



ENGINEERING THE **DRIVING EXPERIENCE**

We are one of the world's leading consultancies for driving dynamics. It is a core part of our brand and no-one offers a more comprehensive understanding of the delicate interaction that exists between vehicle and driver.

Driving dynamics are vital; not only do they help satisfy customer desires, they add to vehicle safety and help define the values of the product and brand. They encompass how the car performs and responds, how it sounds and how it makes the driver or passenger feel.

Lotus has a deep understanding of how to unite all aspects of driving dynamics ergonomics, vehicle dynamics, aerodynamics, noise vibration and harshness (NVH), performance and safety to create the right overall experience for the vehicle.

At Lotus, we are skilled at manipulating all the elements of driving dynamics to create a driving experience that matches our client's expectation and those of the vehicle occupants.

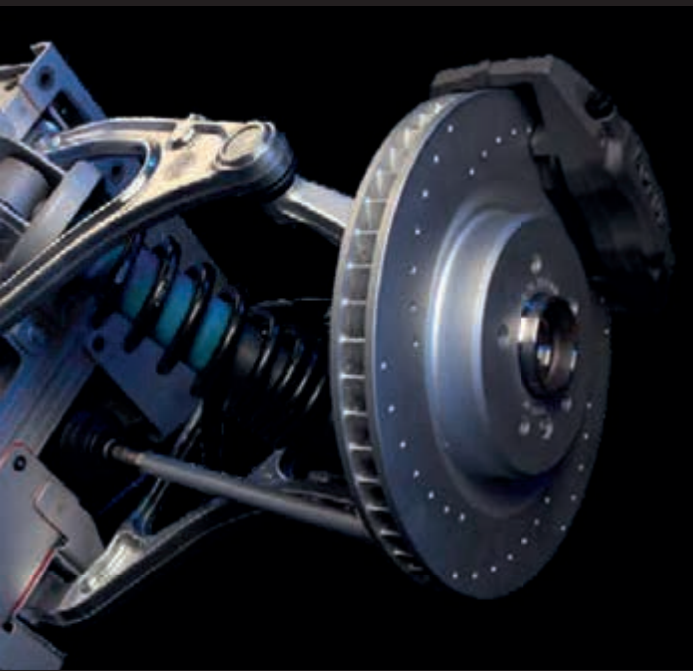


DRIVING DYNAMICS SERVICES

- Defining the vehicle attributes
- Chassis concepts and design
- Dynamics attribute development
- Enhancing dynamics with active systems
- Training in dynamics assessment and vehicle control
- Troubleshooting and problem solving

DRIVING DYNAMICS EXPERTISE

- Global reputation for excellence in driving dynamics as proven by award winning Lotus cars
- Over 30 years experience in extending the boundaries of vehicle dynamics using active systems
- Integrated team applying a multidiscipline approach to design solutions and problem solving
- Robust processes developed on our own vehicle manufacturing
- Simulation, analysis and target setting



AN ART AND A SCIENCE

No-one offers a more complete understanding of the interaction between vehicle and driver, all the way through from the initial design stage to on-road development and testing.

We couple subjective vehicle assessment by our expert engineers with state-of-the-art objective testing and simulation techniques. Computers, technology and raw data can help to quantify driving dynamics, but ultimately it's the

driver behind the wheel that needs to be impressed and kept safe. Key to this is specialist engineers from across technical disciplines working closely together to arrive at the optimum solutions.

This integration of the different functions combined with our focus on the end-user experience makes the Lotus approach unique.

ENHANCING DYNAMICS WITH ACTIVE SYSTEMS

Our aim is to extend the boundaries of vehicle dynamics with application of active control.

Lotus pioneered fully active suspension in 1981. Over 30 years and 50 active research and prototypes later, we are now exploiting the possibilities presented by electric drive and torque control.

Active control systems for suspension, steering, braking,

traction and aerodynamics improve the inherent dynamic envelope of even a very good 'passive' vehicle.

The end result is an improved customer driving experience and a honed brand identity. Agility and ride comfort benefits, stability is improved and aerodynamic drag losses are reduced.

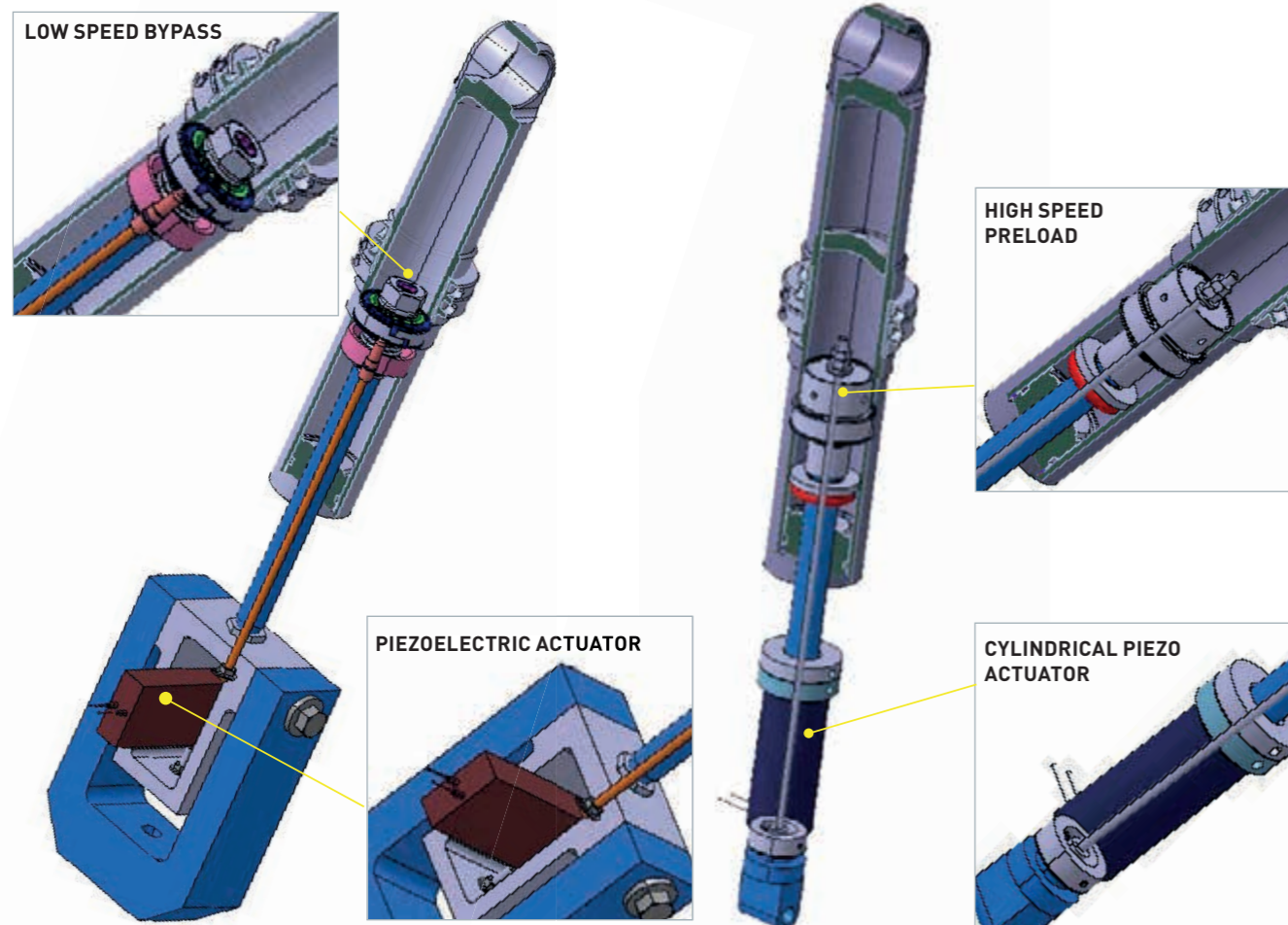
Active systems are not just for the realms of Formula 1 and

high performance vehicles, we have applied the technology to trucks, buses and even tracked vehicles.

We can provide simulations, concept definition and prototypes and demonstrator vehicles.



LOTUS PIEZOELECTRIC DAMPER CONCEPTS



Low Speed Damping Control

High Speed Damping Control

PIEZOELECTRIC DAMPING RESEARCH

Lotus works with the client for the concept design of suspension and chassis systems to create the desired dynamics attributes of a vehicle appropriate to the market requirements and its brand identity.

Driving dynamics attributes are important in convincing a customer to purchase a vehicle and in fulfilling the customers expectations of the vehicle in use.

Lotus takes a holistic approach at the design stage across all vehicle attributes including: ride, handling, steering, aerodynamics and NVH.

The piezoelectric damper concepts are part of Lotus' continuous research and development into new suspension technologies and designs.

Lotus' full active suspension system measured suspension loads, displacements and vehicle acceleration. From this the controller commanded each individual wheel station to move appropriately to manage roll, pitch, yaw and heave modes, helping to make the vehicle more agile, stable and comfortable to ride in. Wheel stations were actuated by fast double acting hydraulic rams which replaced the conventional

dampers and by adding energy could move the actuators against a load.

With any passive damper system the suspension only moves with the load, resisting motion depending on the damper characteristics. The fast acting piezoelectric damper has the potential to apply the modal control strategy from the full active system achieving a large percentage of the benefits but with very low energy consumption.

The piezoelectric damper system could be incorporated in to conventional shim

dampers to vary shim preload, affecting the transition to higher (damper) speed control, and orifice control affecting the lower speed damper forces. This is achieved with conventional hydraulic fluid and manufacturing technology.

Passive suspension is still important, even with a full active system a good passive suspension was essential to get the best out of the active enhancements. Lotus is of course experts in this field and is well placed to provide an integrated solution

POTENTIAL SYSTEM BENEFITS

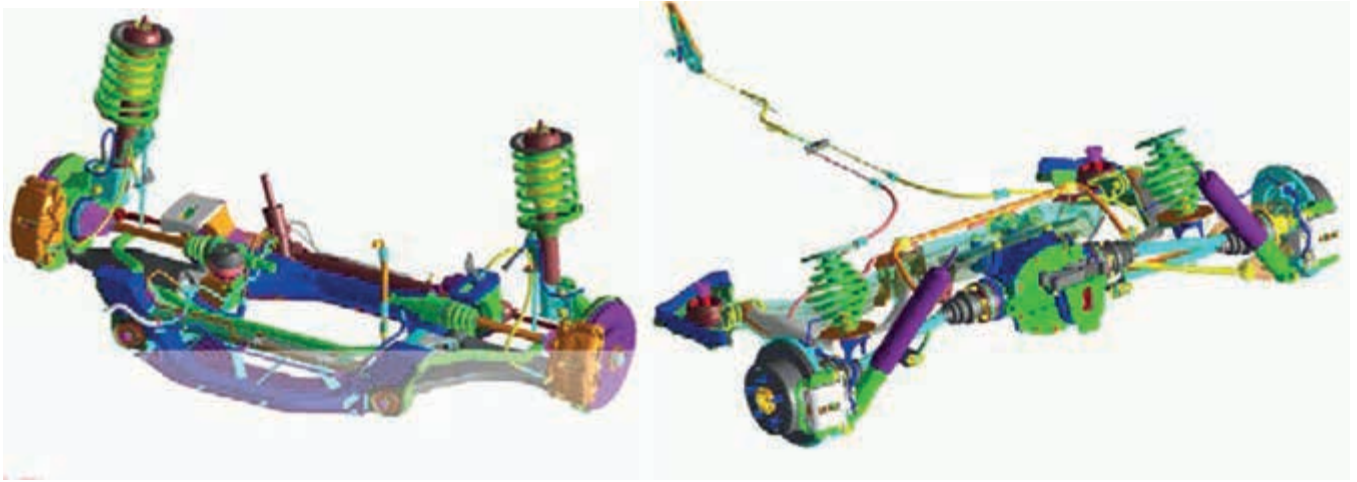
Improved frequency response and positional accuracy:

- Improved ride comfort
- Improved vehicle stability and control
- Reduced fuel consumption

Reduction in damper tuning development time

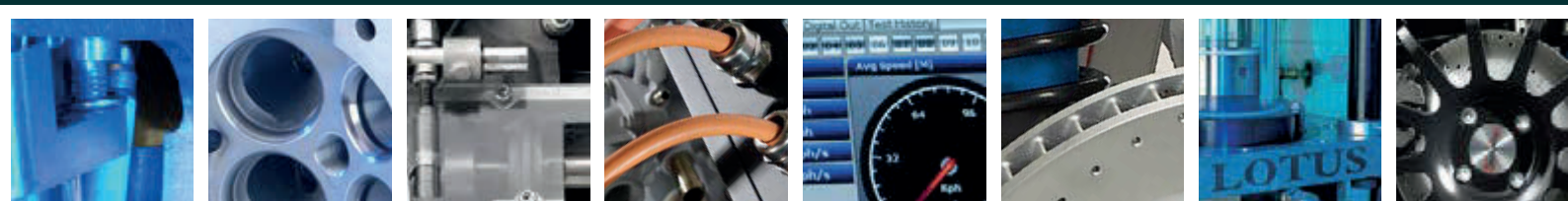
Compared to existing active suspension solutions:

- Reduced electrical power consumption
- Reduced mass



| CAPABILITIES AND SERVICES | |
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| Dynamics Attribute Engineering | <ul style="list-style-type: none"> • Defining the vehicle attributes • Dynamics attributes development • Target setting and benchmarking • Analysis and simulation • Testing and development • Validation and sign off |
| Enhancing Dynamics with Active Systems | <ul style="list-style-type: none"> • Active suspension • Active noise control using Lotus' HALOsonic |
| Chassis Concepts and Design | <ul style="list-style-type: none"> • Chassis design and development • Chassis prototype build • Suspension design |
| Dynamics and Driver Training | <ul style="list-style-type: none"> • Kinematics and compliance • Vehicle control skills • Subjective assessment and objective measurement training • Damper tuning training |
| Research and Development | <ul style="list-style-type: none"> • Suspension systems and design • Active systems • Dynamics of in-wheel motors • Ride comfort |
| Troubleshooting and problem solving | <ul style="list-style-type: none"> • Ride and handling • NVH |

LIGHTWEIGHT ARCHITECTURES - EFFICIENT PERFORMANCE - ELECTRICAL AND ELECTRONIC INTEGRATION - DRIVING DYNAMICS



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