



Modeling and Simulation in the Automotive Industry - Engaging the Engine of Change

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Over the past three decades, advances in product quality, design/development methodology, and manufacturing technology have all made tremendous strides throughout the automotive industry. From process optimization to virtual prototyping, Modeling and Simulation technology has played a vital role in this revolution. The opportunity for the future, however, is that the fundamental value of Modeling and Simulation to the automotive industry has yet to be realized.

State of the Present

The economic climate in the world automotive industry remains steady in the face an iffy economy. Low interest rates are helping, as is our ongoing love affair with the automobile. Nonetheless, the competitive environment for consumer revenue remains intense. Limited capital and skilled human resources, high consumer expectations, and pressure from the regulatory environment will create many formidable challenges over next decade. *Modeling and Simulation will be instrumental in the industry's ability to meet these challenges.*

Modeling and Simulation (M&S), in various forms, is already an integral technology in the automotive industry. The presence of computer-aided-engineering (CAE) and computer-aided-design (CAD) are

so familiar as to be the basis of advertising campaigns. In addition, math-based, dynamics simulation is becoming pervasive worldwide. These systems are used to represent disparate phenomenology (e.g. mechanical, electrical, thermal, acoustical, etc.); by means of alternative modeling schemas (e.g. continuous simulation, discrete-event simulation, and finite-element analysis, etc.); and for a variety of uses (e.g. vehicle dynamics, structures, engines, controls, and full vehicle integration). These technologies are expected to yield improvements of up to 50% in a variety of crucial metrics within 5 years (e.g. design effectiveness, design cost, number of vehicle prototypes, and development cycle duration). In addition, complex embedded simulations systems with driver-, hardware-, software-, and environmental influences-in-the-loop are becoming prevalent.

The value of employing these modeling and simulation techniques is readily evident to managers, technologists, and operational personnel. And their use is expected to increase considerably. For instance, according to The Delphi X Forecast and Analysis of the North American Automotive Industry: "The proportion of vehicle-engineering activities using math- and computer-based tools (CAE, excluding CAD) is forecast to increase from 40 percent currently to 70 percent, ... and the number of vehicle prototypes is forecast to decrease by 40 percent by 2009 as a result of improved simulation tools."

Future needs

Change will occur in virtually every phase of product life cycle management over the next decade. These dimensions of change are the basis of the opportunity for the influence of Modeling and Simulation to be realized in qualitatively new and different ways.

Motivated by pressure for ever shorter development cycle time, design and development practice must accommodate a burgeoning array of sophisticated features such as: on-board command, control, communications, sensing and passenger interface functions, while supporting emerging distributed collaborative engineering processes. Manufacturing practice must accommodate migration of facilities, outsourcing, supply-chain management and overall inter-process communications in order to control build-to-order time. The entire range of customer interface operations, including marketing, sales, distribution, and O&M support, admit to considerable process engineering, in light of customer expectations and evolving electronic communications and commerce capabilities.

While not all of these circumstances beg for M&S solutions, the general circumstance establishes a perspective for reconsideration of the most effective role of M&S in the automotive industry.

Power for change

Modeling and Simulation is a technology whose power to affect constructive change

within the industry is only coming to be appreciated. The potential of Modeling and Simulation in general, as for the automotive industry in particular, lies in its technology, its infrastructure, and its special relevance to enterprise support.

The tools and techniques of Modeling and Simulation are relatively mature, ...and effective. Schemas and notations for capture of conceptual models are readily available (e.g. Unified Modeling Language – UML, IGES, STEP, ACIS, Parasolid). Developmental standards, such as the High Level Architecture (HLA) and corresponding techniques for stand-alone as well as distributed simulation architectures are gaining traction. COTS applications supporting each of several types of simulation representation as well as distributed hybrid simulation systems are generally available.

Less mature, perhaps, but evolving, is the establishment of a clearly identifiable Modeling and Simulation profession, industry and market place, relevant beyond the narrow confines of particular modeling tools and techniques and specific application domains. Academic curricula and advanced degree programs in Modeling and Simulation, topical research by Government, industry and academia, and the establishment of vendor-independent standards are evidence of this growing robustness.

Most significant for the automotive industry, however are the new forms of M&S-based enterprise operations that are being demonstrated. Coherent M&S activity conducted across the product life-cycle, and serving to establish shared appreciation of the product throughout the product community-of-interest - M&S 'becoming' the product - will be the future of modeling and simulation in the automotive industry... and others. The special quality of modeling and simulation to represent the product's structure and process in ways that are powerfully intuitive and intimately linked to existing

forms of product design, development, test, evaluation, training, and operational support makes it uniquely powerful as a higher-order integrative specification.

Opportunity for the future

Based on the needs of the industry and the capability of Modeling and Simulation technology, several trends are clear.

We can safely expect uses of M&S to be constructively driven by market pressures – demand for better, faster, cheaper. Simulation technologies already available will be progressively employed in addressing the industry's issues. These include enterprise-wide conceptual modeling for the sake of semantic interoperability of product components and uses, formal verification and validation (V&V) to establish the enterprise-wide credibility of simulation assets, and high-performance parallel computing for design-turn-around and real-time simulation uses. Within the next decade, the use of Modeling and Simulation will come to be appreciated as one of the few powerfully integrating perspectives of the industry and will, in time, serve as the fundamental 'instrument' for product life-cycle management.

The implications of these trends for those responsible for harnessing the power of modeling and simulation to the engine of change for the industry are, likewise, clear. There is no free lunch. Overt investment in adoption and adaptation of technical standards, tools, and processes will be necessary. Open-architecture and true interoperability of COTS products will be required. The economics of M&S will need to be fully appreciated. And, the art of enterprise establishment and operations providing self-evident win-win, managed risk opportunities among all the stakeholders must be practiced.

Taking advantage

Taking the broadest, most liberal 'enterprise-wide' view of the relationship of modeling

and simulation technology to the evolution of the automotive industry is the surest way to capitalize on M&S technology.

Modeling and Simulation will serve to a greater or lesser degree as a 'natural' engine of change in the automotive industry. Certainly, all change entails both risk and opportunity, and prudence in adopting fundamental technologies into core cultures is certainly advisable. Nevertheless: "Organizations that effectively develop and implement rapidly changing technologies [such as modeling and simulation] to reduce cost and improve customer satisfaction (increase value) will certainly have a competitive advantage." ■

While the race may be to the swift and the battle to the strong, the competitive advantage offered by Modeling and Simulation, will go to the visionary, the savvy, and the decisive.

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