Model-Based Development: Realizing Fully Integrated Algorithm & Software Development for Production Automotive Electronic Control Units

www.aam.com
AAM Introduction

• American Axle & Manufacturing (AAM) is a tier 1 global automotive supplier with design, engineering, testing, validation and manufacturing capabilities. Traded at NYSE as AXL.

• AAM core competencies are in driveline, drivetrain and chassis systems for light trucks and buses, sport utility vehicles, crossover vehicles, and passenger cars.

• Established in 1994 from purchase of 5 plants in USA from GM. Today, it has 23 plants/offices in 10 countries and growing.

• Electronic Systems were introduced in 2001. Software development started in 2002. Currently, AAM is working on 7 customer programs involving software algorithms.
Production Development with Hand-Coding - 2002

1. Determine objectives

2. Identify and resolve risks

3. Development and Test

4. Plan the next iteration

Source: wikipedia
Rapid Prototyping

- Requirements
- Algorithms Auto-Code
- Drivers, OS Hand-Code
- Code Repository
- Hand Integrate Code
- Vehicle Test & Calibration
Proposed AAM R&D
Model-Based Development Sequence

- REQUIREMENTS
- ALGORITHM MODELS (Simulink)
- PLANT MODELS (Simulink)
- ALGORITHM INTEGRATION MODEL (Simulink)
- SCHEDULER (Simulink)
- SCHEDULER (Hand-Code)
- AUTOCODE INDIVIDUAL ALGORITHM MODELS (RTW Embedded Coder)
- DEVICE-DRIVERS ABSTRACTION LAYER, etc. (Hand-Code)
- INTEGRATE & TEST (Hand-Code & Hand-Test)
System Architecture Model for Simulation Testing
BIOS Software Integration

SYSTEM TOP LEVEL

Application Layer (Target Independent)

BIOS (Target Dependent)

INPUT DRIVER

S12X CONFIGURATION

BIOS
Moving from a Code Centric to a Model Centric Process

- Requirements
- Drivers, OS Auto-Code
- Model Repository
- Integrate Pre-Cal Test Models
- HIL/Vehicle Test & Calibration
- Integrate for RP
- Algorithms Hand-Code
- Algorithms Auto-Code
- Rapid Prototype
AAM Production Data

Effort (Man Months)

- Hand-Code
- Simulink Application; Hand-Code Drivers & Hand-Integration
- Simulink, UniPhi, QuantiPhi (No Hand-Code)

Application
BIOS
Integration & Debug
Test & Rework

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Productivity Improvement

Effort [man-months]

20 85 100

HAND-CODING ONLY

MATHWORKS TOOLS
(HAND-CODE BIOS & HAND INTEGRATION)

MATHWORKS + SimuQuest TOOLS
(ZERO HAND-CODE)

Results from Customer Production Programs

Cost [$millions]

0.6 1.2 1.4
Focus Changes

• FOCUS ON INTELLECTUAL PROPERTY
• HANDLE MORE COMPLEXITY
• MUCH FASTER TIME TO MARKET!
• ACCOMPLISH MORE WITH LESS
Key Aspects of the Model-Based Development Solution

- Simulation Testing of Controls, State Machine, Diagnostic handler
- Integration and Test of Controls within Simulink
- Configuration of Micro within Simulink
- Integration and Debugging of BIOS within Simulink
- Full CAN Configuration within Simulink
- All Integration and Testing Performed before Code Generation
- Validation Testing on Hardware
  - Not Integration and Debugging