The Role of Real-Time Workshop® Embedded Coder in Supporting Cummins Inc. Vision for Model Based Development

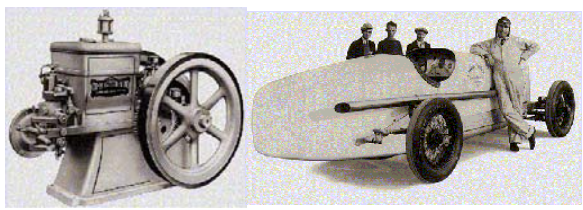
MathWorks Automotive Conference
June 19-20, 2007
Dearborn, Michigan

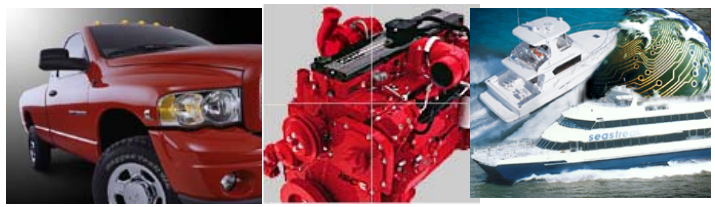
Agenda

- Introduce Cummins
- Analysis Led Design Strategic Initiative
- Vision For Embedded Controls Development
- Meeting the Need:
  - Model Based Development
  - Product Line Architectures
- Challenges
- Why Real-Time Workshop® Embedded Coder?
- Future of Real-Time Workshop Embedded Coder
- Conclusions

Cummins is a Worldwide Diesel Engine Leader

- Cummins at a glance (2006)
  - Engines & power generation since 1919
  - 33,500 employees
  - $11.4 billion in sales revenues
- Engines cover a wide range of applications
  - Engines to equip from Dodge RAM SUV to 200 tons mining truck
  - Heavy-duty trucks, buses, marine equipment, and power generation
- Cummins serves customers in over 160 countries





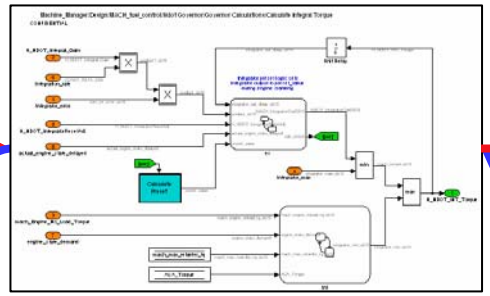
Why Analysis Led Design at Cummins?

- Cummins is a major producer of diesel engines in the automotive, industrial, power generation, & marine markets.
- Cummins is under constant pressure to deliver excellent fuel economy, emissions compliance, & durability at the lowest possible cost.
- EPA emissions mandates are driving increases in the complexity of controls' algorithms, and hence, the embedded controller code.
- Analysis is key to getting the highest quality products into customer's hands as rapidly as possible - "cut and try" is not efficient.
- Even after careful analysis, Cummins requires tools & processes to allow the more efficient development & testing of new designs.
- Anything Cummins can do to streamline & dovetail all phases of the V-cycle helps reduce cycle time and error.

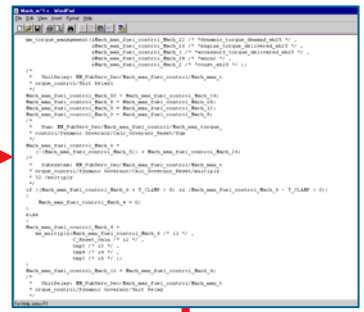
Cummins' Vision for Embedded Controls Development

Cummins generates models of the controller . . .

Func. Design & Rapid Prototyping

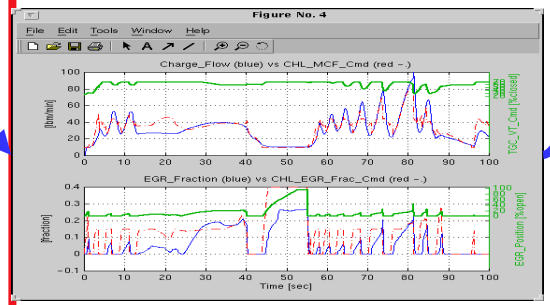


Target Code Generation



to produce automatic C-code straight from the controller model . . .

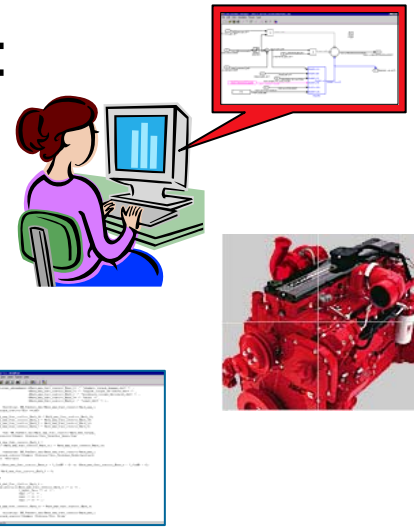
& test these models in simulation . . .



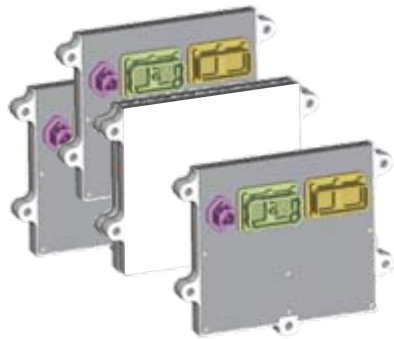
that is tested on actual hardware which is >95% bug free.

Meeting the Need

- Model Based Development (development side):
  - Create system design environment
  - Design, develop, & analyze a controller for managing a plant
  - Generate C code automatically from Simulink® diagrams

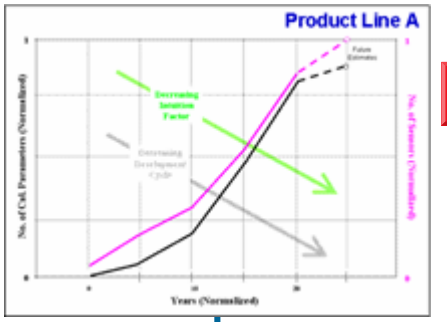


- Product Line Architecture (software side):
  - Realize similar core software throughout multiple product lines
  - Define interfaces to allow addition/deletion of SW without compromising system integrity (plug-&-play)

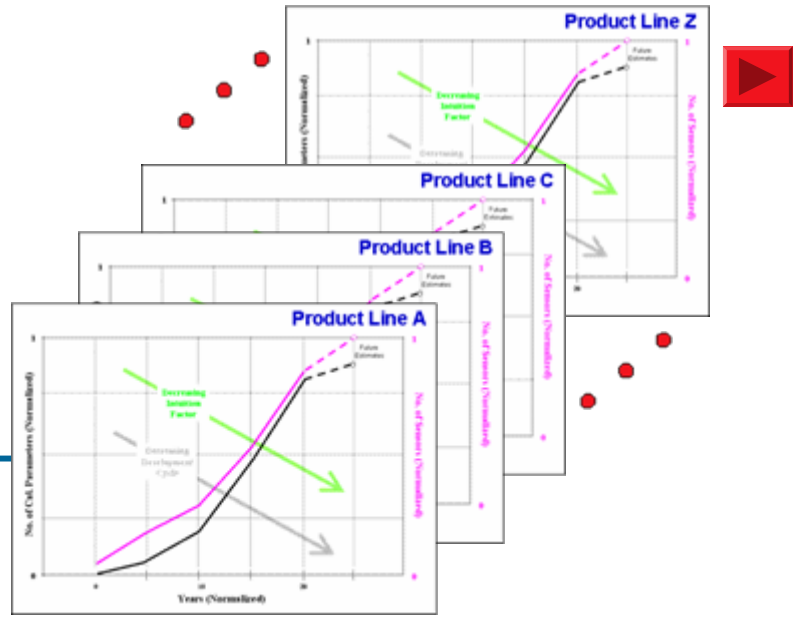


Merging of Model Based Development & Product Line Architecture

MBD: Solution to Controller Complexity WITHIN a Product Line



PLA: Solution to Controller Complexity ACROSS Product Lines

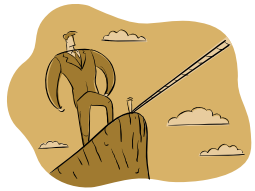


Automatically Generate Embedded Code

Produce Embedded Controller

Without Sacrificing Simulation Capability

Challenges



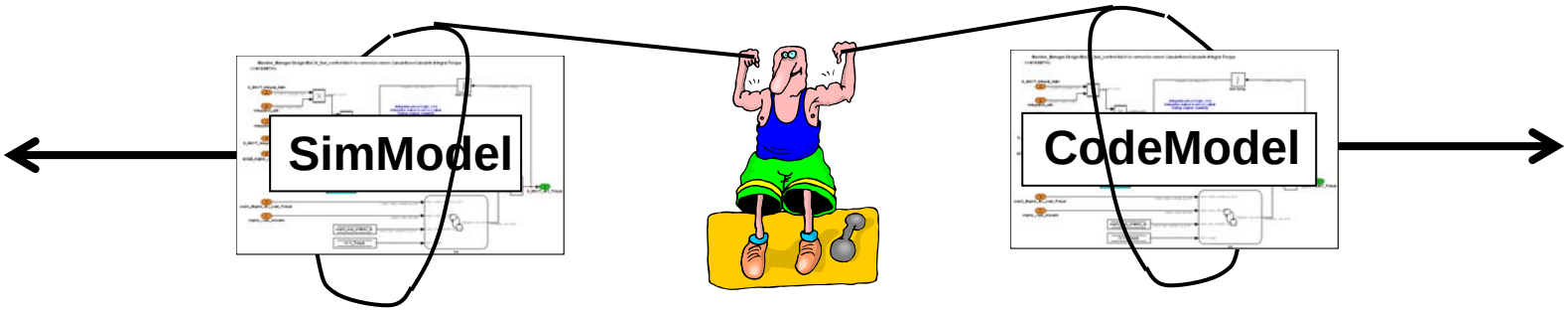
- Product Lines are currently not pervasive throughout industry.
- Current 3rd party code generation tools are not based on this paradigm → *but they are getting there!*
  - Biggest roadblock is less about code generation & more about simulation:
    - e.g., function calls → how to realize in simulation?
    - e.g., pointers → how to realize in simulation?

  - Modifications are needed to allow current tools to meet requirements.
- Embedded controller design spans many different organizations within the company.
  - Workflows are different
  - End products are different

- Burden of proof rests with showing/proving benefits.

Why a Code Generator Now?

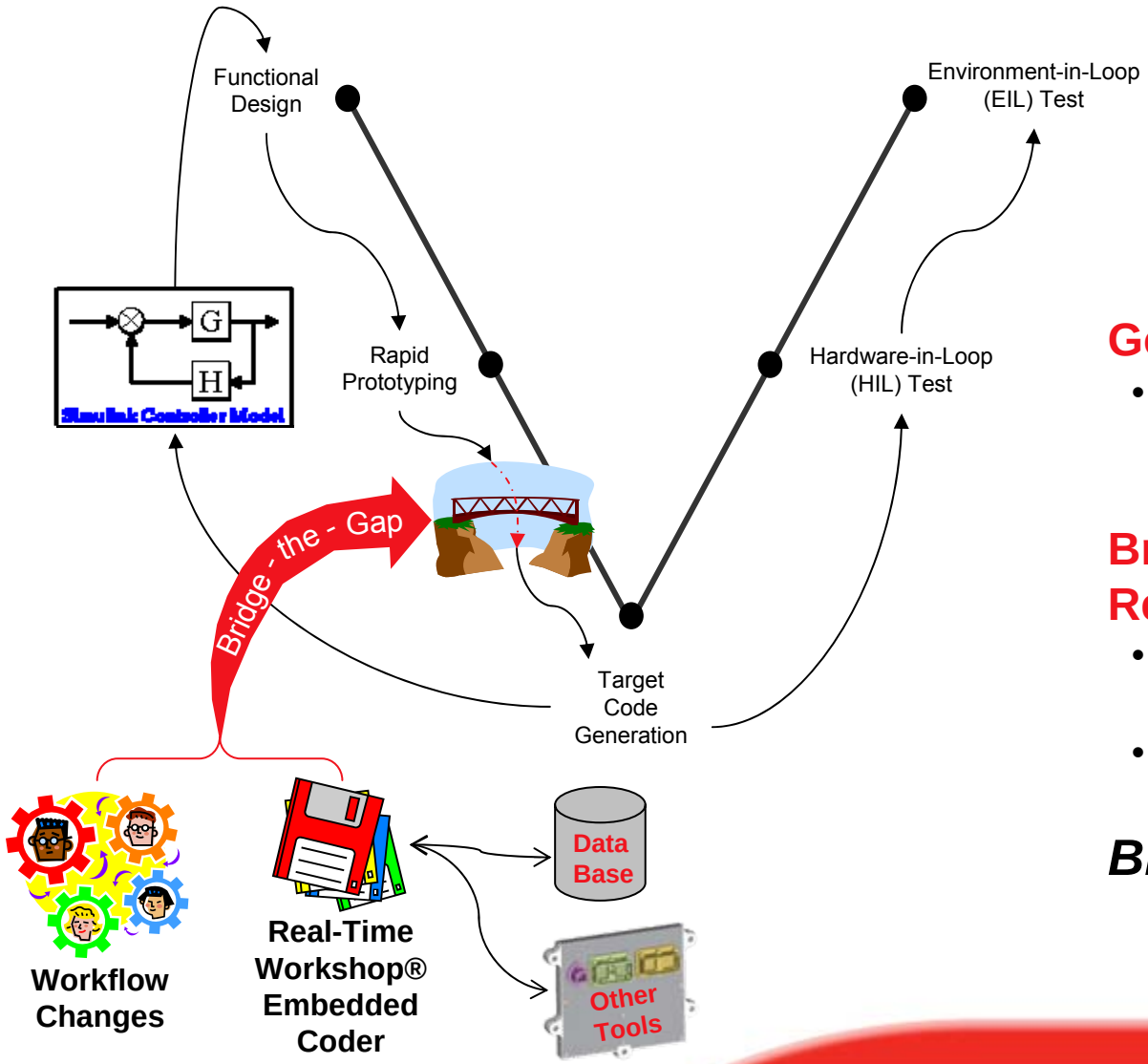
- Our workflows, existing tools & current processes foster the divergence of models → This divergence will only grow!



2002 controller was complex. 2007 is more complex. 2010 is even more complex.

- Industry is adopting Model Based Development methods to design controllers.
- New code generation tools are becoming capable of meeting our architecture requirements.
- There is a synergy to do this now & it is a corporate technical productivity strategy.

Embedded Controller Development V-Cycle



Goal:

- Single Simulink model of controller for entire V-cycle

Bridging the Gap to Reach Goal:

- Synergistic embedded controls culture
- Fully integrated tool base

Bridge-the-Gap

Why Real-Time Workshop Embedded Coder?

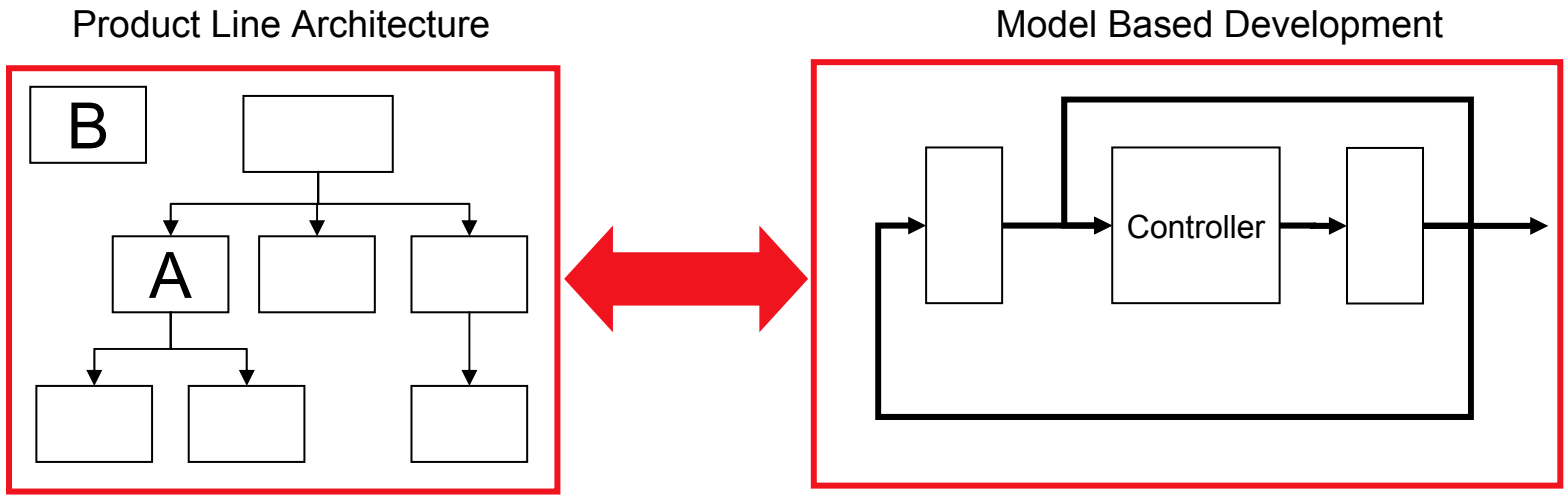
- MATLAB® and Simulink® are already workhorses of Cummins controls development organization.
- The MathWorks has demonstrated a superior support environment.
- Real-Time Workshop Embedded Coder . . .
  - Links code generation directly to simulation
  - Provides greater flexibility in the design of controller models
  - The MathWorks pilot team provides support packages allowing the “bending” of the tool to meet our needs.

Current Status of Real-Time Workshop Embedded Coder

- The support packages help to meet our basic architectural needs.
- Key SW parameters (throughput, memory, code size) are being monitored & early results look promising.
- Targeted component models are being converted & integrated into our total system simulation modeling framework.
- Model Based Development using Real-Time Workshop Embedded Coder is beginning to be embraced by upper management.
- Process & workflow changes are being pushed throughout company.
- Other tools are being modified to integrate with Real-Time Workshop Embedded Coder.

Future of Real-Time Workshop Embedded Coder

- **Cummins Key Initiatives**
  - PLA is key to success of software
  - MBD is key to success of controller algorithm development
- **Real-Time Workshop Embedded Coder must**
  - embrace PLA
  - as well as MBD
  - continue to foster a collaborative relationship with Cummins



Conclusions

- The design of embedded controllers has become more challenging due to EPA rules & regulations.
- Cummins has been pursuing Model Based Development for last decade.
- Our major challenge is closing the gap between development & code generation.
- Cummins selected Real-Time Workshop Embedded Coder to close this gap.
- Preliminary analysis shows great promise both in realizing simulation and in code generation.
- The MathWorks has given us excellent support so far.
- Real-Time Workshop Embedded Coder must continue to evolve to meet demands of SW created by Product Line architected systems.