

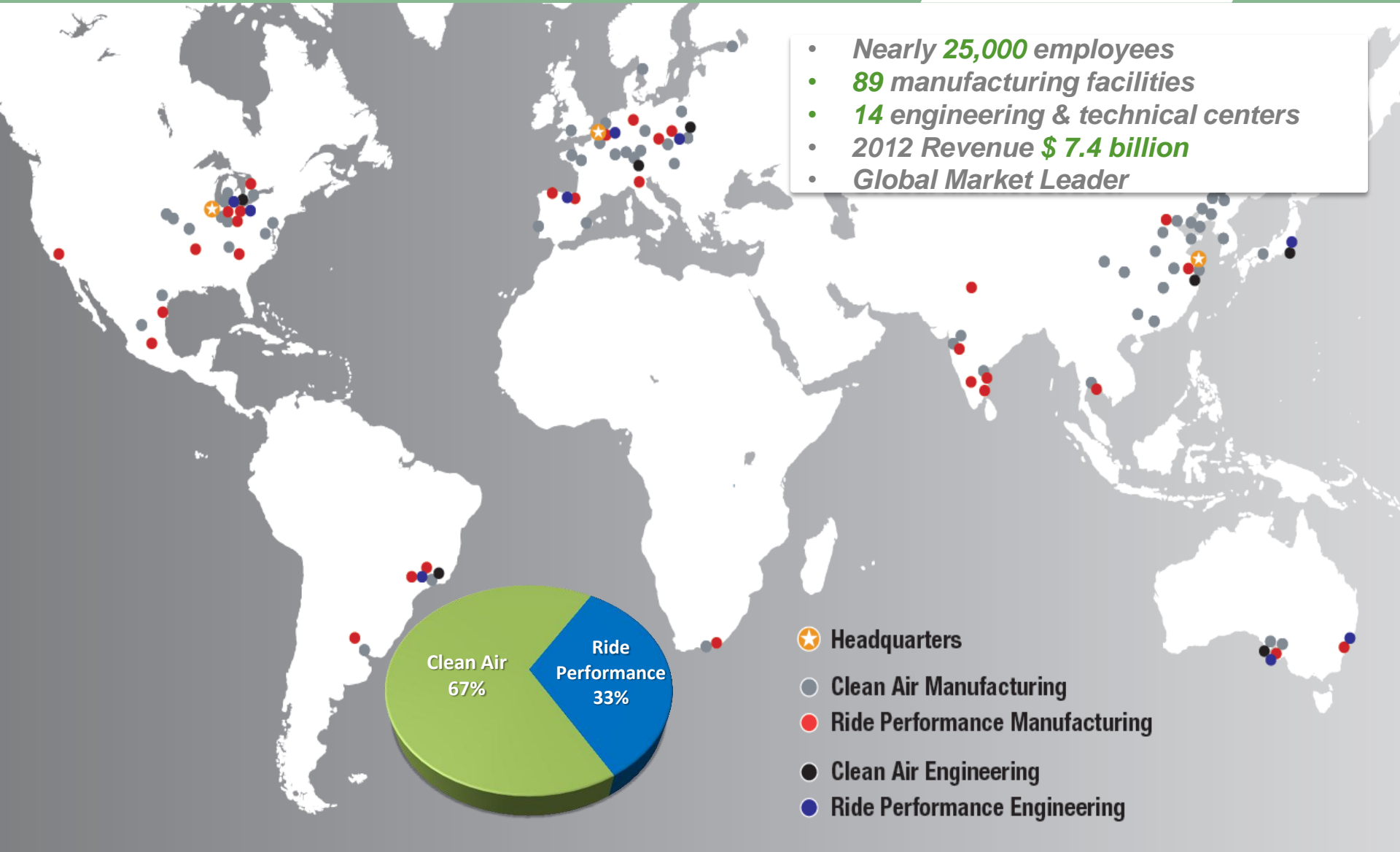
## *ACOCAR active suspension systems*

*Miguel Dhaens - advanced chassis research*

- TENNECO company profile
- **Towards automated driving**
  - *MegaTrends for mobility*
  - *Link to suspension systems*
- **ACOCAR**
  - *New hydraulic layout*
  - *Working principle*
  - *Achievements to date*
- **VISION: next steps**
  - *Achievements to date*
  - *Future Opportunities*

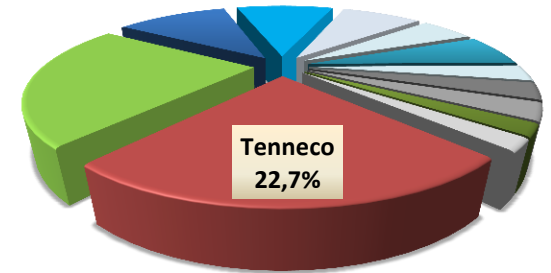


- Nearly **25,000** employees
- **89** manufacturing facilities
- **14** engineering & technical centers
- 2012 Revenue **\$ 7.4 billion**
- **Global Market Leader**

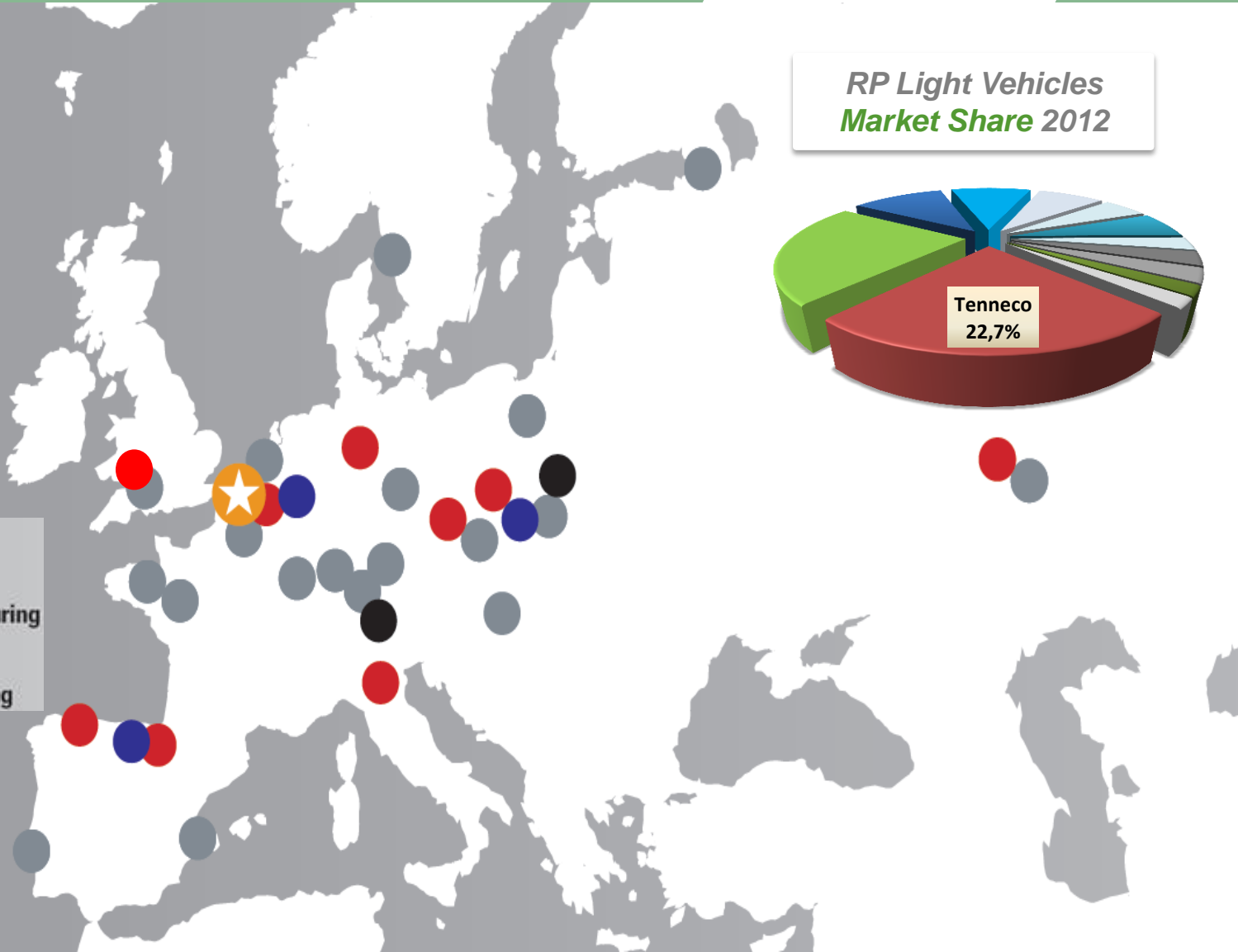


- ★ Headquarters
- Clean Air Manufacturing
- Ride Performance Manufacturing
- Clean Air Engineering
- Ride Performance Engineering

RP Light Vehicles  
Market Share 2012



- ★ Headquarters
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- Ride Performance Manufacturing
- Clean Air Engineering
- Ride Performance Engineering



*Climate change*

*Urbanisation/  
demographic change*

*Connectivity*



*Spend less energy for mobility*

*Utilize sustainable energy source*

*Intermodality to handle people demand for mobility*

*Safety extend mobility for aging generation*

*Support people to go from A to B hassle free & at elevated comfort and social entertainment during travel*



## INTELLIGENT MOBILITY

*(NEAR) ZERO EMISSION through more efficient and alternative energy*

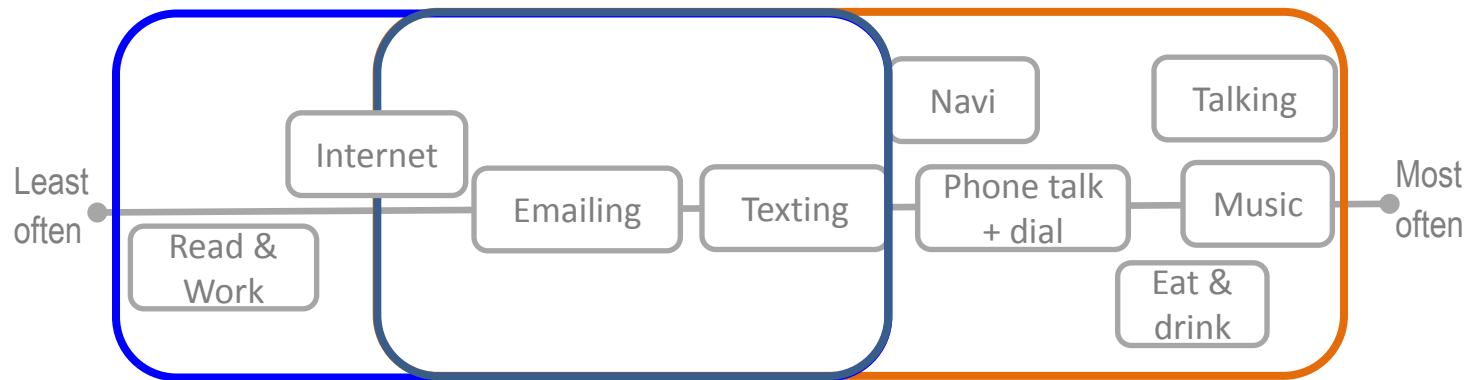
*URBAN MOBILITY through telematics and Smart Grid Integration*

*ZERO ACCIDENTS by stability and predictive ADAS systems*

# Towards automated driving

In a world where everything is possible, time becomes the bottleneck.  
Time spending will be optimized, even while driving!

Today



**Perceived as dangerous**  
Only done during slow traffic or standstill

**Are already done but still perceived too dangerous**

**Regularly done while driving and (mostly) not perceived dangerous**

Tomorrow:

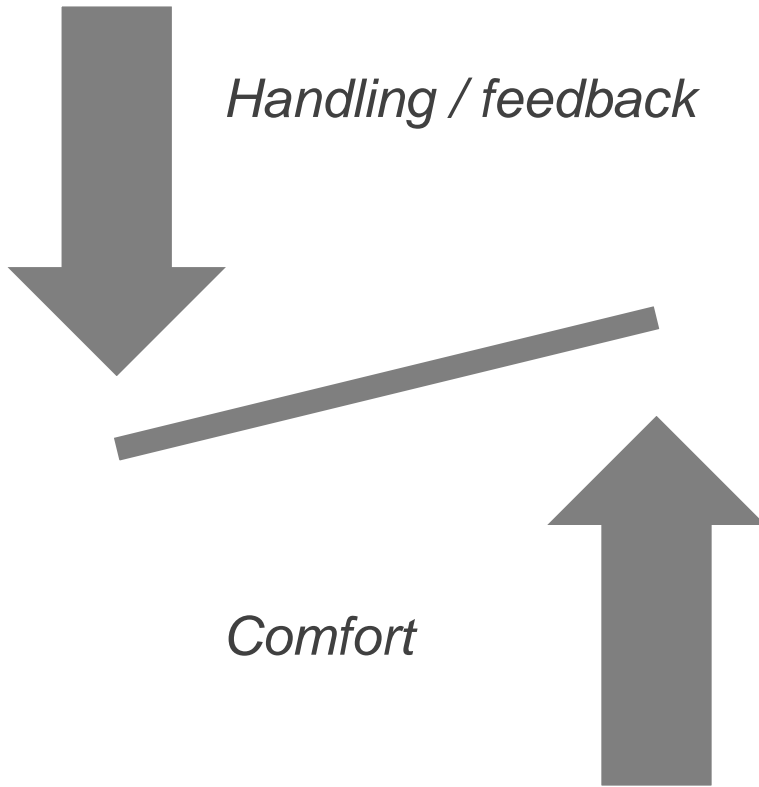
**Automated driving** (mid to long term)

- system takes over in case of delegation by the driver
- relieving the driver for enjoyment increase

# Towards automated driving



Our expectations of the desired information feedback is depending of time and conditions such as road surface, weather and situation and can be reverted at any time!



**Broken (vehicle speed 40 Km/h)**



**Broken Concrete (vehicle speed 50 Km/h)**



**Broken Lane (vehicle speed 40 Km/h)**



**Cobblestone Road (vehicle speed 30 Km/h)**



**Concrete Road (vehicle speed 96 Km/h)**



**Country Lane (vehicle speed 40 Km/h)**



**Motorway Road (vehicle speed 110 Km/h)**



**Noise Road (vehicle speed 80 Km/h)**



**Cobblestone City Road (vehicle speed 40 Km/h)**



**Tarmac Road (vehicle speed 96 Km/h)**





Conventional  
Strut



Conventional  
Module



CVSA



CVSA  
Air Spring



ACOCAR  
Active Suspension



Moto / Bike  
Suspension



SPORT

Dual Mode

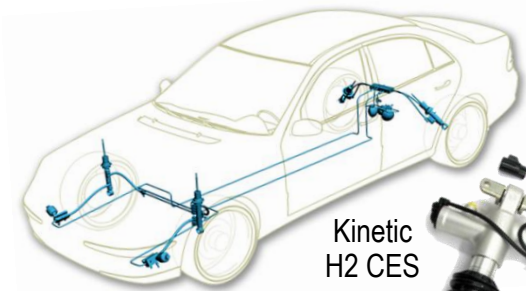


Elastomers

Light Weight



Axle damper



Kinetic  
H2 CES



Cabine  
Demper

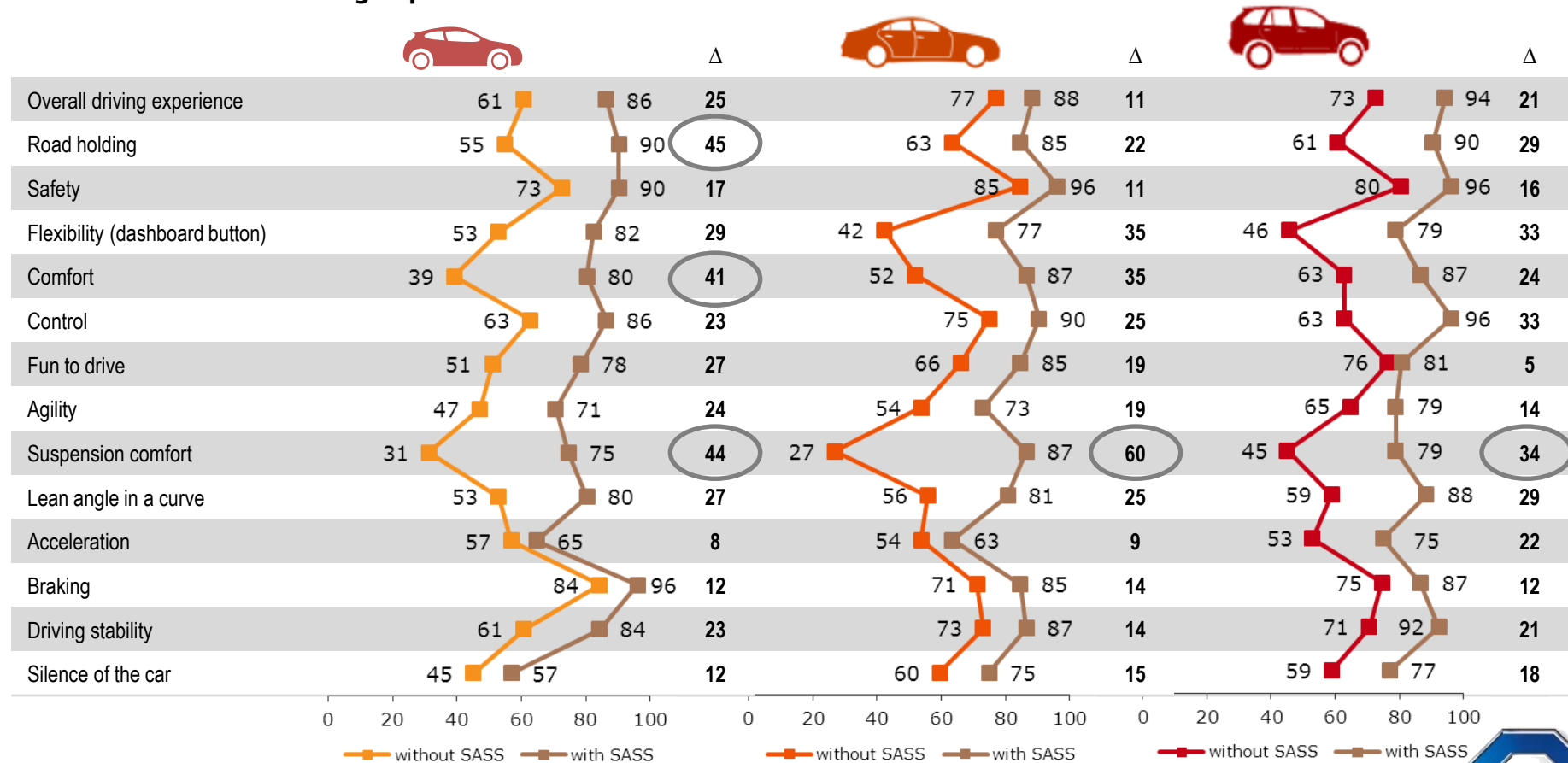


# Consumer test - Driving experience



The detailed evaluation shows a better felt performance over all criteria of driving experience for the vehicle with CVSA but especially for suspension comfort over all three segments.

## Overall evaluation of driving experience



DT8: How do you describe the overall driving experience according to the following criteria?  
 Base: n=51 (CC), n=52 (UMC), n=52 (SUV); Top2 ('excellent, very good') answers in %



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# Monotube ACOCAR

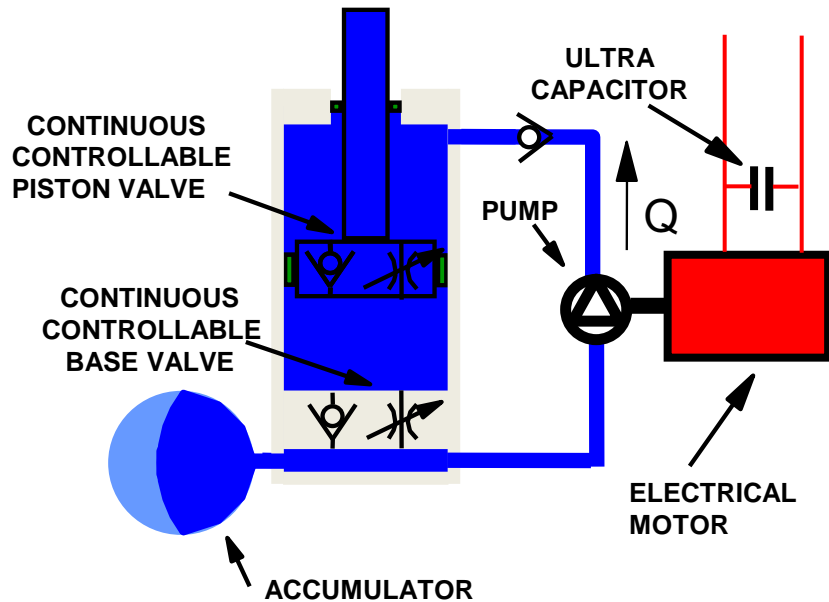


Fully active suspension

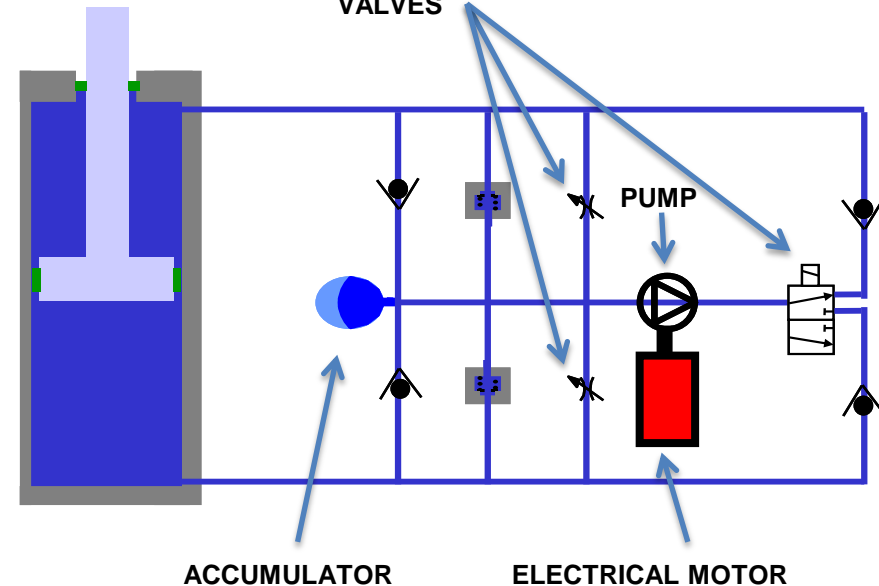


ONE BOLD VISION ONE EXTRAORDINARY FUTURE

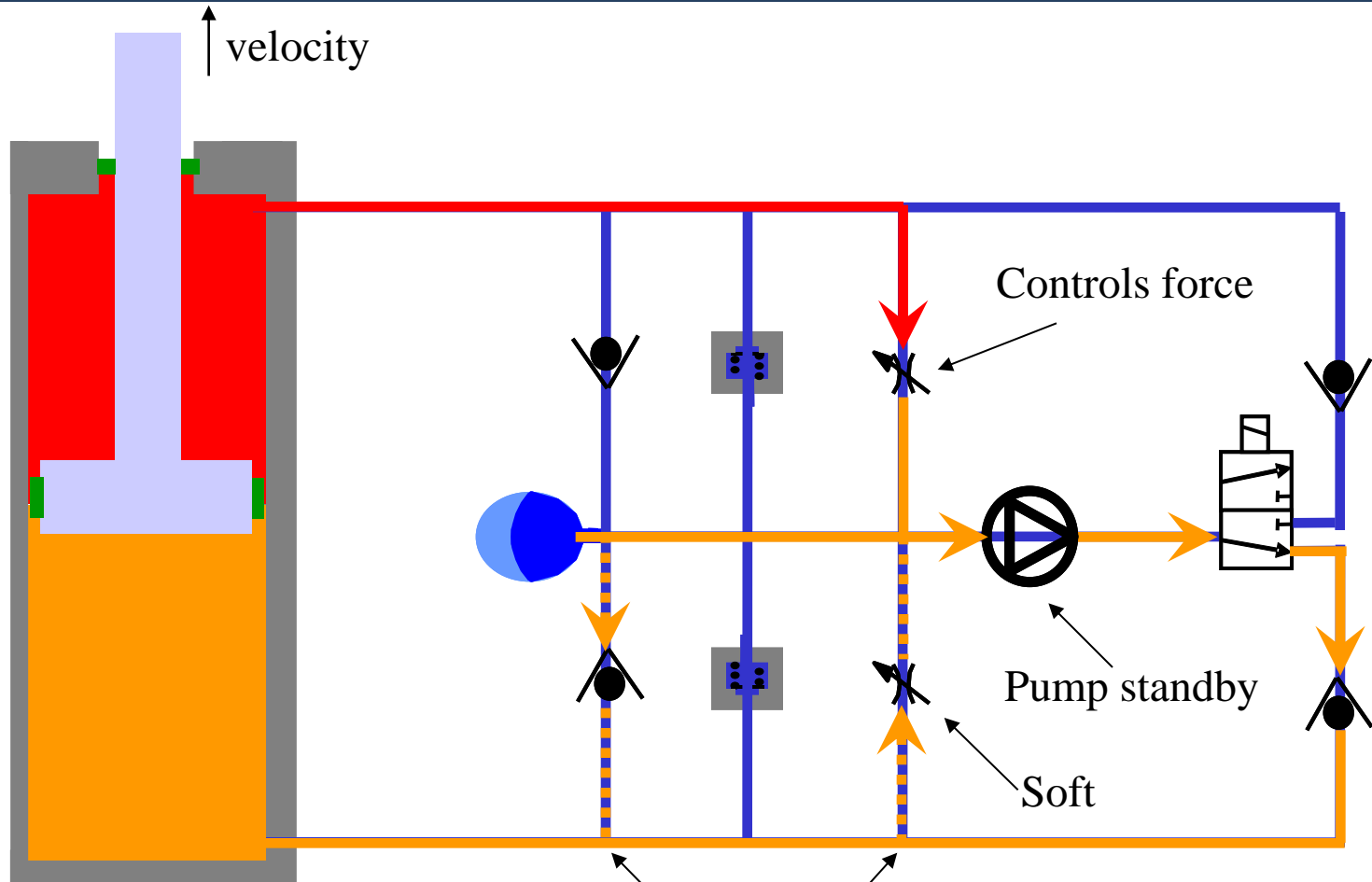
## Next generation ACOCAR



### CONTINUOUS CONTROLLABLE VALVES

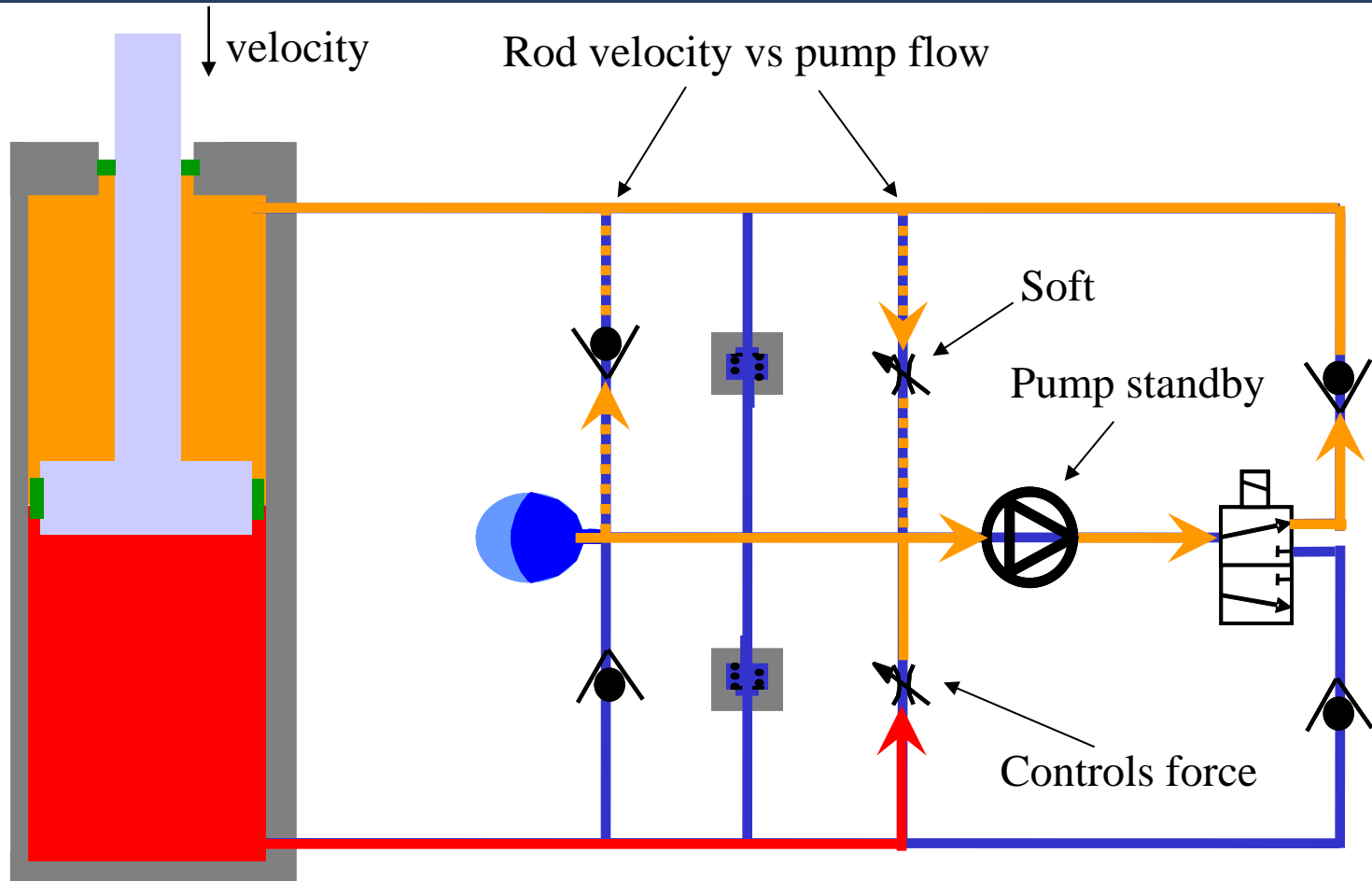


Working principle: Passive rebound

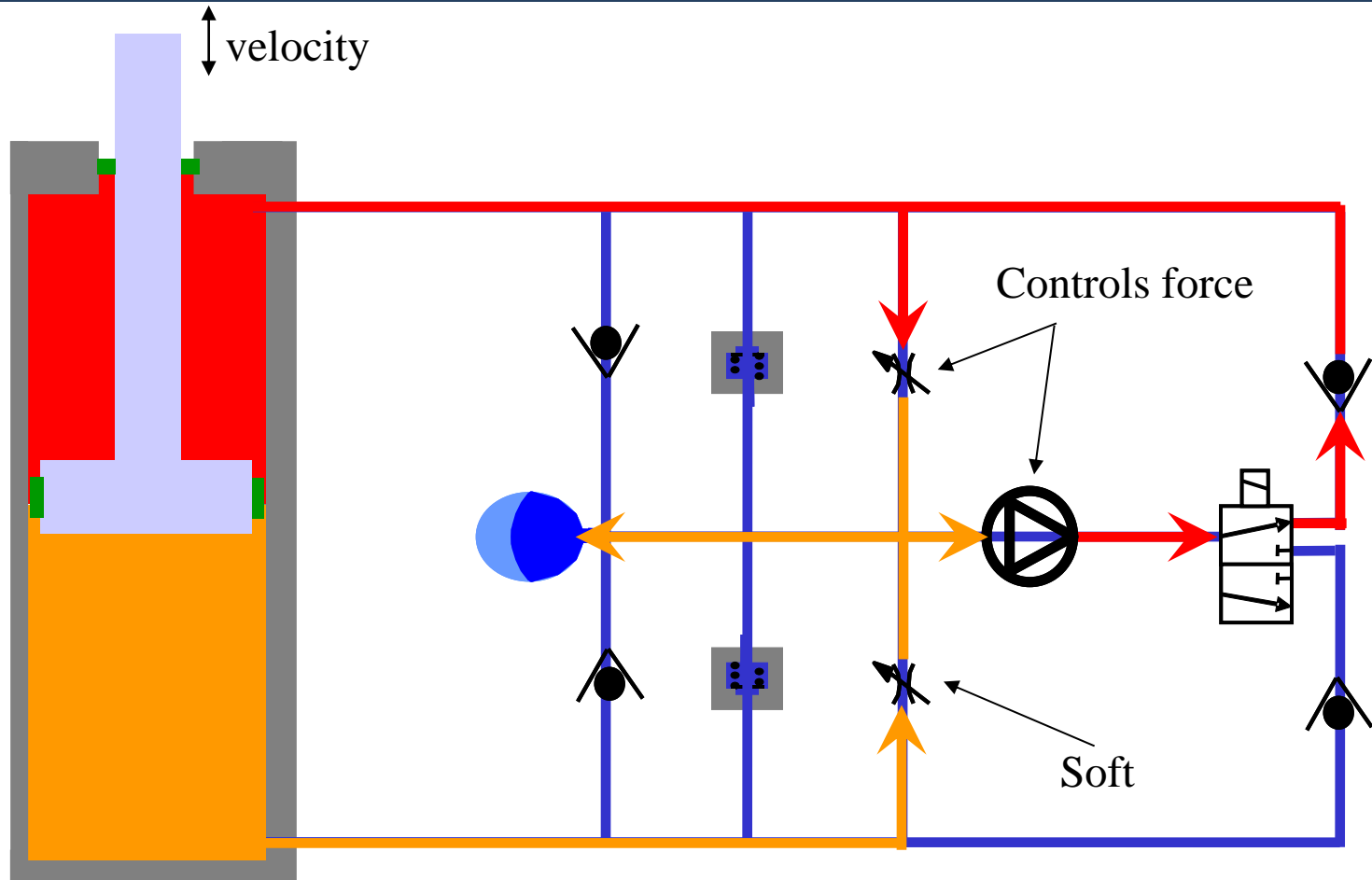


Rod velocity vs pump flow

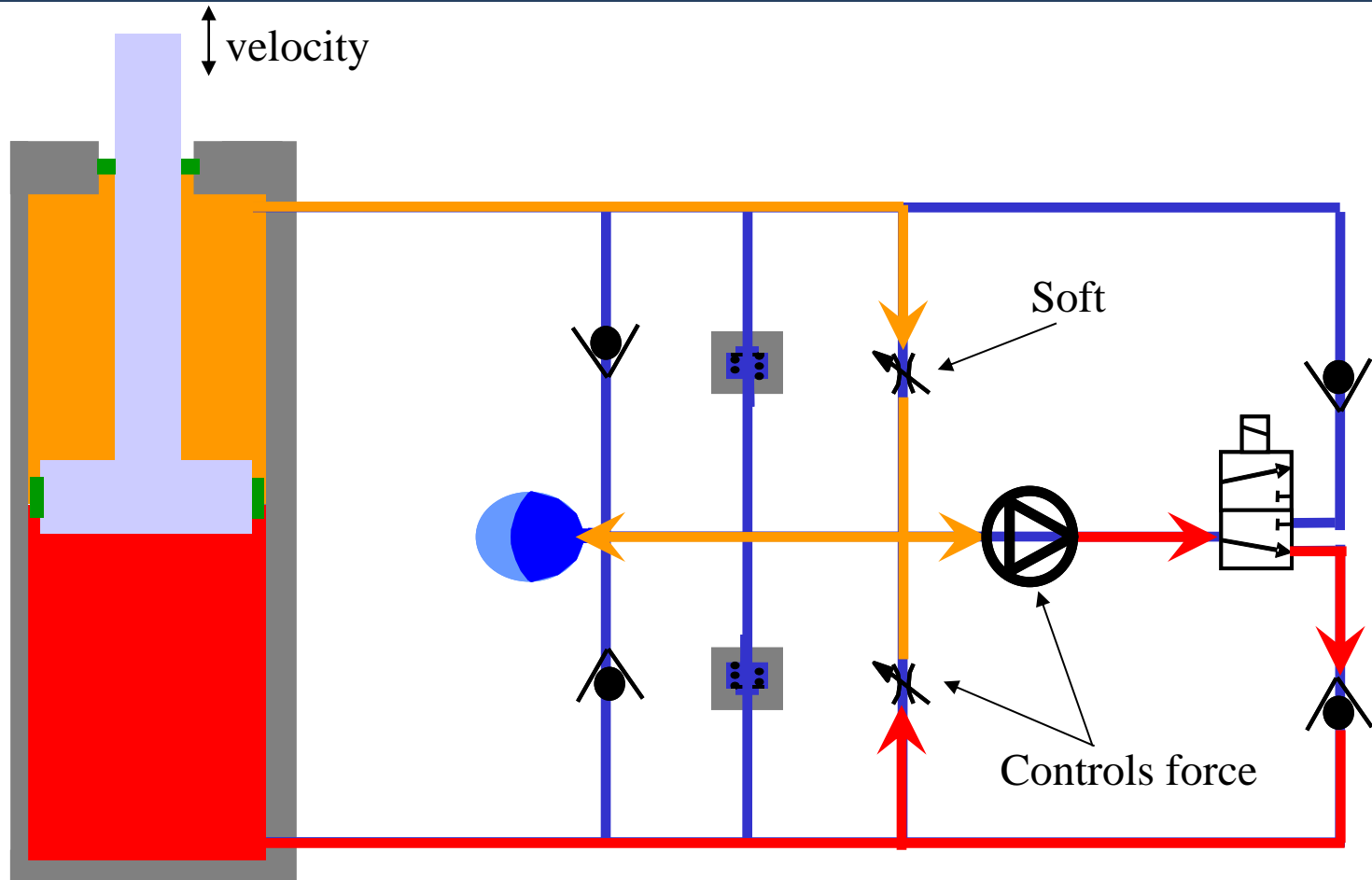
## Working principle Passive compression



Working principle Inward force (active & passive)

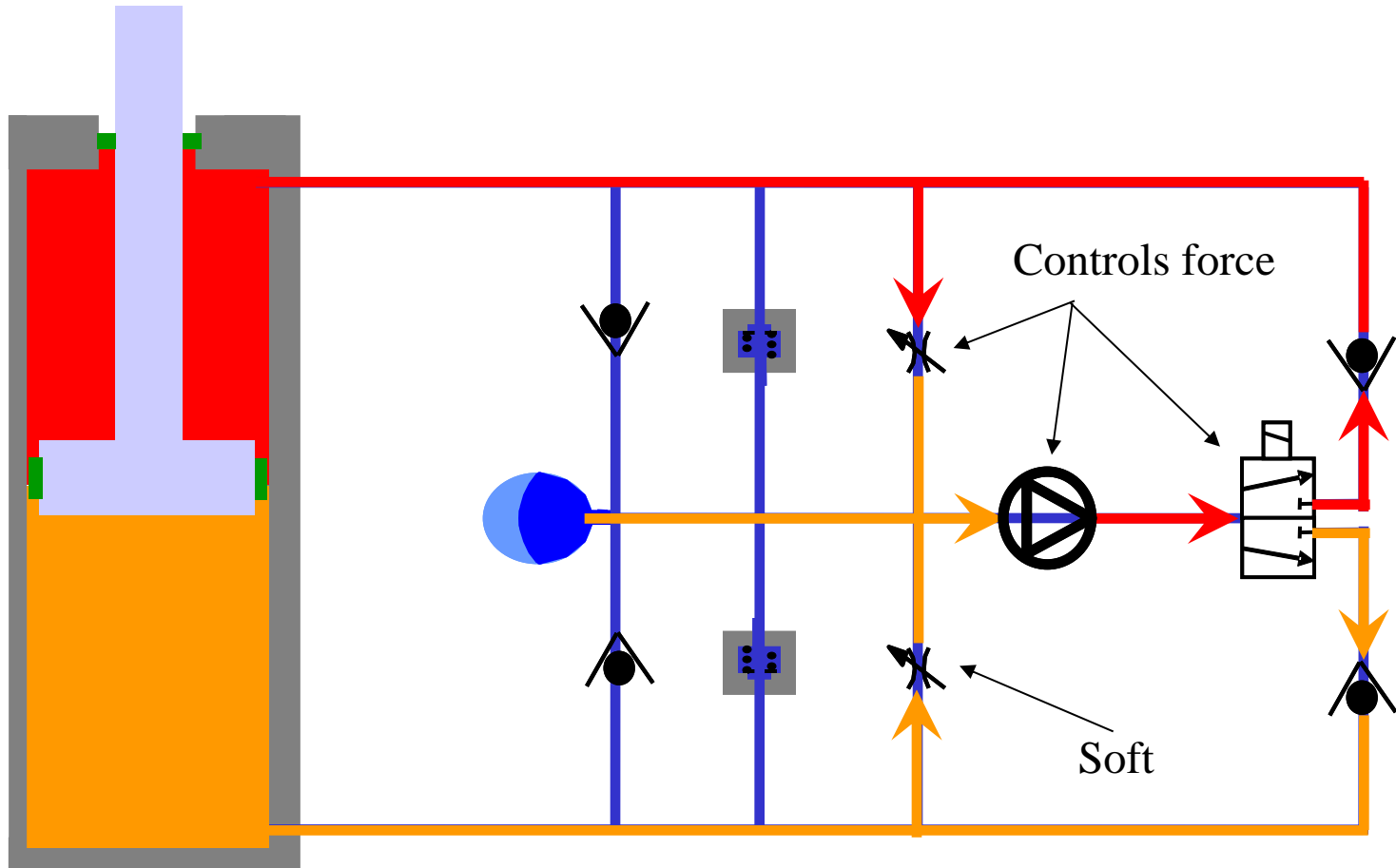


Working principle Outward force (active & passive)





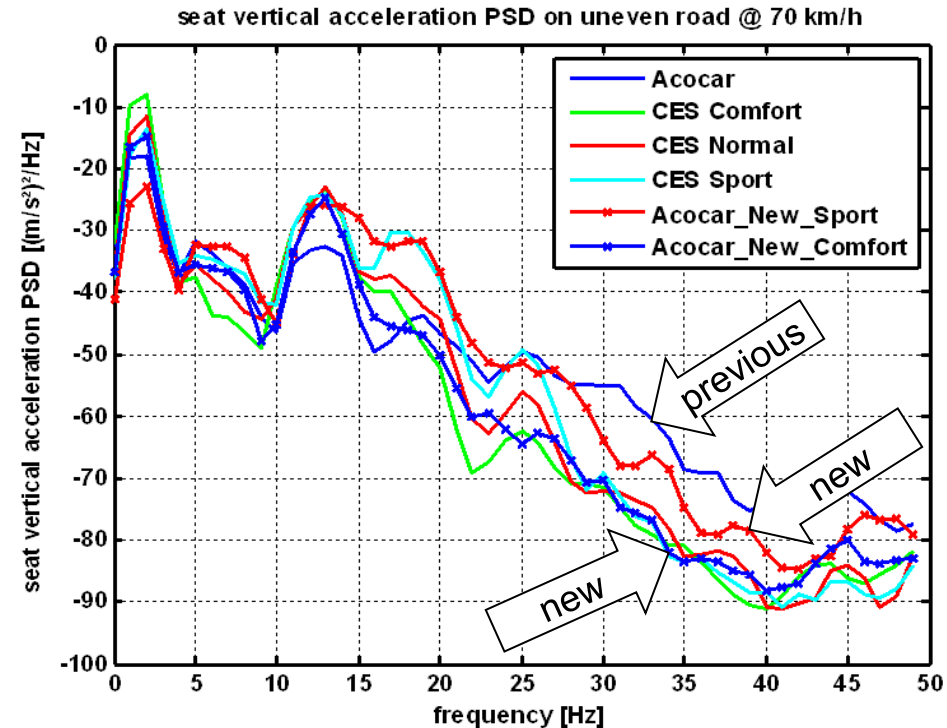
Working principle Low forces (active & passive)



## Achievements to date

### Improvements:

- Increased static forces
  - Optimized hydraulic layout
- Even lower power consumption
  - More efficient use of hydraulic power
  - Low power standby mode with fast response time
- Significant improvements in ride performance
  - New clean sheet controller developed

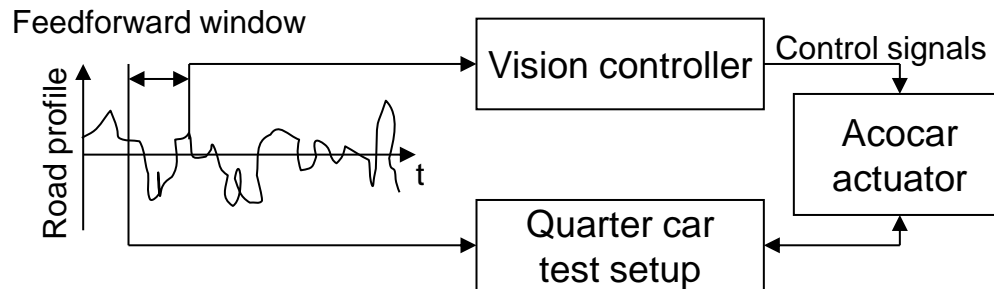
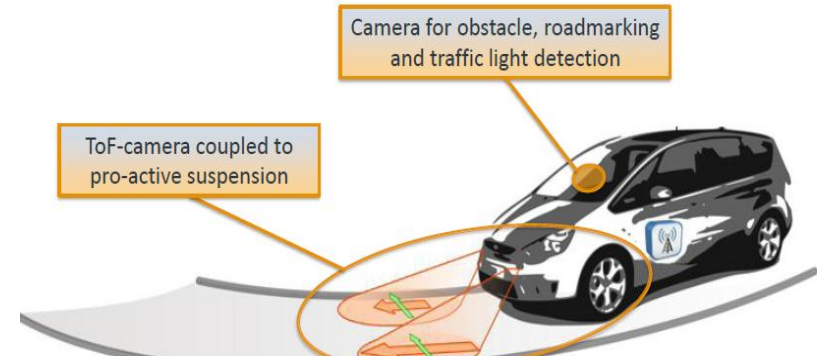


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### *Vision: Scanning the road upfront*

- **Potential:**
  - Feedforward control for road roughness and pothole detection



- **Status:**
  - Completed control strategy
  - Ongoing Quarter car & four poster tests with prototype sensor

- **Increased functionality**
  - *Balancing feedback versus comfort*
- **Predictive controllers**
  - *Using preemptive systems*
  - *Enhanced comfort*
- **Future opportunities**
  - *Integration with ADAS systems*



# Tenneco – Technology Driver



For more info, please contact:

[www.tenneco.com](http://www.tenneco.com)

VEHICLE **DYNAMICS**  
AWARDS INTERNATIONAL  
**2013**

