Foreword

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Biographical notes: Dr. Gillespie is an Emeritus Research Professor at the University of Michigan Transportation Research Institute. He joined the University in 1976, after working at Ford Motor Company as a design analyst and development engineer. Over the years he has conducted research in road roughness characterisation, road-vehicle interactions, and modelling and simulation of vehicle dynamic behaviour. The work in road roughness led to the development of the International Roughness Index. His experience in vehicle dynamics is largely reflected in the book, *Fundamentals of Vehicle Dynamics*, published by the Society of Automotive Engineers. In the late 1980s, Dr. Gillespie served as a Senior Policy Analyst in the White House Science Office for the Reagan Administration. Upon returning to the University he served as the Director of the Great Lakes Centre for Truck and Transit Research. Currently, he teaches courses in the subject areas of vehicle dynamics, automotive engineering, and integrated vehicle systems design. He also works part time at Mechanical Simulation Corporation in Ann Arbor.

It is a great pleasure to be associated with the founding of the *International Journal of Vehicle System Modelling and Testing* to provide another forum in the International Journal Series of Automotive Engineering Publications. The introduction of this new journal is quite timely when one considers the evolutionary changes in the automotive engineering focus over the years.

The significance is put into context when one looks at how the engineering focus has changed over the past 100 plus years of history in the industry. The earliest engineers dealt with very rudimentary questions, such as how many wheels to use and where to put them. Nicholas Cugnot, most frequently acknowledged as the inventor of the motor vehicle, used three wheels with a front-wheel-drive configuration in his 1769 invention. Other inventors tried two in the front and one in the back. Still others like the Sunbeam Mabley of 1901 used four, distributed as one in the front, one in the back and one on each side. Although automotive design quickly settled on four wheels, one at each corner, other practical questions remained to be answered, such as whether to steer with a tiller or a steering wheel as a part of the bigger questions about how to control the vehicle. Viewed from today's perspective it is interesting to observe that the Ford Model T, the largest selling vehicle in the early years of the industry, was controlled by three floor pedals (forward/reverse, low gear/neutral/high gear, and a brake). The throttle was a manual control on the steering column and the parking brake was also a neutral control. This control paradigm was used in over 15 million vehicles and endured through the year 1927.

During the first few decades engineering centred on finding designs that would achieve the desired functionality and durability, but by the 1930s the engineers began to focus on nuances of performance, such as ride and handling. Maurice Olley did much to refine the design for ride with the revelations of principles learned from his 'K-squared' rig that are still observed today. Tire companies devised methods to measure tire cornering force properties significant to handling, thereby fostering the early development of directional response models. By the 1950s, engineers at the Cornell Aeronautical Laboratories brought our understanding to the level of explaining understeer and stability limits.

Through that period the design and function of the motor vehicle was largely the purview of mechanical engineers trying to design the various mechanical systems to achieve performance that was acceptable under all conditions, although not necessarily optimal in any. As is well recognised, a suspension tuned for ride was not optimal for handling, and one with good handling was not especially capable of good ride. Similarly, a brake system designed for good performance at full load on dry roads was not optimal with light loads, or on wet roads.

The 1970s marked the beginning of the end of the purely mechanical era in automotive design. With advancements in technology for sensing, computation and actuation systems, electrical and controls engineers found a place in automotive design. With these capabilities it was possible to sense the state of the automobile and its environment, make basic logical and computational decisions, and intervene to 'tune' the various systems to prevailing conditions. The new technology gained a foothold with the introduction of anti-lock brake systems in the 1970s, and paved the way in subsequent decades for new applications in traction control, stability control and roll control systems. Today, the application of control systems on automobiles extends far beyond these to include highly sophisticated interactions with operation of powertrains, emissions controls, cruise controls, crash sensing and protection systems, navigation systems, entertainment systems and more. Those on the forefront of new automotive technologies will testify that the end is not in sight. Such people envision the vehicle observing, communicating, and interacting with the environment to assist the driver in dramatically new ways within the next decade or two.

In this new world automotive engineers are being asked to take on more responsibility for making vehicles 'safer' under all possible conditions. This may translate into devising restraint systems that re-tune themselves in accordance with an imminent crash, or developing means to make vehicles harder to rollover. As an example of the increasing complexity, the NHTSA research program to push the envelope of rollover testing has resulted in a test protocol calling for steering inputs so complex that they can only be achieved with an automatic steering controller.

With this responsibility comes the need to better define the universe of possibilities. Modelling and testing are the means to this end. The axiom of the medical profession to 'First, do no harm' applies to us. With complex control systems that take control away from the driver at times, we engineers will face similar challenges. As a consequence, we carry the burden of learning all the possible operating and environmental conditions in which a vehicle could be used, so that we can design a system that is, at best – safer, and at worse – benign.

The introduction of ABS illustrates this concern. Prior to ABS, we produced vehicles in which the driver knew that pushing the brake pedal would apply the brakes in proportion to the pedal force. ABS broke this paradigm. The ABS designer took responsibility to intervene and release the brakes for brief periods during the braking manoeuvre, in effect asserting that "there are times when the controller knows better than the driver" and takes authority over the brakes. While generally successful at preventing brake lockup and maintaining stability, it became apparent over time that the action of an ABS did not necessarily shorten the stopping distance under all conditions. The control methods developed for dry and wet roads were not the best choice for roads with snow or gravel on the surface, hence compromising the primary function – stopping the vehicle – in some of the earliest designs.

Coincident with the trend to more complex automotive systems is pressure to shorten the product development cycle. The five-year development cycle is now as antiquated as the hand crank. Engineers have responded to the pressure by developing new ways to design, test and validate vehicles using virtual test methods and virtual proving grounds, thereby eliminating many of the time consuming hardware steps in development. The engineering tools we had in the past for modelling vehicle systems and predicting performance were only simple equations representing approximations of physical systems. Today, these have been supplanted by comprehensive computer models, which allow simulation of systems with representation of multiple complexities and non-linearities. Finite element models are able to predict crash performance long before hardware is at hand, such that design refinement can precede tooling commitments. Vehicle dynamics models can be called upon to predict ride, braking and handling performance at the design stage. While powerful, these tools are not perfect. Improvements in fidelity only come with improvements in modelling and testing. Those of us in the field of developing these tools know the need for better models for tires, vehicle structures, powertrains, and other systems.

Coupled with these familiar needs will be the new paradigms required for modelling and testing the new systems now being contemplated. Engineers at the forefront of the community are contemplating systems to enhance driver situational awareness not only by sensing the environment surrounding the vehicle, but also by communicating with other vehicles and the highway infrastructure. We can only begin to imagine some of the new tools that will be needed to evaluate, and validate the quality of the information being collected, and the methods used to communicate such to the driver. Hand in hand with that is the need to better understand the driving task itself – a new area being given the name 'science of driving'. With the advent of more complicated interacting systems we will be challenged to devise more thorough protocols for testing to ensure only desirable outcomes while avoiding unintended consequences that can befall complex systems operating outside of the design space.

This is where the *International Journal of Vehicle System Modelling and Testing* fills an important need. Experts in every area are aware of the limitations of the tools available today, and look forward to improvements in fidelity. These improvements will only come about from advances in modelling the driver, the vehicle, and the environment, along with more comprehensive methods to test and validate the models.

This is our challenge. This new journal provides a forum in which we can all meet to map out the future in modelling and testing of automotive technologies. With your participation, we look forward to developing better ways to design safer, and more efficient vehicles for society and for our families.