INTRODUCTION TO PART I

The first part of this book is dedicated to the study of the often complex subsystems (such as suspensions) that constitute the chassis. Their primary function is to mediate the exchange of force with the ground, thus obtaining the desired vehicle speed and path.

With reference to the system of coordinates that will be defined in part four, the forces exchanged with the ground can be classified as:

- Forces perpendicular to the ground (vertical for the motion on a plane road); in steady state conditions these forces can be considered constant, but because of obstacles on the road, they are variable; they are a factor in passenger comfort.

- Longitudinal forces; these are primarily due to propulsion (engine and transmission) and braking systems; they are relevant to vehicle speed control.

- Transversal forces; these are due to wheel steering angles, and they are relevant to road holding and stability.

All these forces act on tires that because of their deformable structure, make the dynamic behavior of the vehicle more like a floating or flying vehicle than a rail vehicle.

Although chassis technologies can be defined as mature, we should not underestimate the ongoing evolution of controlled or active systems based upon electronic and informatic technologies.
In fact the rapid development of automotive electronics, in terms of performance and cost has had and will continue to have a big influence on improving the active safety and comfort of vehicles.

Nor it should be forgotten that in many markets the development and production of chassis systems is being outsourced by car manufacturers to parts manufacturers, who are becoming specialists in their business.

This has been true for many years of brake systems, steering systems and tires; it is now becoming true for suspensions. Given this situation, it is important for those who will address their career to car or parts manufacturing to develop a good understanding of these systems; the development of these components is virtually impossible if separated from that of the vehicle.

As we will see, chassis components have evolved quickly in recent years: today almost all cars feature radial tires with low aspect ratios (the radial dimension is much smaller than transverse dimension) and need suspensions with precise elasto-kinematic behavior. McPherson and double wishbone suspensions share the market as far as front axles are concerned, while a significant percentage of rear axles feature multilink suspensions.

It is unlikely that the kinematic configuration will see new innovations; the same can be said for the steering system, where the wide diffusion of power systems has almost standardized the rack and pinion configuration.

A similar situation can be seen for car brake systems, where disc brakes are widely diffused with the exception of the rear axle of economy cars that preserve the drum solution.

New developments are, however, expected for electronic control systems and the related fields of sensors and actuators, where electromechanical actuators offer more opportunities for performance improvements.

Electronic control systems have initially entered the marked as add-on devices.

The case of the brake antilock system (ABS) is typical: It made significant performance improvements to the brake system at the cost of new and sophisticated components (the electronic control system, wheel speed sensors, a valve group able to regulate the pressure on the brake actuators of the wheel independent of the pedal pressure).

Although the introduction of this system was gradual, it later reached high volumes with consistent cost reduction and now, as a consequence, its diffusion is nearly total. At the same time system performance was improved, offering new possibilities, either in terms of cost reduction (i.e. offering the possibility of incorporating the brake distribution valve function at no cost), or in terms of functions where, with the addition of various sensors vehicle dynamic control has been obtained.

A similar story can be told for power steering systems, initially totally hydraulic; the addition of electronic controls allowed better regulation of the power assistance pressure, reducing the sensitivity of the steering wheel torque to the vehicle speed.
The present trend consists in substituting an electric electronic system for the hydraulic electronic system: Power assistance comes from a controlled electric motor. This offers the possibility of having an active steering system that can improve vehicle performance while avoiding sudden obstacles.

It is likely that all actuators will become electric in the future, with cost reductions and increased performance; the next step could be to avoid any mechanical linkage between pilot controls (pedal, steering wheel, etc.) and actuators.

This goal has already been reached for the engine, where throttle position or fuel injection quantity are no longer controlled mechanically by the accelerator pedal, but through a drive-by-wire system. We can easily foresee for the future a brake-by-wire system or a steer-by-wire system.

The next step, now a topic of discussion in many technical congresses, is the corner-by-wire that is a wheel-suspension group (corner) with total electric actuation (driving, braking and steering functions); a system like this could have a significant impact on vehicle performance and architecture.

Similar evolutionary processes are present in the suspension field: a first step is the application of electronic controls to the damping properties of shock absorbers and to the position of the body relative to the ground while the vehicle is standing still (trim); this could lead to a suspension where the body position is also controlled dynamically. Such an achievement would simplify the elasto-kinematic requirements of the suspension.

We think that these and other examples offer a view of the possible paths of chassis evolution.

After a chapter dedicated to the historical evolution of the chassis, the most widely used configurations for chassis components will be described. The following components will be considered.

Wheels and tires
Tires will not be studied from the stand point of their product and process design techniques, which are useful in determining their performance. They will be studied almost as a black-box, examining their static and dynamic response which is the basis of vehicle static and dynamic response.

A good knowledge of tire performance is fundamental for effective communication between vehicle and tire specialists.

Suspensions
While studying suspensions, the main kinematic schemes will be considered along with their influence on the working angles of the tires, on vehicle roll and pitch. The most important suspension components will be described, such as the primary elastic elements, the secondary elastic elements and the damping elements.
INTRODUCTION TO PART I

Steering system
The primary mechanisms of the steering system will be studied along with their mechanical properties; the primary components will be described, such as the steering box and the most important power assistance systems.

Brake system
The most important brake types will be introduced along with their actuation and power assistance systems. Industrial vehicle brake systems will be described separately because they use a different actuation system (pneumatic instead of hydraulic power).

Control systems
As far as chassis control systems are concerned, this volume will describe sensors and actuators in use and the technical target these systems should reach in terms of vehicle dynamics; the most diffused control strategies that the different systems adopt will be also described, while the interaction between control system and dynamic behavior of the vehicle will be examined in the second volume.

Chassis structures
Although this topic could be better tackled in a book dedicated to body design, this chapter will outline the integration of the chassis functions into the body structure and will offer a short description of the primary types of auxiliary frameworks in use on unitized bodies. A short description of industrial vehicle frameworks is also offered.