

# **ERC32 SOFTWARE TOOLS EVALUATION**

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## **Evaluation Objectives**

- Port SOHO AOCS software to ERC32.
- Simulate I/O Interfaces.
- Introduce tasking instead of cyclic scheduler.
- Use Normal mode software.
- Carry out timing analysis.

## Rationale

For:

- a significant system (6000 lines of Ada).
- a working system, concentrate on tools.
- real time properties important.

Against:

- problems of porting code.

## Timescales

### Planned:

- Start September
- Finish December

### Actual:

- September
- illness ♥
  - missed training day
- January

## **Planned Activities**

- Assess SOHO application.
- Identify needed files.
- Copy to Sun Workstation.
- Compile (functional).
- Bind.
- Extract WCET information.
- Apply HRT tools.
- Link (ESTEC).
- Functional simulation.

## **SOHO AOCS**

- Multiple modes.
- Each mode self contained.
- Frequency/phase scheduler.
- Mode change by table change.
- Choose Normal mode.
- Follow WITH chains to identify needed files (70 out of 120).
- FTP all needed files (VAX -> Sun)

## Compilation

- ❑ Tools installed, set up in ½ day.
- ❑ Simple program compiled and bound.
- ❑ Started at lowest level software.
- ❑ Stubbed out assembler routines.
- ❑ New Tasks package added.
- ❑ Some general problems:
  - System.Unsigned | Created special
  - Package Machine\_Code | ERC32 packages
  - Package Bitops

## Compilation (cont)

- ❑ Some particular problems:
  - Address calculations (e.g. TM buffers)
  - Unchecked Conversions not allowed as assignment targets.
  - Integer to/from Enumerated type conversions.
    - Implementation restriction - why?
  - Integer to/from Boolean type conversions.
  - Long\_Integer, Storage size.
  - Unchecked Conversions with size differences.



# Examples 1

Formatted\_Torque

```
:= System.Unsigned(abs(Fix(Wheel_Torque(n) * Scale_Factor)));

declare -- local block to perform bit manipulation on
        Formatted_Torque

    subtype Bit_Index is Integer range 0..15;
    MSB : constant Bit_Index := 0;
    type Boolean_Array_Type is Array (Bit_Index) of Boolean;
    Pragma Pack (Boolean_Array_Type); -- pack into one word
    function CUB is new Unchecked_Conversion
        (Source => System.Unsigned, Target => Boolean_Array_Type);

begin -- set bit 7 of Formatted_Torque to sign of Wheel_Torque(n)

    CUB(Formatted_Torque)(7) := (Wheel_Torque(n) < 0.0);

end; -- local block
```

### Examples 2

```
type FPSS_Data_Error_Type is
    (OK, Bad_Ap, Bad_Ay, Bad_Angle_P, Bad_Angle_Y,
No_Sun_P, No_Sun_Y);
--
for FPSS_Data_Error_Type use (0, 1, 2, 4, 8, 16, 32);
--
function CFI is new Unchecked_Conversion
    (Source => FPSS_Data_Error_Type,
    Target => Integer);
--
function CIF is new Unchecked_Conversion
    (Source => Integer,
    Target => FPSS_Data_Error_Type);
```

Use of these functions flagged as an error

## **Tool Observations**

- Error messages usually good, with LRM references.
- Deletion of obsoleted units from library listing surprising (initially).
- Unable to print from Library Manager (Motif).
- It would help if a successful compilation produced a message in the AdaWorld window.
- Colour change in icon only after browsing.
- Locked library caused Library Open to hang.
- AdaMake worked well.

## Timing Data Extraction

- ❑ Achieved successful Bind at functional level.
- ❑ Turned on WCET data in compiler options.
- ❑ Recompiled complete application.
- ❑ WCETE warnings in 8 files.
  - compound assignments.
  - pointers (access).
  - 'pos attribute.
  - loops with parameter for upper limit.
  - Raise statements (but there are none).
  - task declaration location.

### Examples 3

```
352     MACS_Error_Data := (Counter => 0, Time => 0,  
                          First_Error => True);
```

```
353
```

```
354     On_Time_Increment := (others => 0); (array (1..8) of natural)  
1
```

1 \*COD WCETE subset warning: This construct is not permitted in the WCET Ada HRT Restrictions. The containing subprogram must not be called within the main body of a critical task.

```
2220     type Address_Pointer is Access ERC32_System.Address;  
                                           <--1-->
```

1 \*EXP WCETE subset warning: This construct is not permitted in the WCET Ada HRT Restrictions. The containing subprogram must not be called within the main body of a critical task.

### Examples 4

```
102 -- function Arctan(X : in Float) return Float is
103
104     begin
105
106         if abs(X) < X_Small then
107
108             return X;
109
110                 1
111                 2
```

1 \*COD WCETE warning: Block containing explicit raise statement has been excluded from worst case path analysis.

2 \*COD WCETE warning: Block containing explicit raise statement has been excluded from worst case path analysis.

## Execution Profile generation

- ❑ Enabled HRT processing in Binder.
- ❑ First bind flagged errors in 3 procedures.
  - Issue\_RD in MACS object, undefined loop counts.  
Had to hard code - no PRAGMA Loop\_Count.
  - Read\_FPSS in AOCS\_Units, a compound assignment.  
Rewrote as set of individual assignments.  
WHY IS THIS NOT DETERMINABLE BY COMPILER?
  - Process\_FPSS\_Data in Sensor\_Processing, a 'pos attribute.  
Replaced by Fixed value. ALL ATTRIBUTES?
- ❑ Obtained bindable system with 10 tasks, giving execution profile with 10 threads.

## Timing comparison

Comparison between execution profile times and original SOHO calculated times:

<u>Task</u>	<u>ERC32</u>	<u>SOHO</u>
FPSS_Task	5157	955
Mode7_Ctl	1134	400
Control laws	1989	4411
Control laws HK	2124	568
Mode7 roll	473	153
SSU7	2280	2103
SSU Data	2408	3063
SSU8	119	42
RSL	202	107
Wheel	<u>2530</u>	<u>2160</u>
Total	18416	13962

NB: ERC32 1MHz, SOHO MAS281 15MHz, 3 wait states



## **HRT tools**

- Tools easily installed.
- Straightforward to run.
- UCF file generated from original scheduler table data.
- ESF file from compiler used.
- DEMO run time file used.
- Analyser shows thread set schedulable.
- GANTT chart generated from Simulator.

## Conclusions

- ❑ Evaluation has been useful, given time constraints.
- ❑ Tools acceptable.
- ❑ Future directions:
  - ERC32? Yes
  - Ada Compiler? Probably
  - WCET extraction? Yes (standalone table of times?)
  - Functional simulation Yes
  - HRT tools? ? (tasking vs frequency/phase)