Pragmatic Strategies for Adopting Model-Based Design for Embedded Applications

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Introduction

- What’s MBD?
- Why do it?
  - Make Products Faster
  - Minimize HW prototypes
  - Build it right the first time
- How to do it?
Best Practices for Establishing a Model-Based Design Culture (SAE Paper 2007-01-0777, Smith, Prabhu, Friedman)

1. Identify the problem you are trying to solve
2. Use models for at least two things – “Rule of Two”
3. Use models for production code generation
4. Treat models as the sole source of truth
5. Use migration as a learning opportunity
6. Focus on design, not on coding
7. Integrate the development process
8. Designate champions with influence, expertise, and budgetary control
9. Have a long-term vision
10. Partner with your tool suppliers
**Phased Approach Leads to Success**

- **Plan**
  - Proof of Concept: Develop Migration Plan
  - Initial Migration Plan

- **Execute & Refine**
  - Deploy Component
  - Deploy Full Application
  - Initial MBD Process

- **Optimize & Improve**
  - Deploy Enterprise-wide

**Supplier Involvement**

- **Adv Engineering**
- **Product Engineering Teams**
- **Research**
- **Time**
Pragmatic Adoption of Model-Based Design

Phase 1
(3-6 months)
- Plan & Train
- Org
- Proof of Concept
- Assess

Phase 2
(5-9 months)
- Plan & Train
- Org
- Process
- Component
- Assess

Phase 3
(1-3 years)
- Plan & Train
- Org
- Process
- Full Application
- Assess

Phase 4
(continuous)
- Plan & Train
- Org
- Process
- Assess

Time
Theme: **Proof of Concept**

- Define objectives
- Get trained
- Develop the P.O.C. control algorithm
- Execute on the target
- Migration Plan

**What does success look like:**

- Focus on technology – prove the tools can do the job
- Develop understanding of MBD Tools and Processes
- Build support for future changes
- **KEY OUTPUT:** Initial Migration Plan
The Migration Plan

- Objectives
- Metrics
- Organization
- Training
- Process Changes
- Constraints
- Standards

This plan will change – it is not static!
Theme: “Component” Design

- Test and refine new capabilities
- Control risk

What does success look like:

- Larger number of people engaged in Model-Based Design
- Bigger model representing more functionality
- More than just modeling and code generation
- Increased automation
- Model-Based metrics and process definition

KEY OUTPUTs:

1. Production “component” delivered
2. V1.0 Model-Based Process Definition

This should take 5-9 months depending on scale and scope
Theme: Full Application Design

- Apply what was learned and model and automate code production for a full application – Scale up!
- Platform Software is not automated, but build process is.

What does success look like:

- Industrial grade process, tools and high quality product
- Significant return on investment
- KEY OUTPUTs:
  1. Production application delivered
  2. V2.0 Model-Based Process Definition – full spectrum

*This should take 1-3 years depending on scale and scope*
Improve & Replicate the Success

Theme: Continuous Improvement
- Adapt & Deploy Enterprise Wide
- Optimization

What does success look like:
- Replicated success at multiple sites
- Dramatic productivity improvement
- Increased capacity for complexity
Pragmatic Strategies for Adopting Model-Based Design (SAE Paper 2010-01-0935, Dillaber, Kendrick, Jin, Reddy)

Assess organizational challenges and impact

Plan for change
1. Identify the problem you are trying to solve
2. Choose a project with proper complexity and technology
3. Mitigate risk with a phased approach
4. Choose the appropriate legacy components for migration

Create a process and tool migration plan (key items below)
1. Use executable spec development as an opportunity to solidify requirements
2. Make the model a source for documentation
3. Choose architecture and component technology early
4. Establish and enforce design standards
5. Develop a plant model with “trend-correct” behavior
6. Verify what you need, not what you want
7. Migrate key supporting processes such as CM
## User Stories

<table>
<thead>
<tr>
<th>Company</th>
<th>Application</th>
<th>Strategy</th>
<th>Result</th>
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| Astrium       | First of its Kind Laser Link    | • Modeling, Early Verification, Code Generation, HIL/RPC                   | • Design iterations reduced from days to hours  
• Overall development time reduced by six months                                                   |
| BAE Systems   | SDR                             | • Modeling, Early Verification, VHDL                                     | • Project development time reduced by 80%:  
  • SDR SP Devel 10:1  
  • Overall time 4:1                                                                                   |
| Honeywell     | Flight Control System           | • Modeling Early verification, code generation                             | • 5:1 improvement in productivity  
• Highly accurate, reusable code  
• A superior product                                                                                   |
| Lockheed Martin | JSF - Flight Control System    | • Modeling Early verification, code generation                             | • Reduced Software Defects  
• Overall Reduction in Manhours/SLOC of ~40%                                                              |
Caterpillar
Phased Adoption of Model-Based Design and Code Generation

- **Background**
  - Needed to satisfy demands for increased software feature content, added complexity, and short turn-around time

- **Results**
  - Caterpillar uses MathWorks simulation, rapid prototyping, and code generation products as part of their production development capability
  - The data collected indicated a reduction in person hours by a factor of 2 to 4 depending on the project and a reduction of calendar time by a factor of greater than 2
Thank You for Your Attention

Are there any questions?

Larry E. Kendrick, PhD        Senior Principle Technical Consultant
The MathWorks, Inc.
Astrium Creates World’s First Two-Way Laser Optical Link Between an Aircraft and a Communication Satellite

Challenge
To develop controls to ensure the precision of a laser optical link between an aircraft and a communication satellite

Solution
Use MathWorks tools to model control algorithms and pointing hardware, conduct hardware-in-the-loop tests, and deploy a real-time system for flight tests

Results
- First of its kind optical link demonstrated
- Design iterations reduced from days to hours
- Overall development time reduced by six months

“Using MathWorks tools for Model-Based Design, we simulated not only our control algorithms but also the physical hardware. By automatically generating code for the control software and the test bench, we reduced development time and implemented changes quickly. We visualized simulation and test results, which gave us confidence in the design we ultimately deployed.”

David Gendre
Astrium

Link to user story
BAE Systems Achieves 80% Reduction in Software-Defined Radio Development Time with Model-Based Design

Challenge
To develop a military standard SDR waveform for satellite communications

Solution
Use Simulink and Xilinx System Generator to rapidly design, debug, and automatically generate code for an SDR signal processing chain

Results
- Project development time reduced by 80%
- Problems found and eliminated faster
- Clocking and interfacing simplified

“Using Simulink and Xilinx System Generator™ we designed and developed the signal processing chain of the SDR and achieved a 10-to-1 reduction in development time.”

Dr. David Haessig
BAE Systems

Link to user story
Design Times at Honeywell Cut by 60%

**Challenge**
To update a flight control system while reducing development time and costs

**Solution**
Use design tools from The MathWorks to enable one team to design, model, and simulate the flight-control laws and automatically generate flight-ready code

**Results**
- A five-to-one improvement in productivity
- Highly accurate, reusable code
- A superior product

“[Using Simulink and Real-Time Workshop] we found we could do in half a day what previously took a week or more... It is pretty easy to see at least five-to-one improvement over the way we used to work.”

Wayne King
Honeywell Commercial Aviation Systems

Link to user story
Flight Control Law Development for F-35 JSF