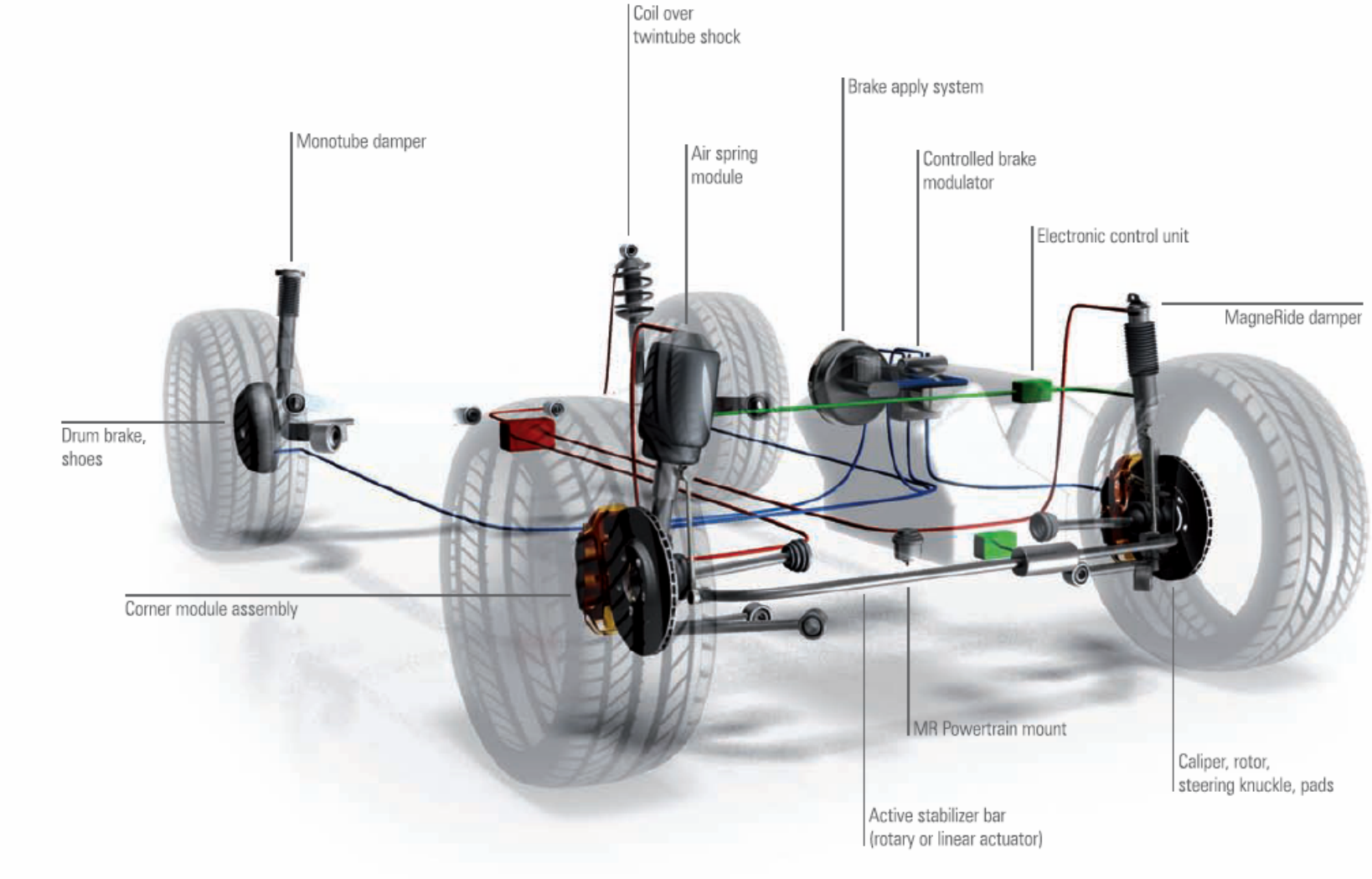
Magneto-Rheological Powertrain Mounts

Vehicle Dynamics Expo: 17-19 May 2011

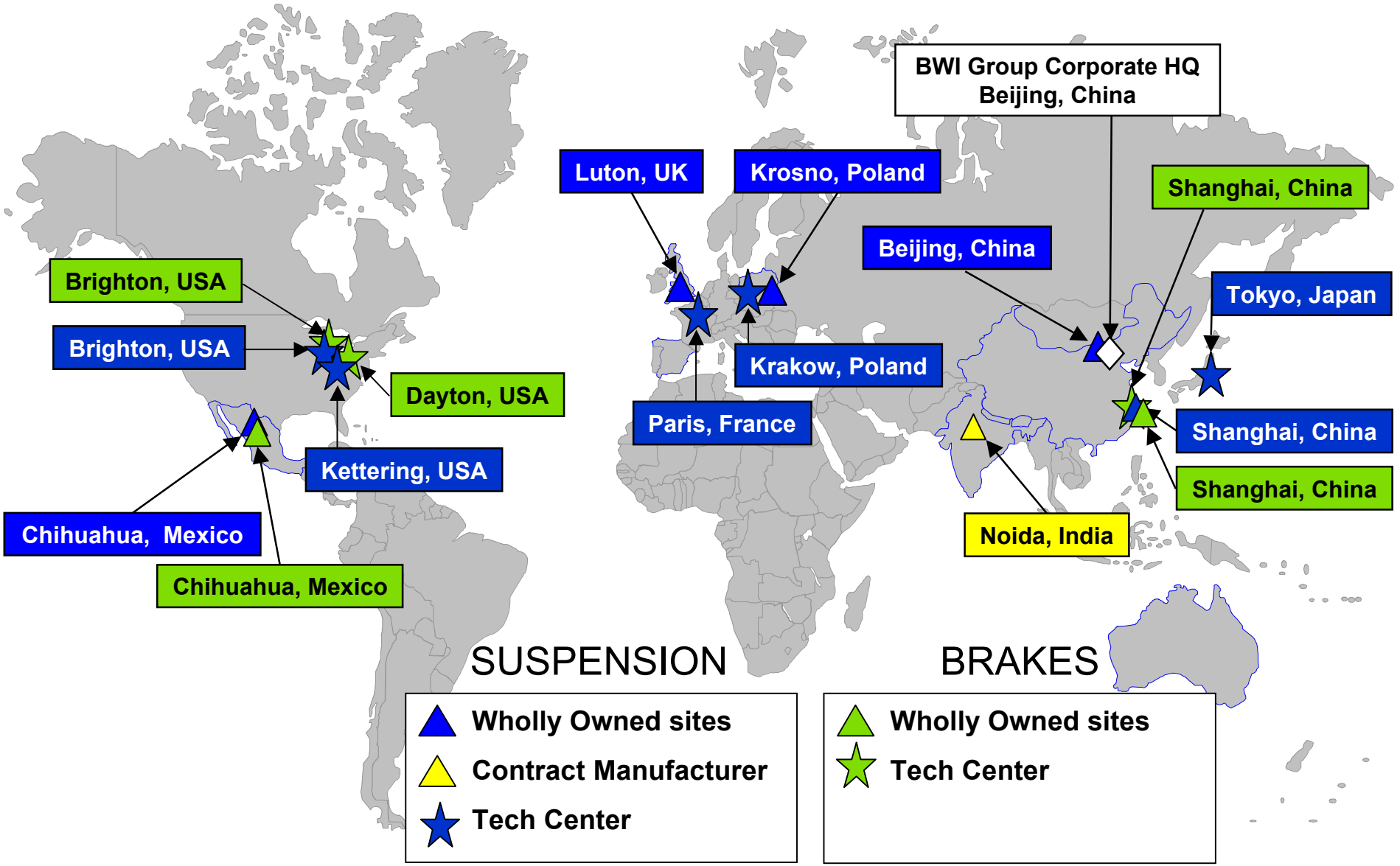
Messe Stuttgart, Germany

New name for a trusted supplier

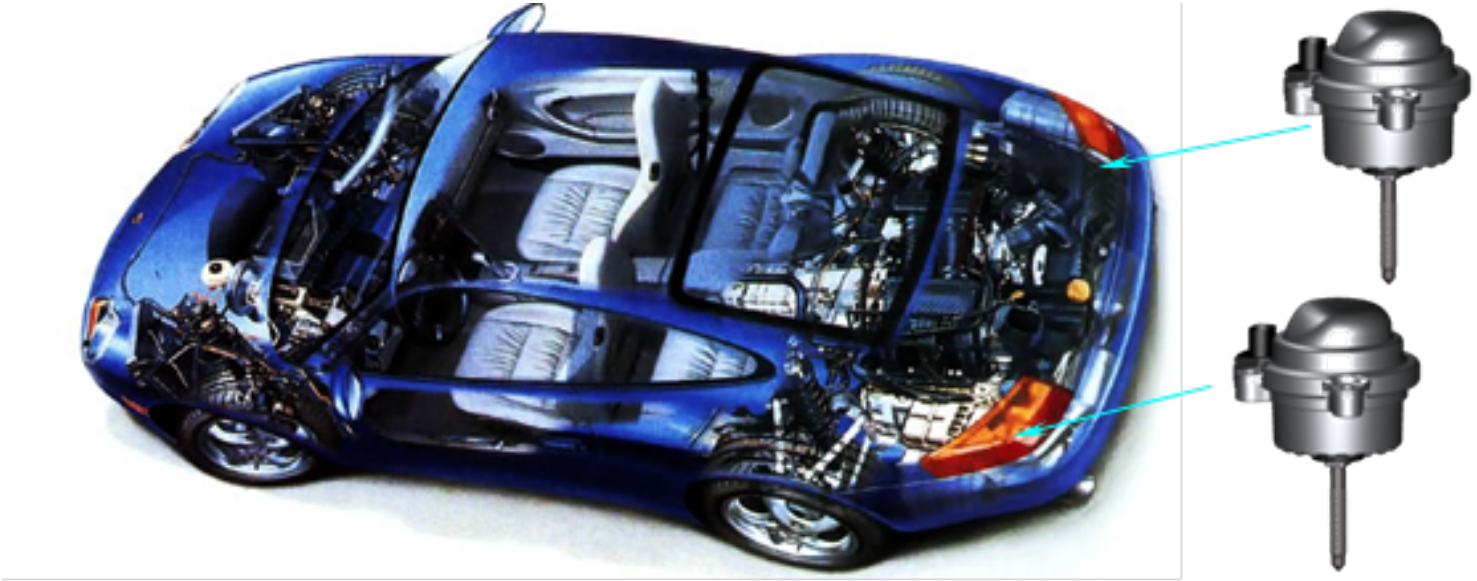
A Premier Chassis Supplier of Brake & Suspension Systems



Global Footprint

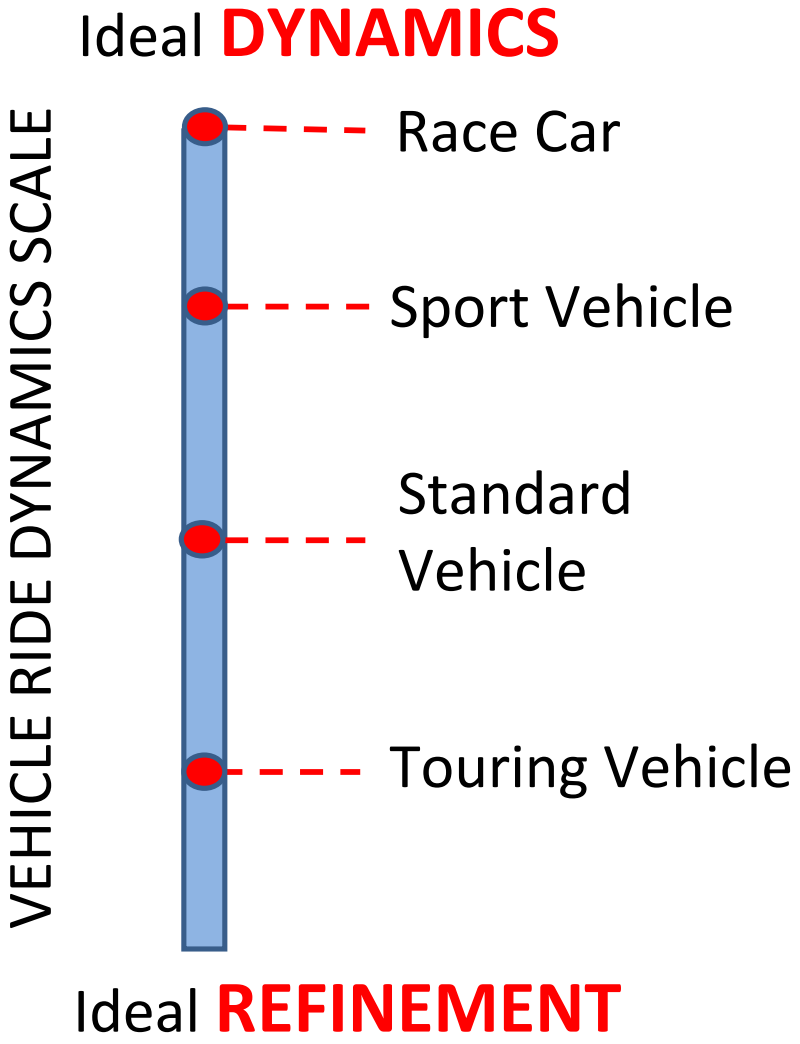


Magneto-Rheological Powertrain Mounts



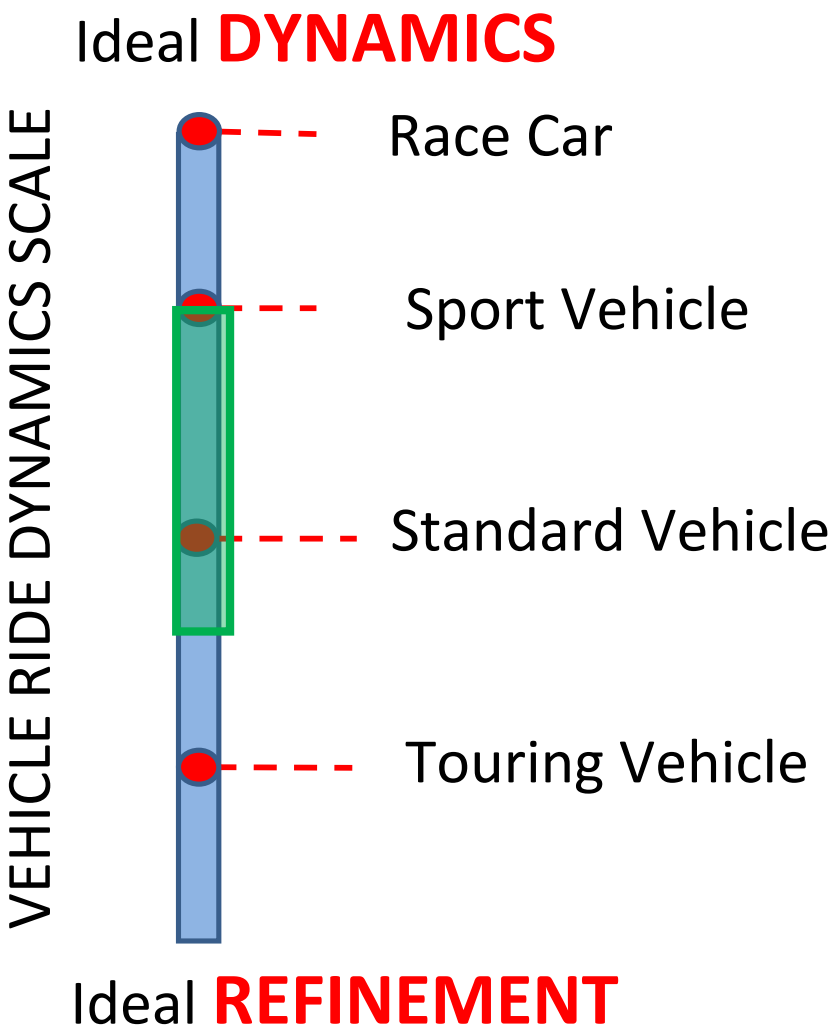
- **Exclusive technology**
  - 2010 model year introduction on 911 GT3 and 911 Turbo
  - Vehicle Dynamics International 2009 Innovation of the Year
- **Use magneto-rheological fluid**
  - MR mount fluid designed and patented by Delphi and transferred to BWI Group
  - This fluid is designed specifically for powertrain mount parameters and durability

Compromise, Refinement vs. Dynamics



- **The ride dynamics of a typical passenger car is selected somewhere between a touring sedan and sport sedan.**
- **Contributing into the selection is that passive hydraulic mounting systems are designed to a single level of stiffness and damping.**

Compromise, Refinement vs. Dynamics

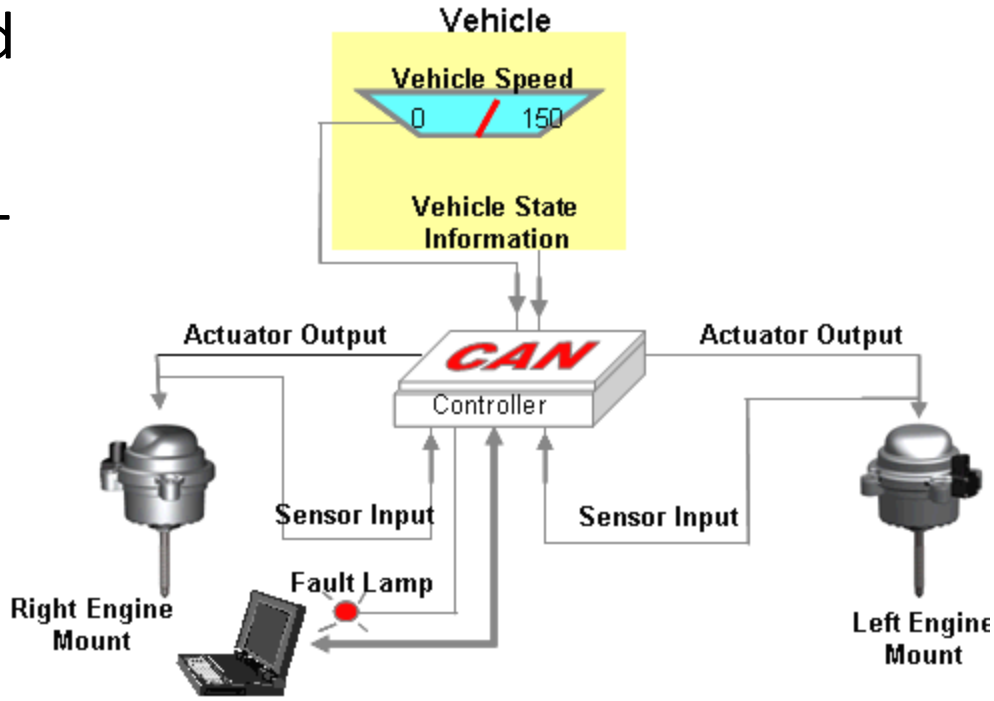


- **<u>GOAL from GT3 engineers</u>: "On the track the car must provide extraordinary dynamics, yet on road it must be sufficiently comfortable to use every day."**
- **Controllable MR Mounts allowed the vehicle to adapt depending upon driving situation.**
- **For instance on smooth roads mounts can be soft to improve isolation, or during hard cornering event can be controlled to reduce powertrain movement.**

Porsche Advertisement

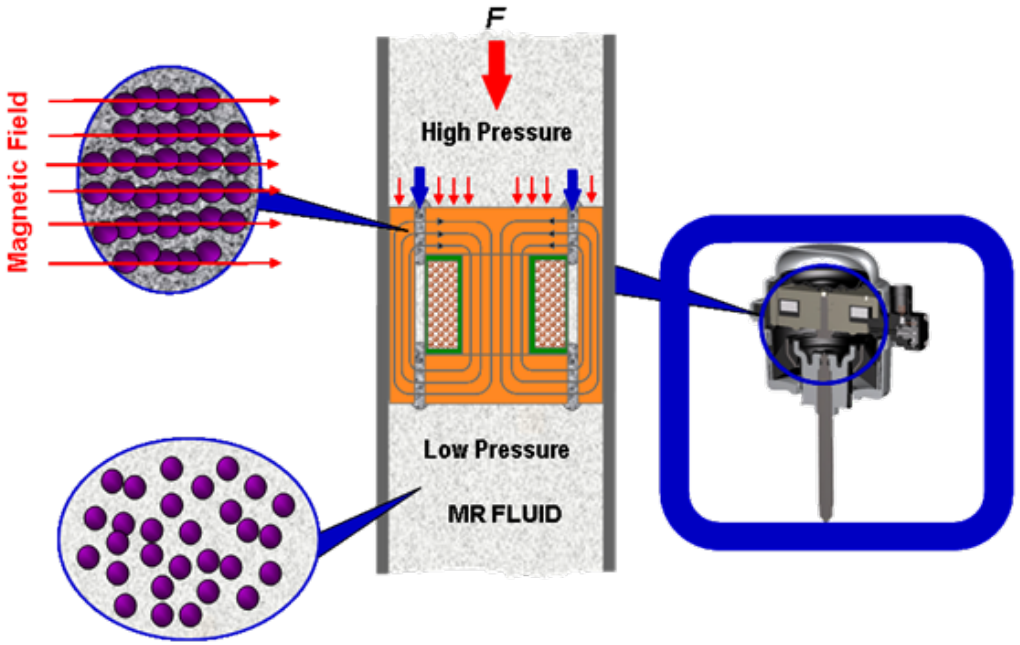
Control Strategy

- Global and Local Control Strategy
  - Feedback using integrated sensor
  - Determine vehicle status - CAN bus
    - Torque reaction events
    - Road conditions
    - Idle
    - Throttle position
    - Engine rotational speed (RPM)
    - Clutch position
  - Determine optimal mount setting for given vehicle state



Fluid Technology

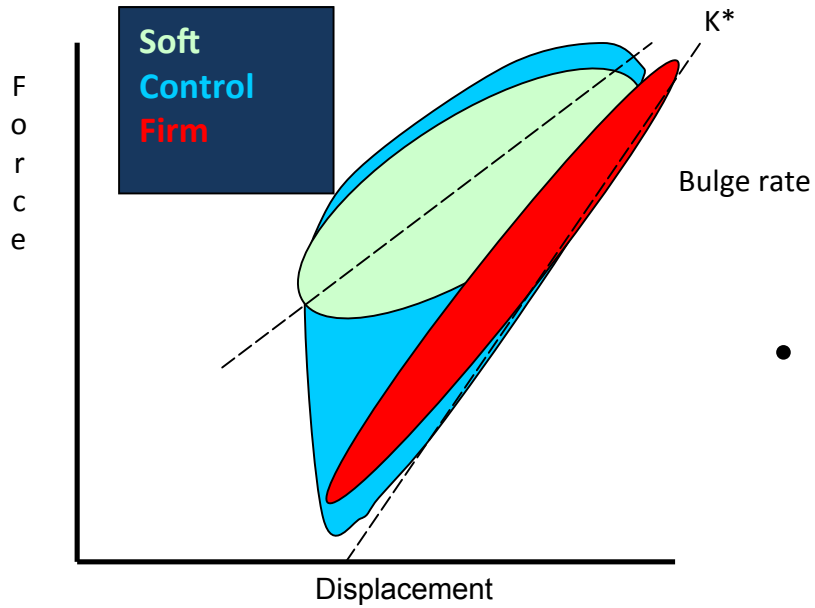
- **MR Mount contains an electromagnetic to generate a variable magnetic flux across the fluid passage.**

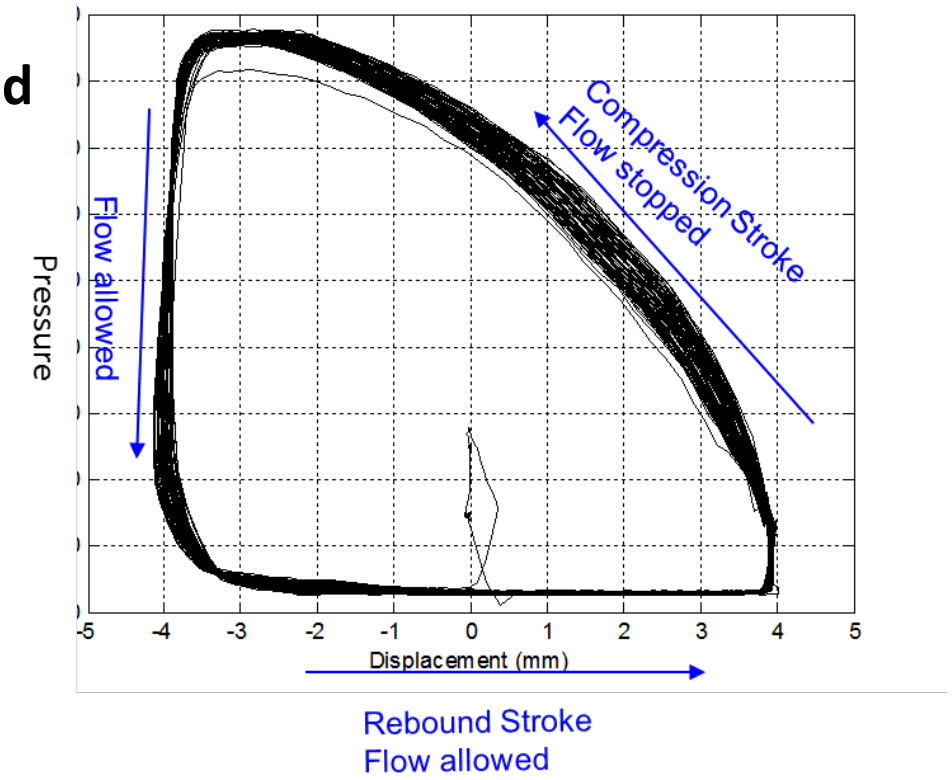


- **Coil state**
  - When the coil is off, MR fluid is not magnetized, thus iron particles are randomly dispersed.
  - When coil is energized particles align in direction of magnetic flux.
- **Sheer stress required to move fluid is proportional to magnetic field.**

Local Control ON Operation

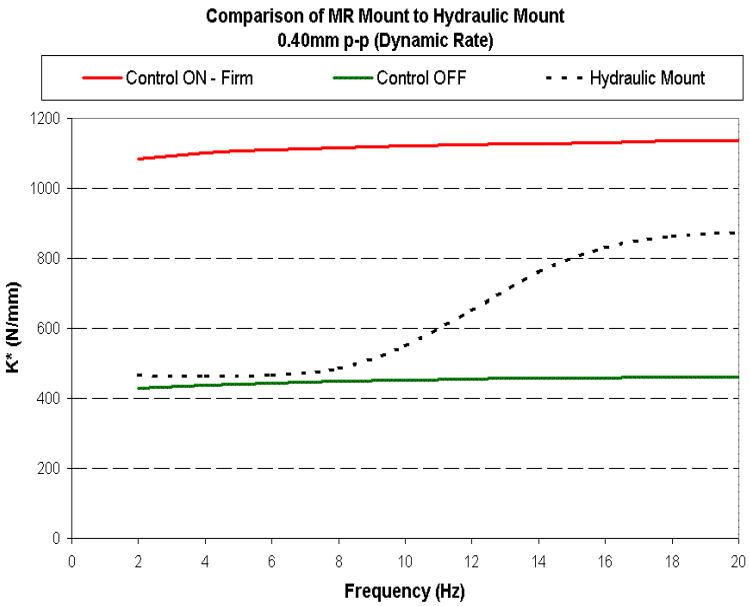
- **The objective is to optimize enclosed area of the pressure displacement curve.**
  - Pressure varies with molded assembly stiffness.





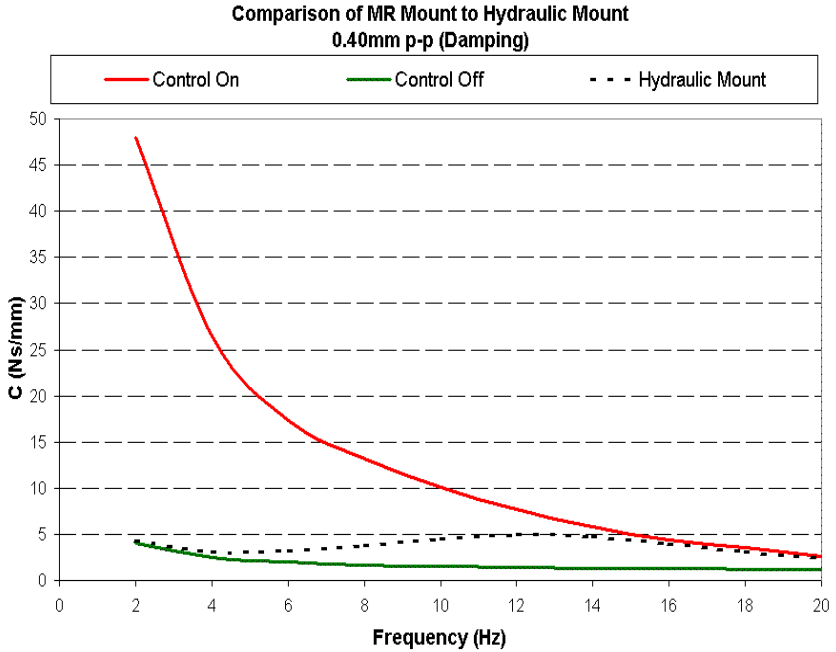
- **Hysteresis loop defines base component level software to control mount.**

Dynamic Rate and Damping



MR technology allows dynamic rate to be instantly changed

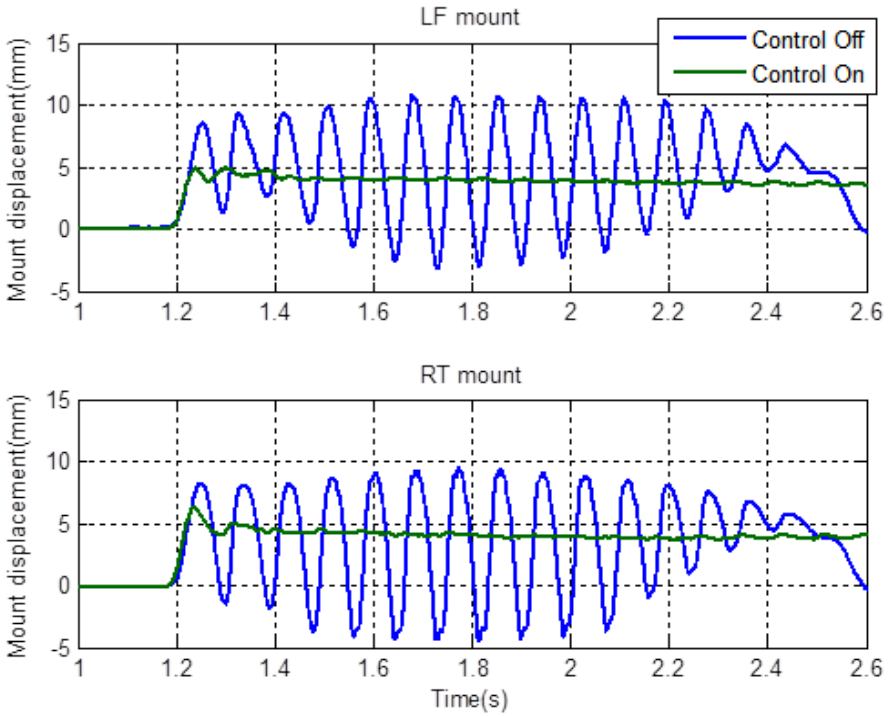
- Dynamic rate (K*) can be instantly changed between the molded assembly's base dynamic rate and bulge rate.

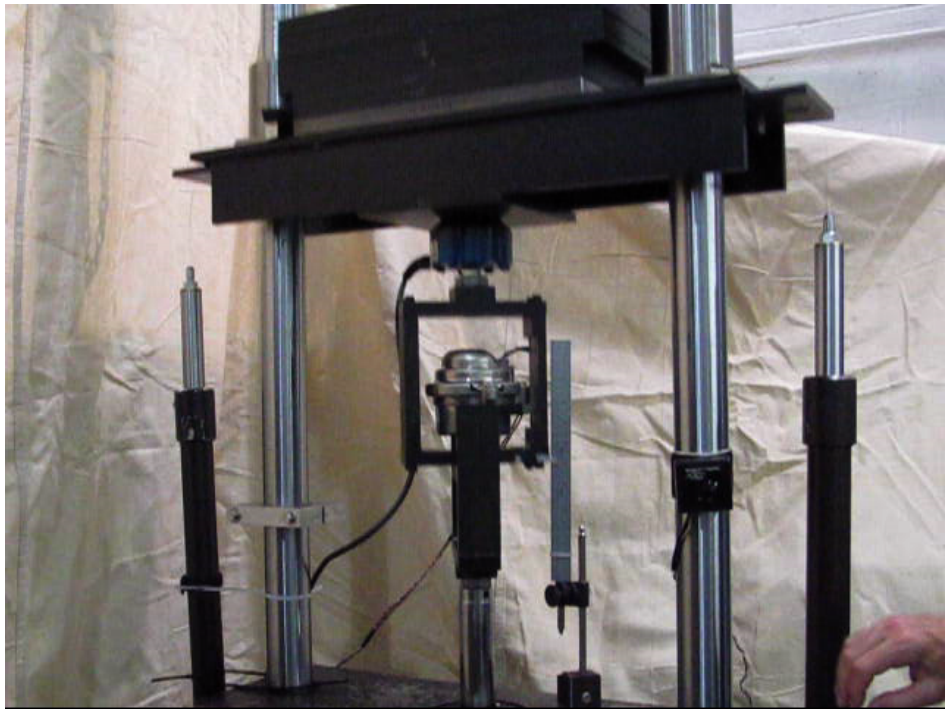


MR mounts provide high damping over a broad range

- Unlike conventional hydraulic mounts which provide peak damping at a single frequency and amplitude, and cannot generate damping at small amplitudes.

Transient Events





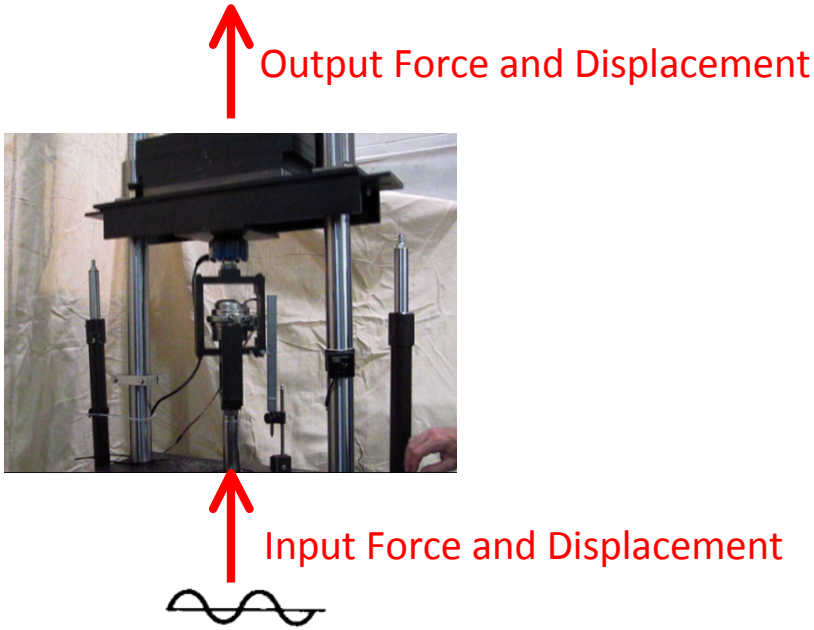
- **Vehicle test data for vertical excitation event**
  - Control ON vs. Control OFF mount displacement versus time data

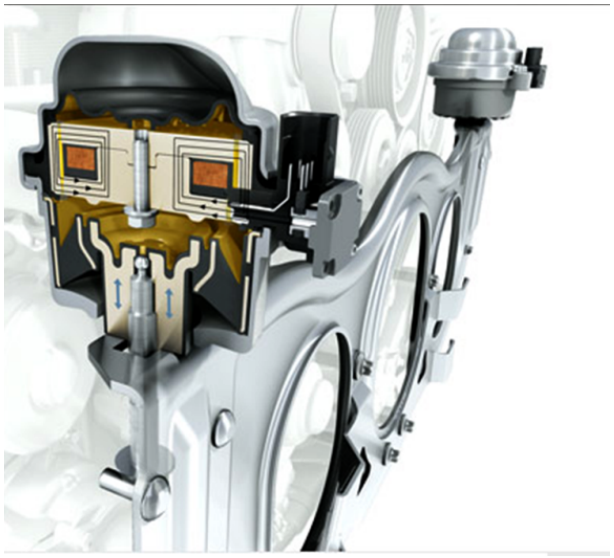
Transmissibility

- **Transmissibility Ratio is a function of output to input.**
  - Output force to input force
  - Output displacement to input displacement

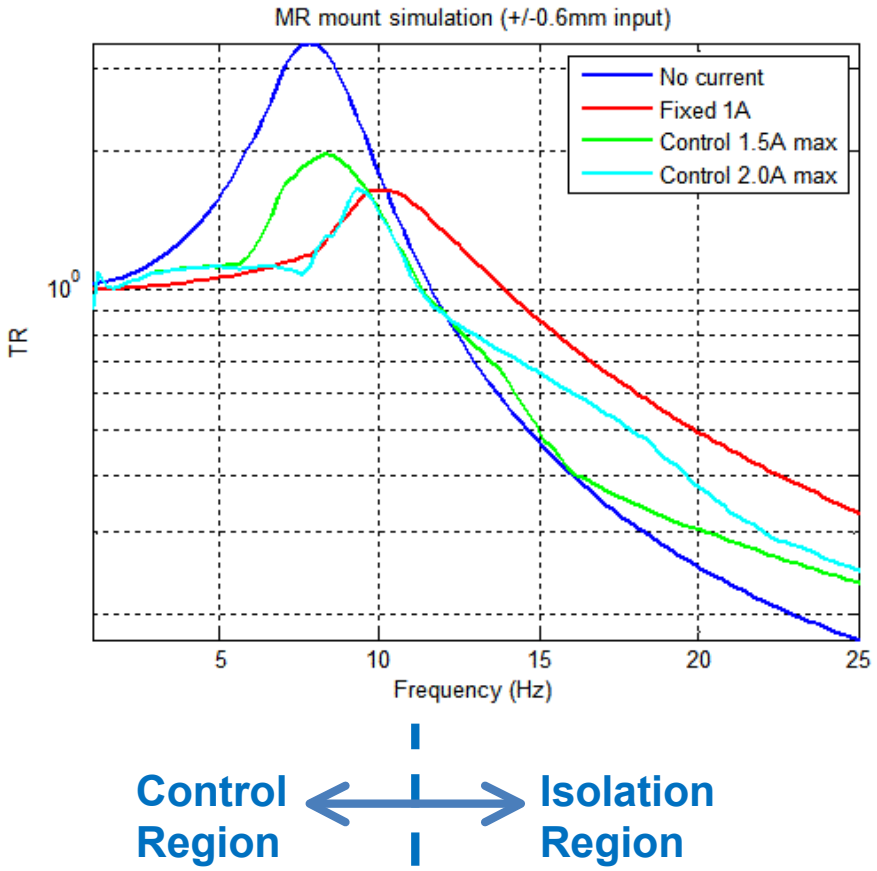
$$T_r = \frac{Force\ Out}{Force\ In}$$

- **An MR Mount's transmissibility performance can be varied by using different control algorithms and current levels.**



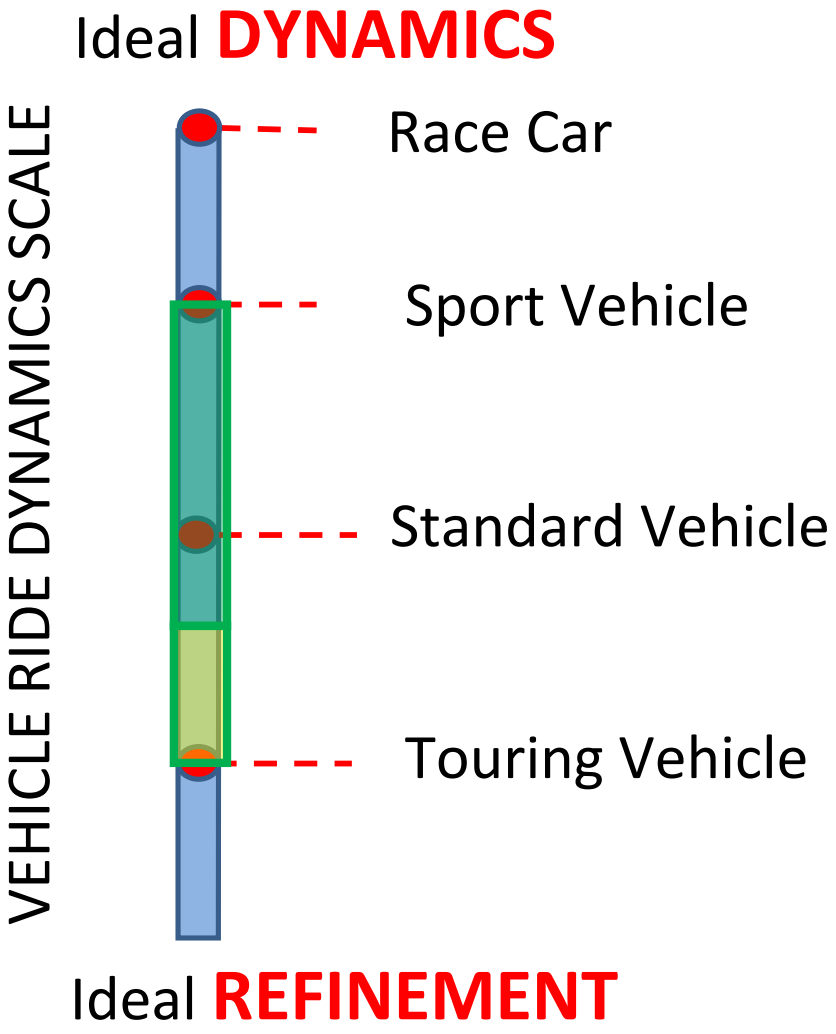


Transmissibility



- **Performance can be varied by using different control algorithms and current levels.**
- **Isolation**
  - reducing the stiffness and damping as much as possible at frequencies above the natural frequency of the system.
- **Control**
  - controlling the natural frequency motion of the suspended mass we would like to increase the damping as much as possible at the natural frequency.
- **Reduced tuning time**
  - tuning changes made electronically instead of with mount's track or molded assembly thus reducing vehicle tuning time.
  - Number of mount sets reduced because performance is changed via algorithm instead of hardware.

Future: Compromise, Refinement vs. Dynamics



Future compression mounts developments geared towards increasing refinement capabilities.