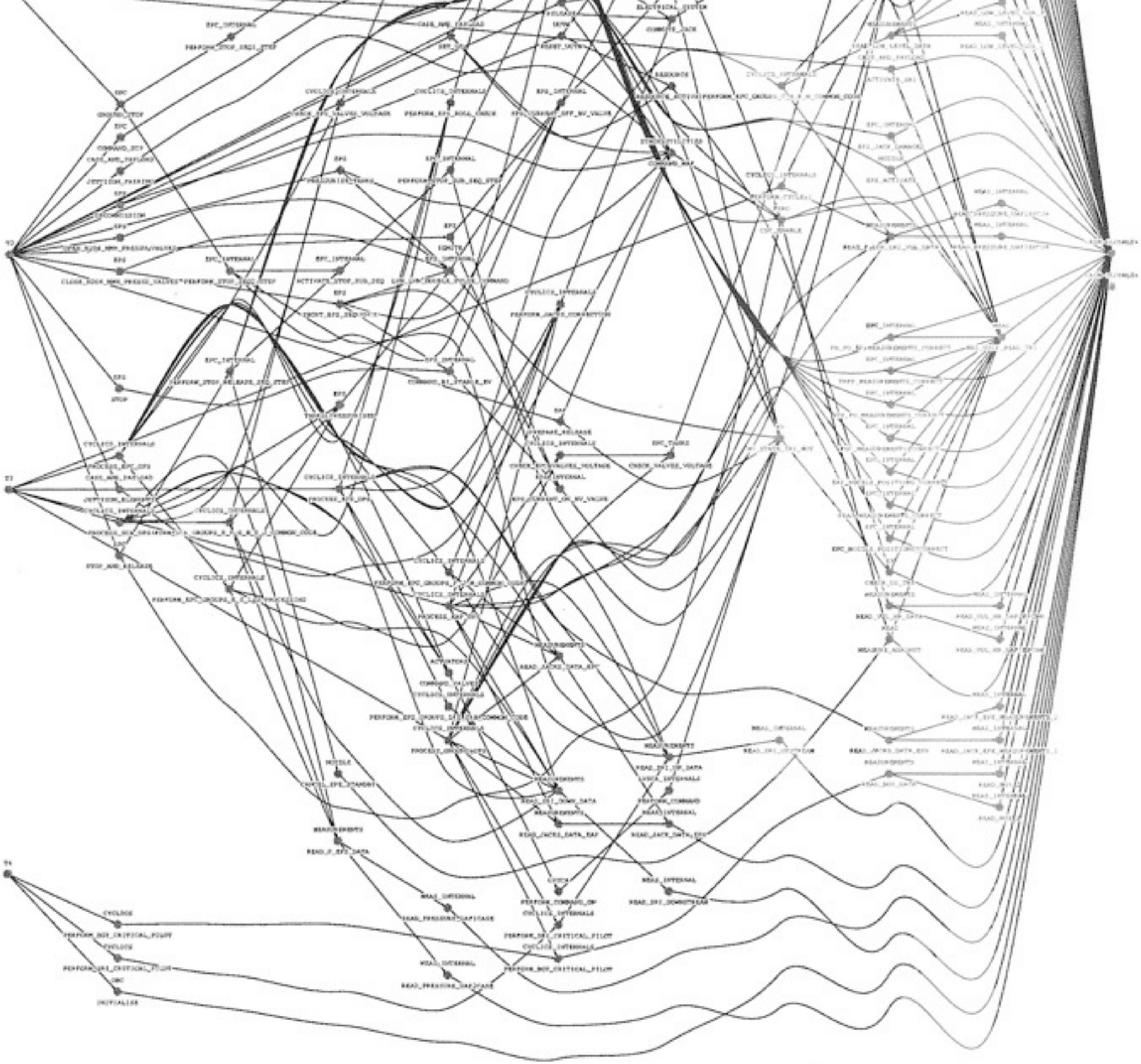
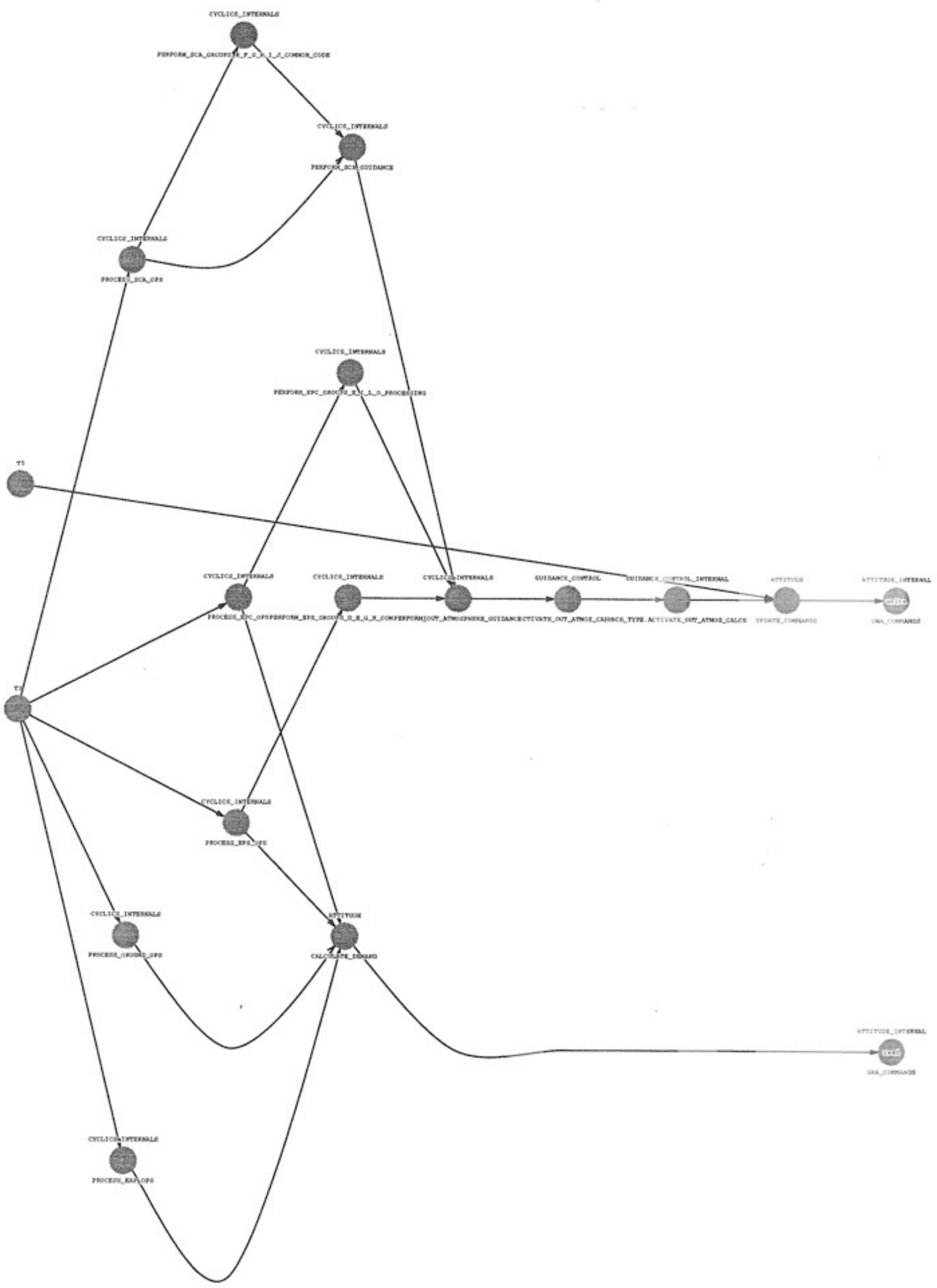
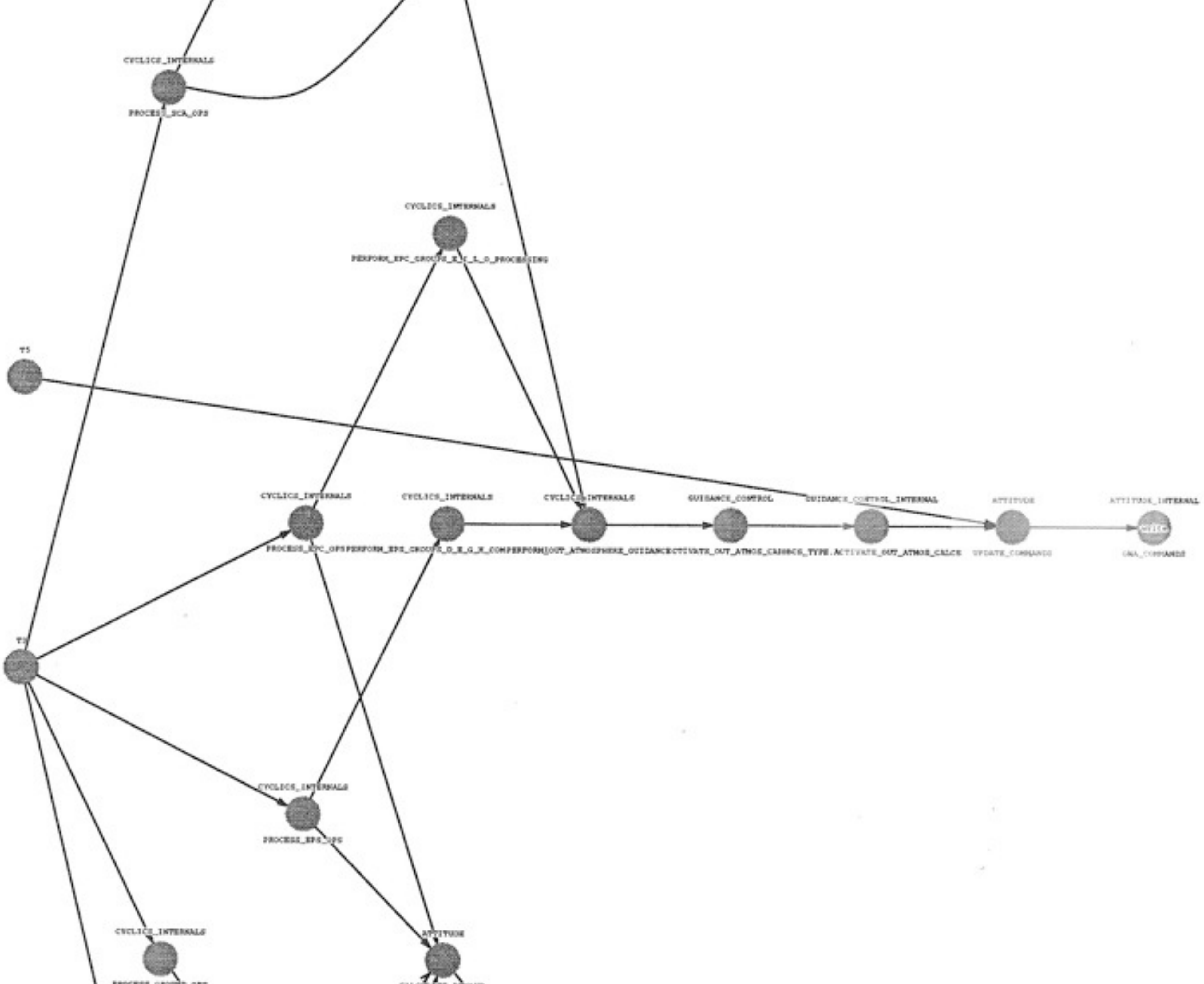
205 | UCTM_INTERNAL.GUIDANCE_CONSTRAINTS        | array(1..25) of -32768..32767 | {T3}           | {T3,T5}
206 | UCTM_INTERNAL.GUIDANCE_SEGMENT_COMMANDS   | array(1..5) of array...f float | {T3}          | {T3,T5}
207 | UCTM_INTERNAL.H0_DM                       | #<record>                     | {T1,T2,T3}     | {T4}
208 | UCTM_INTERNAL.LIST_EVENT                  | array(1..8) of #<record>      | {T1,T2,T3,T4}  | {T1,T2,T3,T4}
209 | UCTM_INTERNAL.MSG_1_EAP_NOMINAL_DM        | #<record>                     | {T3}           | {T3,T4}
210 | UCTM_INTERNAL.MSG_1_EAP_QDP_DM            | #<record>                     | {T3}           | {T3,T4}
211 | UCTM_INTERNAL.MSG_1_EPC_EPS_DM            | #<record>                     | {T3}           | {T3,T4}
212 | UCTM_INTERNAL.MSG_6_DM                    | #<record>                     | {T1,T2,T3,T4}  | {T1,T2,T3,T4,T5}
213 | UCTM_INTERNAL.MSG_8_DM                    | #<record>                     | {T3}           | {T3,T4}
214 | UCTM_INTERNAL.NORMER_DM                   | float                         | {T3}           | {T3,T5}
215 | UCTM_INTERNAL.SRI_ATTITUDE_STATUS_DM      | array(1..3) of -32768..32767  | {T3}           | {T3,T4}
216 | UCTM_INTERNAL.SRI_AXIS_STATUS_DM          | #<record>                     | {T3}           | {T3,T4}
217 | UCTM_INTERNAL.VELOCITY_COMMAND_DM         | #<record>                     | {T3}           | {T3,T4}
```



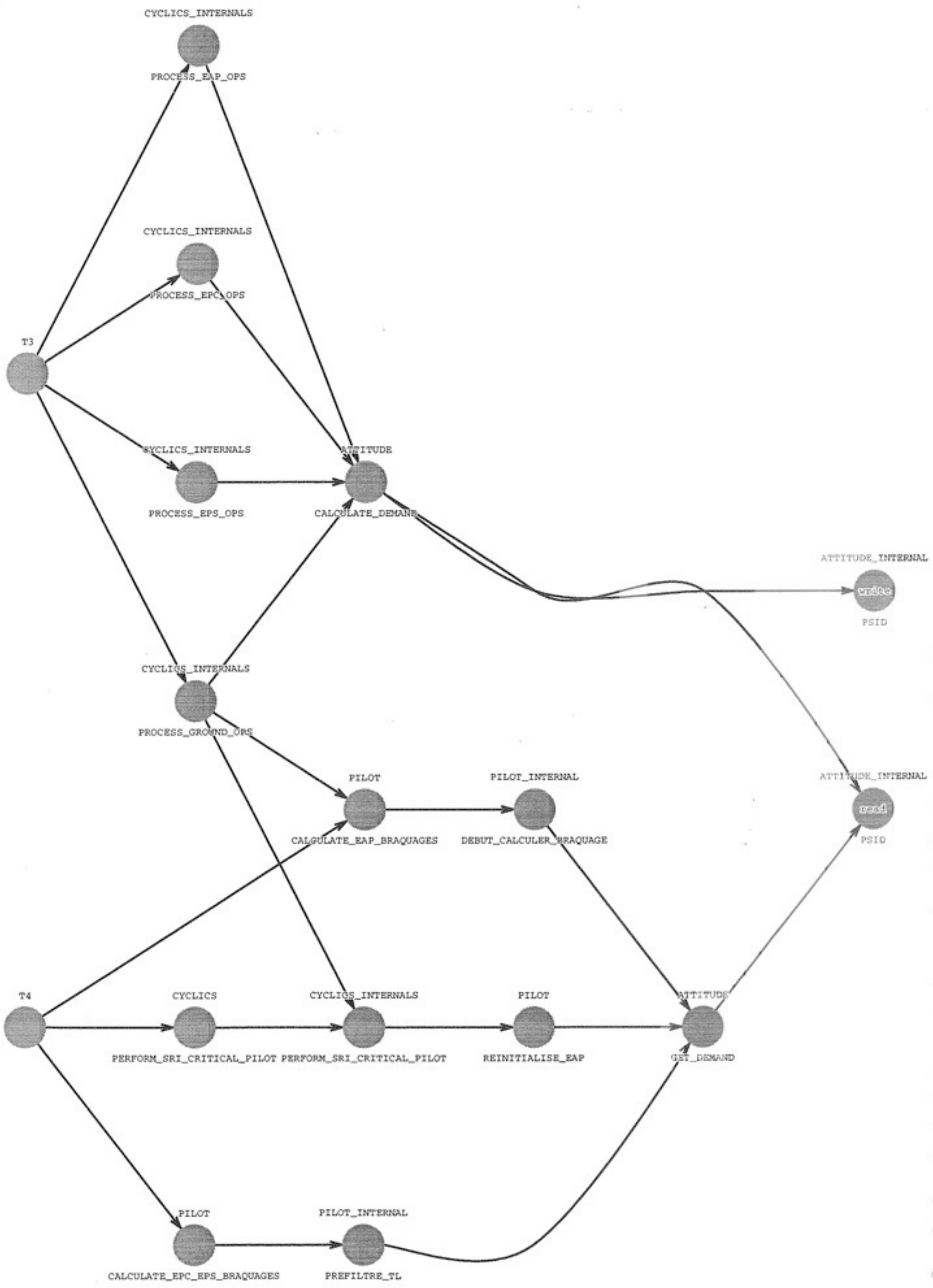
Possibly concurrent accesses for non-scalar #1: <ASM-GLOBALS>



Possibly concurrent accesses for non-scalar #3: ATTITUDE INTERNAL.GHA_COMMANDS

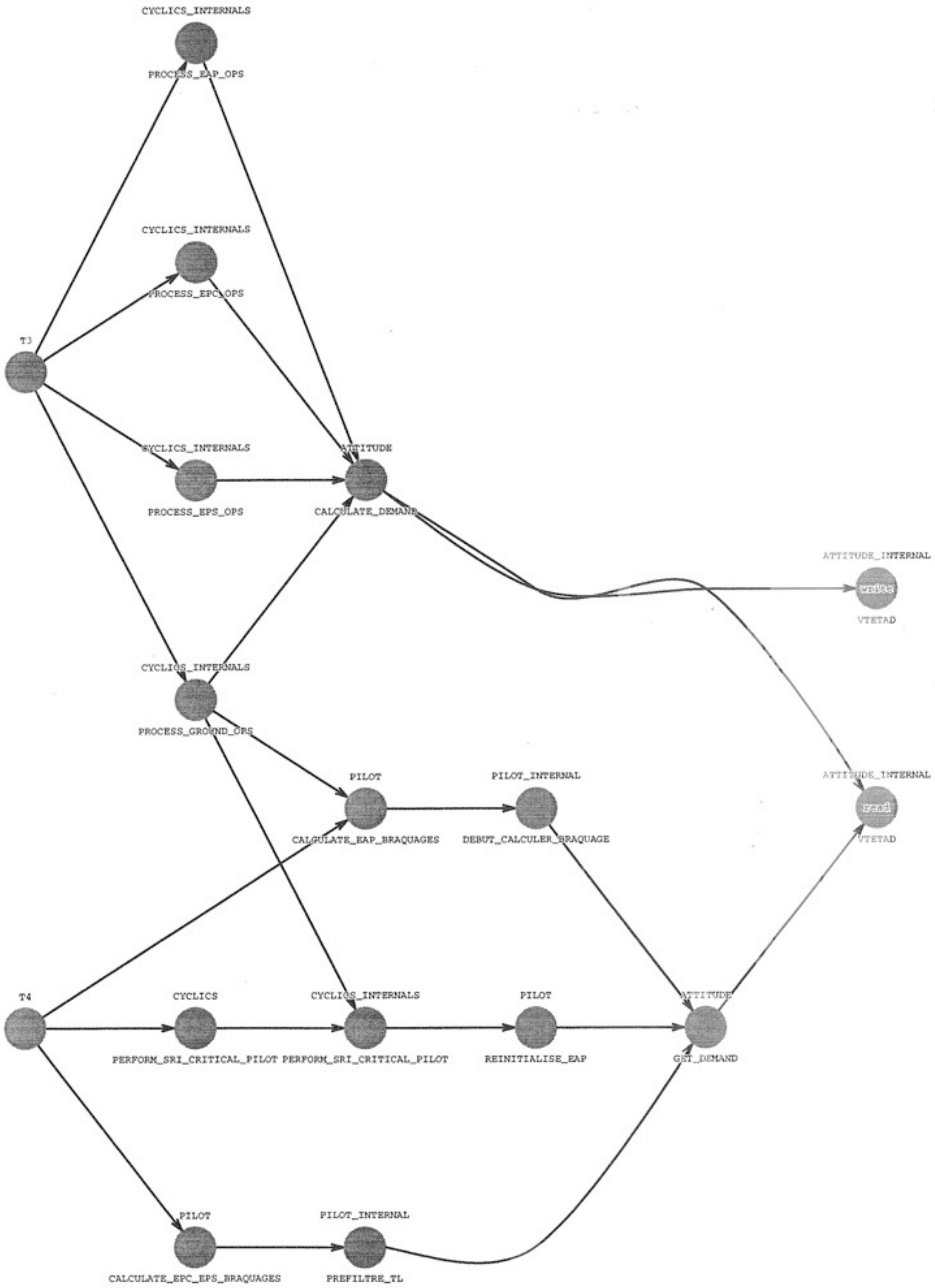

CYCLICS_INTERNALS
PROCESS_SCA_OPS
CYCLICS_INTERNALS
PERFORM_EPC_GROUPS_X_Y_Z_O_PROCESSING
T5
CYCLICS_INTERNALS
CYCLICS_INTERNALS
CYCLICS_INTERNALS
GUIDANCE_CONTROL
GUIDANCE_CONTROL_INTERNAL
ATTITUDE
ATTITUDE_INTERNAL
PROCESS_EPC_OPSPERFORM_EPS_GROUPS_D_E_G_H_COMPERFORMOUT_ATMOSPHERE_GUIDANCECTIVATE_OUT_ATMOS_CASSBCS_TYPE.ACTIVATE_OUT_ATMOS_CALCS
UPDATE_COMMANDS
GNA_COMMANDS
T1
CYCLICS_INTERNALS
PROCESS_EPS_OPS
CYCLICS_INTERNALS
ATTITUDE

File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.

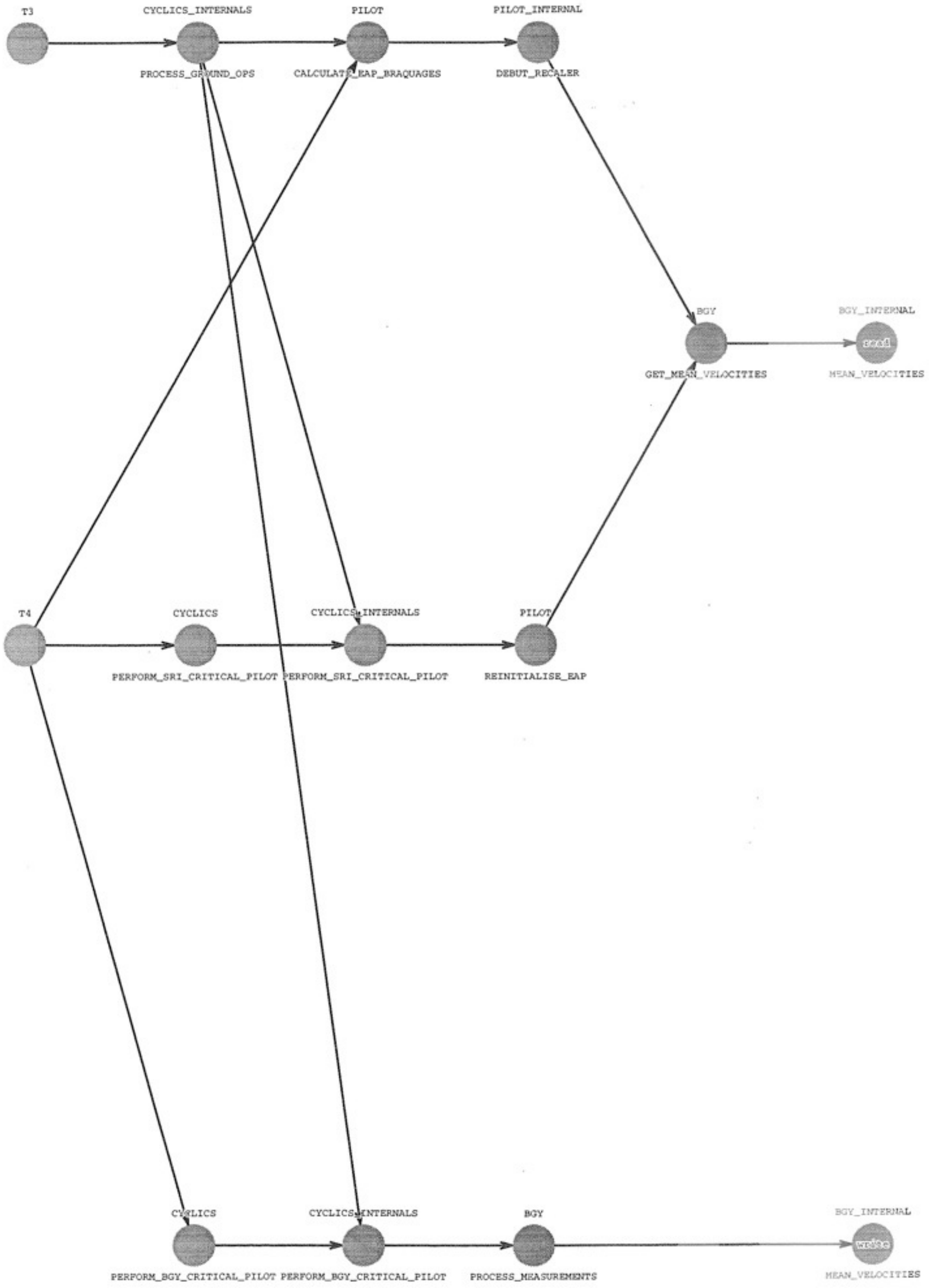


Possibly concurrent accesses for non-scalar #4: ATTITUDE_INTERNAL.PSID

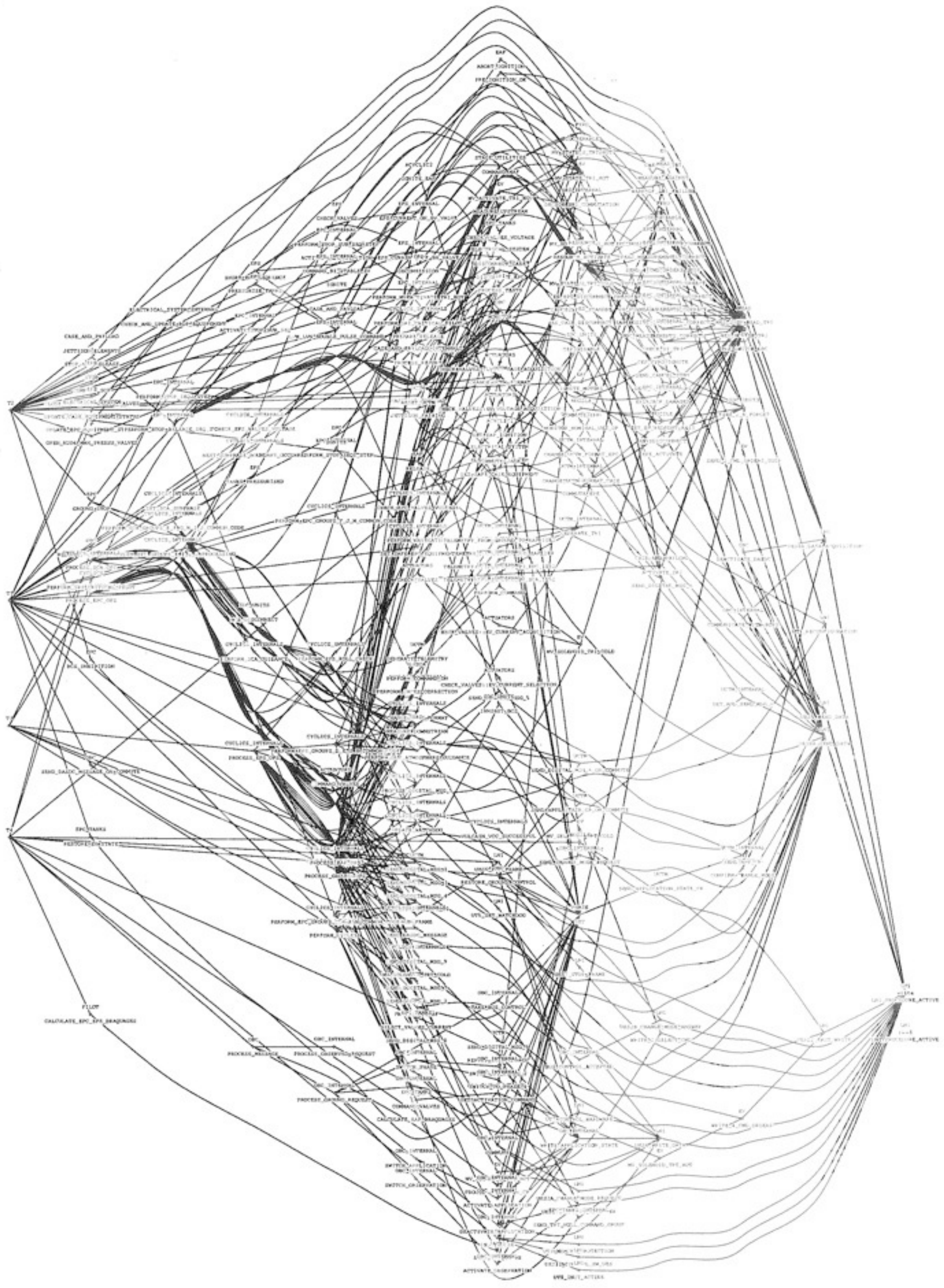
File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.



Possibly concurrent accesses for non-scalar #7: ATTITUDE_INTERNAL.VTETAD

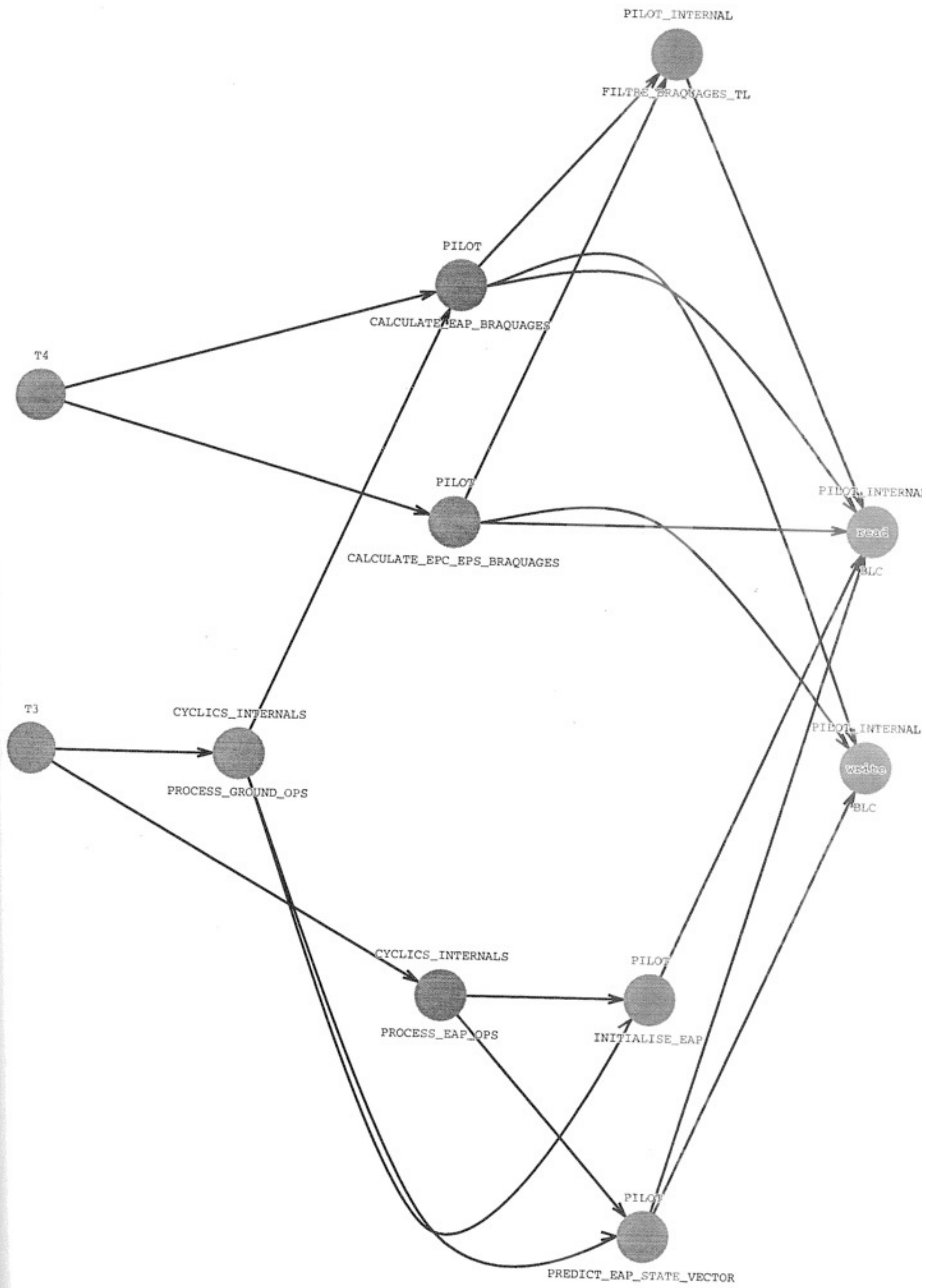


Possibly concurrent accesses for non-scalar #8: BGY_INTERNAL.MEAN_VELOCITIES

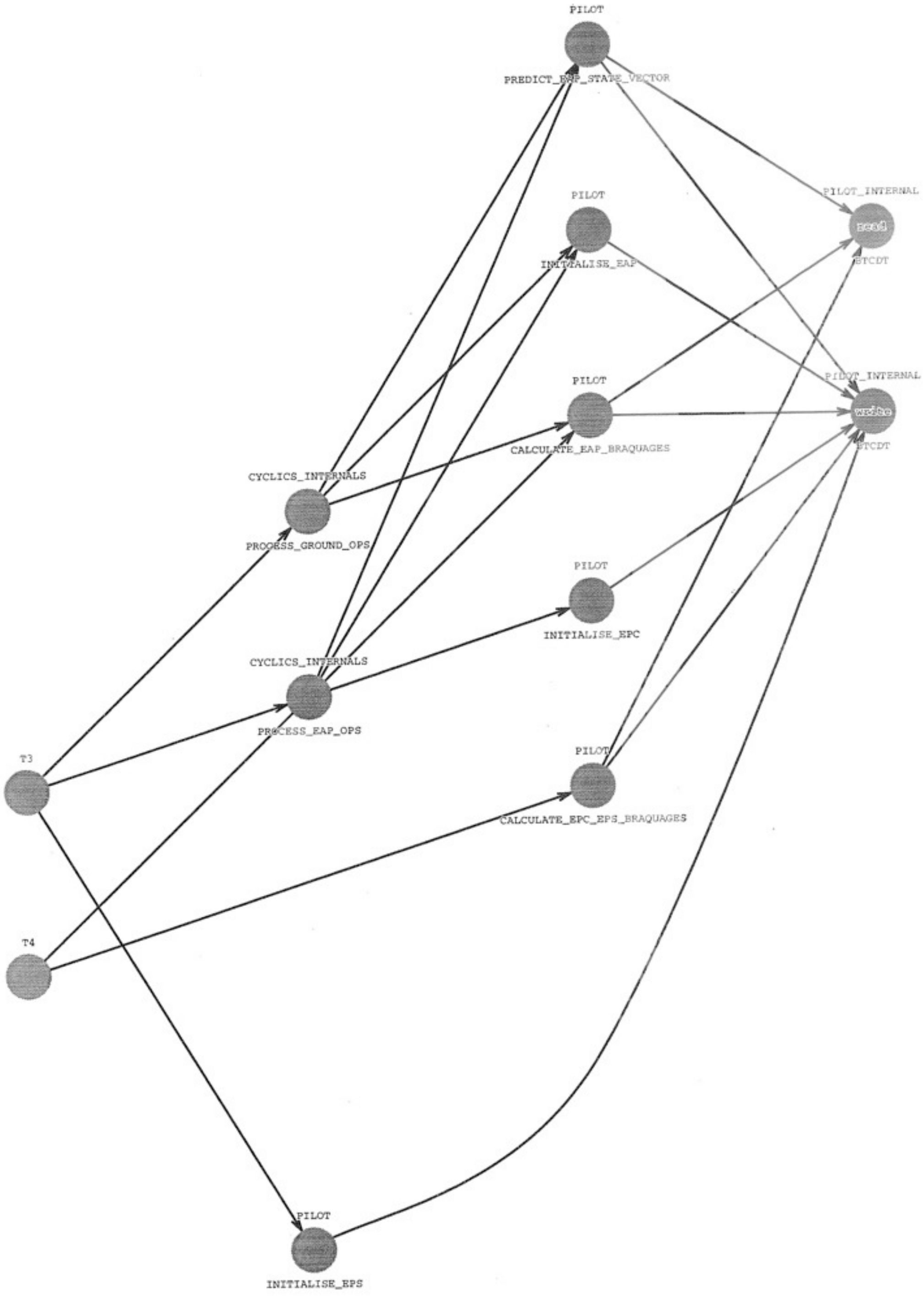


Possibly concurrent accesses for non-scalar #87: LN1.LN1_PROCEDURE_ACTIVE

File generated on Jan 24, 1997 by IABC V0.1, the INRIA static program analyzer.



Possibly concurrent accesses for non-scalar #111: PILOT_INTERNAL



Possibly concurrent accesses for non-scalar #122: PILOT_INTERNAL.BTCDT

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File generated on Mar 14, 1997 by IABC V0.1, the INRIA static program analyzer.


Level 0 Concurrency Analysis for scalars accessed by:
 T1) TRT_200HERTZ.TRAITER_INITIAL (procedure), "trt_200hertz.ads" line 74, column 0:
        procedure TRAITER_INITIAL ( S : in TE.T_SELECTEUR := TE.SELECTEUR_NUL) ;
        ^
 T2) TRT_200HERTZ.TRAITER_OPERAT (procedure), "trt_200hertz.ads" line 81, column 0:
        procedure TRAITER_OPERAT ( S : in TE.T_SELECTEUR := TE.SELECTEUR_NUL) ;
        ^
 T3) TRT_200HERTZ.TRAITER_TEST (procedure), "trt_200hertz.ads" line 88, column 0:
        procedure TRAITER_TEST ( S : in TE.T_SELECTEUR := TE.SELECTEUR_NUL) ;
        ^
 T4) TRT_BUS.TRAITER_IT1 (procedure), "trt_bus.ads" line 76, column 0:
        procedure TRAITER_IT1;
        ^
 T5) TRT_BUS.TRAITER_IT2 (procedure), "trt_bus.ads" line 85, column 0:
        procedure TRAITER_IT2;
        ^
 T6) TRT_BUS.TRAITER_IT3 (procedure), "trt_bus.ads" line 94, column 0:
        procedure TRAITER_IT3;
        ^
 T7) TRT_DATA_STORE.TRAITER_ECR_EXCEPT_DS (procedure), "trt_data_store.ads" line 92, column 0:
        procedure TRAITER_ECR_EXCEPT_DS (S:in TE.T_SELECTEUR := TE.SELECTEUR_NUL);
        ^
 T8) TRT_DATA_STORE.TRAITER_ECRITURE_DS (procedure), "trt_data_store.ads" line 76, column 0:
        procedure TRAITER_ECRITURE_DS (S:in TE.T_SELECTEUR := TE.SELECTEUR_NUL);
        ^
 T9) TRT_DATA_STORE.TRAITER_LECTURE_DS (procedure), "trt_data_store.ads" line 61, column 0:
        procedure TRAITER_LECTURE_DS (S:in TE.T_SELECTEUR := TE.SELECTEUR_NUL);
        ^
 T10) TRT_INITIAL.INITIALISER_OPERAT (procedure), "trt_initial.ads" line 64, column 3:
         procedure INITIALISER_OPERAT (S : in TE.T_SELECTEUR := TE.SELECTEUR_NUL);
         ^
 T11) TRT_SURVEILLANCES.TRAITER_SURVEILLANCES (procedure), "trt_surveillances.ads" line 65, column 0:
         procedure TRAITER_SURVEILLANCES ( S : in TE.T_SELECTEUR := TE.SELECTEUR_NUL ) ;
         ^
 T12) TRT_SURVEILLANCES.TRAITER_TESTS_INTERNES (procedure), "trt_surveillances.ads" line 57, column 0:
         procedure TRAITER_TESTS_INTERNES ( S : in TE.T_SELECTEUR := TE.SELECTEUR_NUL ) ;
         ^

     | variable                                    | type          | reads             | writes
   1 | ALIGNEMENT.G_M_ETAT_ALIGN                   | false..true   | {T3,T7,T1}        | {T2}
   2 | ALIGNEMENT.G_M_SURVEILLANCE                 | false..true   | {T3,T1}           | {T2}
   3 | BOOLEENS_SYSTEME.G_M_VALEUR_BTF             | false..true   | {T2,T3,T12,T1}    | {T2,T3,T1}
   4 | DIALOGUE_ARC.G_M_ECRIRE_ARC                 | false..true   | {}                | {T3,T1}
   5 | DIALOGUE_ARC.G_M_NOMBRE_MOTS_OPERAT         | 0..255        | {T2,T3,T1}        | {T2,T3,T1}
   6 | DIALOGUE_ARC.G_M_PANNE_ARC                  | false..true   | {T2,T3,T1}        | {T2,T3,T1}
   7 | DIALOGUE_BUS.G_M_CASE_TEST                  | 0..65535      | {T2,T3,T7,T1}     | {T2,T3,T7,T1}
   8 | DIALOGUE_BUS.G_M_CYCLES_DEPUIS_ANOMALIE     | 0..65535      | {T2,T3,T1}        | {T2,T3,T7,T1}
 x 9 | DIALOGUE_BUS.G_M_MODIFIE                    | false..true   | {T2,T3,T7,T1}     | {T8,T2,T3,T7,T1}
  10 | DIALOGUE_BUS.G_M_NB_ANOMALIES_PROTONS       | 0..65535      | {T2,T3,T7,T1}     | {T2,T3,T7,T1}
  11 | DIALOGUE_BUS.G_M_SEUIL_PROTONS_QUATER       | 0..65535      | {T3,T7,T1}        | {T2}
  12 | DIALOGUE_BUS.G_M_SEUIL_PROTONS_VITESSE      | 0..65535      | {T3,T7,T1}        | {T2}
  13 | DIALOGUE_BUS.G_M_SURVEILLANCE_PROTONS_ACTIVE | false..true  | {T2,T3,T7,T1}     | {T2,T3,T7,T1}
```

| | | | | |
|---|---|---|---|---|
| 14 | GESTION_DATA_STORE.G_C_TEMPS_SA...LE_EN_COURS | 0..2147483647 | {T2,T3,T1} | {T2,T3,T1} |
| 15 | GESTION_DATA_STORE.G_M_ADRESSE_LUE | 0..65535 | {T2,T3,T1} | {T2,T3,T1} |
| 16 | GESTION_DATA_STORE.G_M_ADRESSE_PFA | integer mod 429496729...94967295 | {T2,T3,T1} | {T9} |
| 17 | GESTION_DATA_STORE.G_M_ANGLE_A_SAUVEGARDER | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 18 | GESTION_DATA_STORE.G_M_BORNE_MESSAGE_ETENDU | 0..65535 | {T2,T3,T7,T1} | {T8} |
| 19 | GESTION_DATA_STORE.G_M_CONTEXTE_PANNE_A_LIRE | false..true | {T2,T3,T7,T1} | {T2,T3,T7,T1} |
| 20 | GESTION_DATA_STORE.G_M_CRC_TROU...SAUVEGARDER | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 21 | GESTION_DATA_STORE.G_M_DS_01_MODIFIEE | true..false | {} | {T8,T2} |
| 22 | GESTION_DATA_STORE.G_M_DS_04_MODIFIEE | true..false | {} | {T8,T2} |
| 23 | GESTION_DATA_STORE.G_M_DS_05_MODIFIEE | true..false | {} | {T8,T2} |
| 24 | GESTION_DATA_STORE.G_M_DS_06_MODIFIEE | true..false | {} | {T8,T2} |
| 25 | GESTION_DATA_STORE.G_M_DS_07_MODIFIEE | true..false | {} | {T8,T2} |
| 26 | GESTION_DATA_STORE.G_M_DS_08_MODIFIEE | true..false | {} | {T8,T2} |
| 27 | GESTION_DATA_STORE.G_M_DS_VALEUR_CS | 0..65535 | {T2,T3,T1} | {T2,T3,T1} |
| 28 | GESTION_DATA_STORE.G_M_ETAT_PREC | e_init0..e_pr | {T2,T3,T1} | {T2,T3,T1} |
| 29 | GESTION_DATA_STORE.G_M_LECTURE_DS_DEMANDEE | false..true | {T9,T2,T3,T1} | {T9,T2,T3,T1} |
| 30 | GESTION_DATA_STORE.G_M_MODIF_TABLE_CPT_STAT | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 31 | GESTION_DATA_STORE.G_M_MODIF_TA...T_DECLENCHE | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 32 | GESTION_DATA_STORE.G_M_NB_MSG_EDS | -32768..32767 | {T8,T9,T2,T4,T3,T5,T6,T1} | {T8,T9,T2,T4,T3,T5,T6,T1} |
| 33 | GESTION_DATA_STORE.G_M_NB_MSG_LDS | -32768..32767 | {T8,T9,T2,T4,T3,T5,T6,T1} | {T8,T9,T4,T5,T6} |
| 34 | GESTION_DATA_STORE.G_M_NLE_PANNE | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 35 | GESTION_DATA_STORE.G_M_NOMBRE_A_LIRE | 0..2147483647 | {T2,T3,T1} | {T9} |
| 36 | GESTION_DATA_STORE.G_M_OK_ECRITURE_BAL | false..true | {T2,T4,T3,T5,T6,T1} | {T2,T3,T10,T1} |
| 37 | GESTION_DATA_STORE.G_M_PFA_LU | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 38 | GESTION_DATA_STORE.G_M_ROMCHKT_A_SAUVEGARDER | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 39 | GESTION_DATA_STORE.G_M_TABLE_09_A_SAUVEGARDER | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 40 | GESTION_DATA_STORE.G_M_TABLE_0A_A_SAUVEGARDER | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 41 | GESTION_DATA_STORE.G_M_TABLE_0A...S_MODIFIEES | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 42 | GESTION_DATA_STORE.G_M_TABLE_0B_A_SAUVEGARDER | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 43 | GESTION_DATA_STORE.G_M_TABLE_0D_A_SAUVEGARDER | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 44 | GESTION_DATA_STORE.G_M_TABLE_0E_A_SAUVEGARDER | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 45 | GESTION_DATA_STORE.G_M_VALEUR_PFA | 0..65535 | {T2,T3,T1} | {T2,T3,T1} |
| 46 | GESTION_ETATS.G_M_ETAT | e_init0..e_pr | {T8,T2,T3,T1} | {T2,T3,T1} |
| 47 | GESTION_ETATS.G_M_ETAT_ALIGNEMENT | e_null..e_algp | {T2} | {T2,T3,T1} |
| 48 | GESTION_ETATS.G_M_ETAT_CALIBRATION | e_null..e_cvolp | {T2,T3,T1} | {T2,T3,T1} |
| 49 | GESTION_ETATS.G_M_ETAT_CBA | false..true | {T3} | {T2} |
| 50 | GESTION_ETATS.G_M_ETAT_INTERNE | e_alim..e_hold | {T2,T3,T1} | {T2,T3,T1} |
| 51 | GESTION_ETATS.G_M_ETAT_TEST | e_module_1..e_module_3 | {T3} | {T2,T3,T1} |
| 52 | GESTION_ETATS.G_M_PFA_ETAT | e_pr..e_null | {T8,T2,T3,T1} | {T2,T3,T1} |
| 53 | GESTION_ETATS.G_M_PFV_ETAT | e_pr..e_null | {T8,T2,T3,T1} | {T2,T3,T1} |
| 54 | SURVEILLANCES.G_C_COMPTEUR_TRAI...EMPERATURES | 0..65535 | {T3} | {T3,T1} |
| 55 | SURVEILLANCES.G_M_BOOLEEN_COUPL...URVEILLANCE | false..true | {T2} | {T2,T3,T7,T1} |
| 56 | SURVEILLANCES.G_M_BOOLEEN_COUPLEUR_TESTS | false..true | {T12} | {T12,T1} |
| 57 | SURVEILLANCES.G_M_BOOLEEN_DATA_STORE | false..true | {T11} | {T8,T11,T7,T12} |
| 58 | SURVEILLANCES.G_M_CHECKSUM_LUE | 0..65535 | {T11} | {T8} |
| 59 | SURVEILLANCES.G_M_CHECKSUM_ROM | 0..65535 | {T2,T3,T1} | {T11,T12} |
| 60 | SURVEILLANCES.G_M_CRC_LUS | false..true | {T2,T3,T1} | {T2,T3,T1} |
| 61 | SURVEILLANCES.G_M_DUREE_BUTEE | 0..65535 | {T3,T1} | {T2} |
| 62 | SURVEILLANCES.G_M_FIN_TESTS_INTERNES | false..true | {T3,T1} | {T3,T12,T1} |
| 63 | SURVEILLANCES.G_M_INCIDENT_ROM | false..true | {T2,T3,T1} | {T11,T2,T3,T12,T1} |
| 64 | SURVEILLANCES.G_M_MODIFICATION_...E_COMPTEURS | false..true | {T2,T3,T1} | {T11,T2,T3,T1} |
| 65 | SURVEILLANCES.G_M_MODIFICATION_TABLE_PANNES | false..true | {T2,T3,T1} | {T11,T2,T3,T12,T1} |
| 66 | SURVEILLANCES.G_M_MODIFICATION_TABLE_TESTS | false..true | {T2,T3,T1} | {T11,T2,T3,T12,T1} |
| 67 | SURVEILLANCES.G_M_MOT_ETAT_ARC_DECLENCHE | 0..65535 | {T3} | {T3,T1} |
| 68 | SURVEILLANCES.G_M_SURVEILLANCE_IMAGE_ET_SAUT | false..true | {T3} | {T3,T1} |

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 69 | SURVEILLANCES.G_M_TEMPERATURE2_APRES_FILTRAGE | -32768..32767                  | {}          | {T8,T2}
 70 | SURVEILLANCES.G_M_TEMPERATURE3_APRES_FILTRAGE | -32768..32767                  | {}          | {T8,T2}
 71 | SURVEILLANCES.G_M_TEST_ROM_TD_FINI            | false..true                    | {T11}       | {T12}
 72 | SURVEILLANCES.G_M_TEST_SAUT_ALC_TERMINE       | false..true                    | {T3}        | {T3,T1}
 73 | SURVEILLANCES.G_M_VALEUR_CRC_ARC              | 0..65535                       | {T2,T3}     | {T3,T1}
 74 | SURVEILLANCES.G_M_VALEUR_CRC_PP               | 0..65535                       | {T2,T3,T1}  | {T12}
 75 | SURVEILLANCES.G_M_VALEUR_CS                   | 0..65535                       | {T2,T3,T1}  | {T11,T2,T3,T1}
 76 | TENSIONS.G_M_AXE_EN_COURS                     | e_aucun..e_z                   | {T3}        | {T3,T1}
 77 | TENSIONS.G_M_CDG                              | false..true                    | {T3}        | {T3,T1}
 78 | TENSIONS.G_M_COMPTEUR_TENSIONS                | 0..255                         | {T2,T3,T1}  | {T2,T3,T1}
 79 | TENSIONS.G_M_DEBUT_SAUT                       | 0..2147483647                  | {T2,T3,T1}  | {T2,T3,T1}
 80 | TENSIONS.G_M_DEBUT_STABILITE                  | 0..2147483647                  | {T3}        | {T3,T1}
 81 | TENSIONS.G_M_ETAPE_STABILITE                  | e_stabilite_1..e_stabilite_3   | {T3}        | {T3,T1}
 82 | TENSIONS.G_M_ETAPE_TEST_ALC                   | e_test_stabilite_1..e...bilite_3 | {T3}      | {T3,T1}
 83 | TENSIONS.G_M_SAUT_EN_COURS                    | e_aucun..e_z                   | {T2}        | {T2,T3,T1}
 84 | TENSIONS.G_M_STABILITE_NON_ARMEE              | false..true                    | {T3}        | {T3,T1}
 85 | TRT_200HERTZ.G_C_CYCLE                        | 0..2147483647                  | {T2,T3,T1}  | {T2,T3,T1}
 86 | TRT_200HERTZ.G_C_CYCLE_200                    | 0..2147483647                  | {T2,T3,T1}  | {T2,T3,T1}
 87 | TRT_200HERTZ.G_C_CYCLE_25_HERTZ               | 0..2147483647                  | {T2}        | {T2,T3,T1}
 88 | TRT_200HERTZ.G_C_CYCLE_50_HERTZ               | 0..2147483647                  | {T2,T3,T1}  | {T2,T3,T1}
 89 | TRT_200HERTZ.G_C_CYCLE_625_HERTZ              | 0..2147483647                  | {T2,T3,T1}  | {T2,T3,T1}
 90 | TRT_200HERTZ.G_C_TEMPS_ALIGNEMENT             | 0..2147483647                  | {T3,T1}     | {T2}
 91 | TRT_200HERTZ.G_C_TEMPS_MST                    | 0..2147483647                  | {T2,T3,T1}  | {T2,T3,T1}
 92 | TRT_200HERTZ.G_C_TEMPS_VOL                    | 0..2147483647                  | {T3,T1}     | {T2}
 93 | TRT_200HERTZ.G_M_CODE_ACTION                  | e_ecrire_arc..e_fin_test       | {T3}        | {T3,T1}
 94 | TRT_200HERTZ.G_M_CODE_TEST                    | e_fin_tests_internes....ee_moins | {T3}      | {T3,T1}
 95 | TRT_200HERTZ.G_M_ETAT_INTERNE                 | e_alim..e_hold                 | {T2,T3,T1}  | {T2,T3,T1}
 96 | TRT_200HERTZ.G_M_NOMBRE_TESTS_COUPLEUR        | -32768..32767                  | {}          | {T3,T1}
 97 | TRT_BUS.G_M_COMMANDE                          | e_mst..e_hold                  | {T2,T3,T1}  | {T4,T5,T6}
 98 | TRT_BUS.G_M_MODIFIE                           | false..true                    | {T2,T3,T1}  | {T2,T4,T3,T5,T6,T1}
```

protégé des
IT

# Collaboration with Aérospatiale

(renamed EADS & Airbus)

- beautiful contract (**700kf** in 3 months...)
- several **bugs** [gonthier] +++
- interval analysis [deutsch] ++
- work on floating point [deutsch] +-
- simulation of LSSI automaton with Promela [gonthier] --
- participation to qualification committees of flight 502 ++ [deutsch, gonthier, doligez, rouaix, skubi]
- article in an international conference on avionics [deutsch, gonthier]

# OCTOBER 1997

**A502 Suspense and Success: report on flight A502**

The 17 months of effort after the June 1996 failure paid off on 30th October 1997 when Ariane 5 fully completed its second qualification flight. There was, however, some suspense during the flight when engineers realized in real time that the launcher was being submitted to an excessive roll after separation of the solid boosters and up to the end of the cryogenic stage flight ....

"Le logiciel a marché à 120%"

# Afterwards...

- **Polyspace**: start-up company [deutsch, pilaud]
- code analysis **ARD**, **ATV**, other satellites [deutsch]
- programming rules of CNES [deutsch, gonthier]
- expertise of **Columbus** code[jjl, gonthier, blanchet, muller]
- ESA programming rules [gonthier, jjl]

- at ENS, Astrée analyzer now does much more for **A380**
- still nice days for static analysis of programs
- ... and verification of programs (embedded or not)

- our research-team Moscova better evaluated:

1994 = team "pizza" → 1998 = team "examplary"

# Conclusion

- Ariane 501 proved in real scale the importance of **software** bugs.

- One can use **elementary** methods taken from theory of programming and/or concurrency.

- Analysis on **existing** programs

- Application of results of **research** (IABC)

- **Lot of fun** ...