A Mentor’s Perspective on EcoCAR

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I, along with the other MathWorks EcoCar Mentors, am pleased to support the EcoCar competition because it aligns well with our company goal of “Accelerating the pace of engineering and science.”

The stated mission of EcoCar is to find new ways to reduce the environmental impact of motor vehicles and prepare future engineering leaders for that task by providing them with industrial experience in the application of state-of-art tools and processes required to design and field prototype hybrid vehicles that meet the goals of EcoCar.

Over the years that I have worked in the industry, public concern over limited natural resources and environmental impact related to motor vehicle use have resulted in ever more stringent emission and fuel economy legislation. Engineers in industry have reacted to legislative requirements by pursuing the option of using multiple energy sources as a way of reducing overall impact.

To control, store, and coordinate the conversion of energy to useful work from multiple sources, vehicle powertrains have multiple complex subsystems (e.g. engines, batteries, inverters, motors, and generators). The control and coordination of these subsystems requires large-scale software development capability and disciplined engineering development processes in order to deal with the increased complexity of the overall powertrain system. Advanced modeling, simulation, and control design tools and skills are required as a result.

Thinking back to when I started in the automotive industry about 20 years ago, there were many barriers to developing complex powertrain systems. Modeling and simulation tools were hard to use, and computers were very weak.

The inability to rapidly and freely test design ideas in simulation software meant that theory had to play a dominant role in decision-making about which ideas to pursue to solve control problems. This often led to rigid, overly idealistic designs that had to be re-worked or discarded after a large investment of time and physical testing. To test an idea in embedded software, a control engineer needed to ask management to provide a highly educated and experienced human being called an “embedded software engineer.”

Because of the productivity barriers mentioned above, a newly minted engineering graduate typically required two to three years of experience working alongside a mentor before any significant contribution could be made to the company that employed them.

Today the situation is much better. The current EcoCar competition emphasizes the use of simulation tools in the form of Model-Based Design to design the vehicle system up-front. This is a shift from a prior emphasis on hardware subsystem development and some manual or semi-automatic software development. The emphasis on Model-Based Design makes sense, because it represents a mechanized form of the Scientific Method, which has proven to be revolutionary over the past several hundred years.

Students have adapted well to the systems-focus required by the EcoCar competition. Their adaptation has been helped by the sponsors in the form of clarified competition rules, the contribution of state-of-art software and hardware development tools, and training in industrial quality development processes.

Some schools have embraced Model-Based Design tools to the extent that they've integrated their use into the school curriculum. This has allowed them to deal with the problem of changing team composition due to graduations every year.

To make sure the investment in Model-Based Design is realized, some schools are tuning their system-level models with measured data. This is a practical activity commonly done in industry, and it's great to see the mix of empiricism and theory and the flexibility and openness in thinking that it requires. The availability of easy-to-use modeling and simulation tools has significantly reduced the age-old conflict between theory and empiricism leading to better plant models, and consequently better control designs.

Over the last 10 years that I have been involved with EcoCar and its earlier forms, it has been very gratifying to see that the gap between industry and university practice in hybrid development has narrowed significantly, due in part to GM's requirement that students follow the GM development process with existing refined subsystems as a starting-point.

Students are successfully using Model-Based Design tools to develop complex large-scale control systems, making many subsystems work together. In the near future, it is my hope that we can move beyond the first level of making a large number of energy conversion subsystems simply play well together and into a new phase where they play optimally together, first through thorough and uniform application of numerical optimization to offline simulation models, and later to the application of embedded real-time optimizers that lead to optimal performance in real-world driving conditions. One or more existing production hybrids already have effective embedded optimizers, so it will not be a surprise to see the majority of EcoCar teams in the future with such capabilities.

The continued adoption of industrial control design tools and processes into university curriculums across subject areas will better reflect the reality that today's engineered systems are inherently multi-discipline, and provide industry with engineering leaders ready to meet the difficult control design challenges we face.