Generation of AADL Architecture Consistent Work Products: Simulink Behavioral Models, and Distributed Embedded Software using OCARINA

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Traditional Development vs. ...

- Program Definition
  - Requirements
    - Software Specifications
      - Embedded Software
        - Distributed Real Time Embedded System
          - Physical System, Embedded Hardware
            - V&V
              - Release
Model Driven Development vs. ...

- Program Definition
- Requirements
- Behavioral, Executable Models
- Embedded Software
- Distributed Real Time Embedded System
- Physical System, Embedded Hardware
- V&V
- Release

Embedded Software

Distributed Real Time Embedded System
Architecture Driven Development

- Program Definition
- Requirements
- Program Architecture
- Behavioral, Executable Models
- Embedded Software
- Distributed Real Time Embedded System
- Physical System, Embedded Hardware
- Demo Toolchain: OSATE, IME, Simulink

V&V (Verification & Validation) process at each stage.
Architecture Driven Development

Program Definition

Program Architecture

Behavioral, Executable Models

V&V

Requirements

V&V

V&V

Release

Embedded Software

V&V

Distributed Real Time Embedded System Models

V&V

Distributed Real Time Embedded System

Physical System, Embedded Hardware

Demo Toolchain: OSATE IME Simulink

Demo Toolchain: IME Simulink OCARINA

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Demo 1 Scenario (Apr Mtg)

AADL
(Corporate)
Program Architecture

User Groups
- Suppliers
- Systems Engineering
- Controls Development
- Design, Analysis and Optimization

Consistency?

Development Environment
- Program Specific Application

Behavioral Models (Simulink, C, Modelica, …)
- Analysis and Simulation Tools (Matlab, Simulink, …)

Program Team
- Business Team
- Project Management
- Systems Engineering
- Other Stakeholders

Program Kick-off
Demo 1 Workflow - Generation of Simulink Model Consistent with Corporate Architecture

OSATE

AADL architecture consists of systems only

```
end A_missile_guidance_system;

system implementation A_missile_guidance

subcomponents

Airframe system T_Airframe.

control system T_Control

inputs/outputs system T_InpOut

connections

Airframe_Ke_De to TestInput
Airframe_Altitude_to TestInput

Airframe_alpha to Controller_a
```

IME (scope of Demo)

Import into IME

IME

Directory Browser

File View

[Images of IME interface]

Compose Model and Export from IME

Visualize Architecture

Configure Architecture Consistent Instantiation Tree

Mine out Relevant Behavioral Models

Simulink

Author or Simulate Behavioral Model and perform V&V

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Multiple Architectural Views

- Multiple, Valid, Architectural Views exist
- Different views or perspectives better suited for different analysis/development purposes

![Diagram of architectural views with components such as Plant, Control, Sensor Dynamics, Physical System Behavior, Actuator Dynamics, Control Task 1, Control Task 2, ..., Control Task n, Sensor Drivers, Actuator Drivers, Control Task n, Tasks at Exec Rate 1, Tasks at Exec Rate 2, ..., Tasks at Exec Rate n, Interrupt Service Routines, Scheduler, ECU1, ECU2, Div 1, Div 2, Div 3, Home Org, Supplier A, Supplier B, ECU n, etc.]
Example Need for Multiple Architectural Views

Distribute application software components among the different ECUs as separate tasks.
Controller Model

Missile Guidance

Auto pilot

System Model

Results

Targeting

Guidance

Controller

Air frame

Demo2 Scenario

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Demo 2 Workflow

Workflow in IME

Workflow in Ocarina

AADL model with references to Simulink model

Allocate Simulink Components to AADL components

Real-time Workshop

Application Code

Distributed Embedded Software

Embedded System Code

Ocarina

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Workflow in IME

Simulink Behavioral Model

Set Attributes for each component

Set the Processor, Process and Thread

View in different Perspective

Export

---

define A_missile_guidance_system;

system implementation A_missile_guidance
subcomponents

Airframe: system T_Airframe.L_
controller: system T_Controller
TestInputs: results: system T_Te
connections
Airframe_Xe Ze to TestInputsRe
Airframe_Altitude to TestInput
Airframe_alpha to Controller a
Airframe_pitch to Controller b...
Application Software Architecture

Simulink Model

controller

airframe

tc_testinputsresults

 ime
 Architectural View

missile_guidance_system

+ airframe

+ controller

+ tc_testinputsresults
Integrating Simulink and Ocarina

Generation of applications from AADL models using Ocarina
Simulation Results

**Alpha**

- Time (sec): 0 to 14
- Y-axis: Alpha from $10^{-3}$ to 1
- Graphs show Simulink (blue line) and Controller Prs (red dots)

**Fin Command**

- Time (sec): 0 to 14
- Y-axis: Fin command from $10^{-3}$ to 2
- Graphs show Simulink (blue line) and Plant Prs (red dots)

**Missile Position**

- Time (sec): 0 to 16
- Y-axis: Missile position (x, m) from 0 to 2
- Graphs show Simulink (blue line) and Results Prs (red dots)
Where next …

- Can we demonstrate an end-to-end process for Architecture Driven Development on an Industrial Scale Problem?
  - Combination of Models, Tools, and Hardware working in sync to demonstrate the true benefits.
  - Can we actually calculate the ROI on these?

Can we demonstrate an end-to-end process for Architecture Driven Development on an Industrial Scale Problem?

Can we actually calculate the ROI on these?