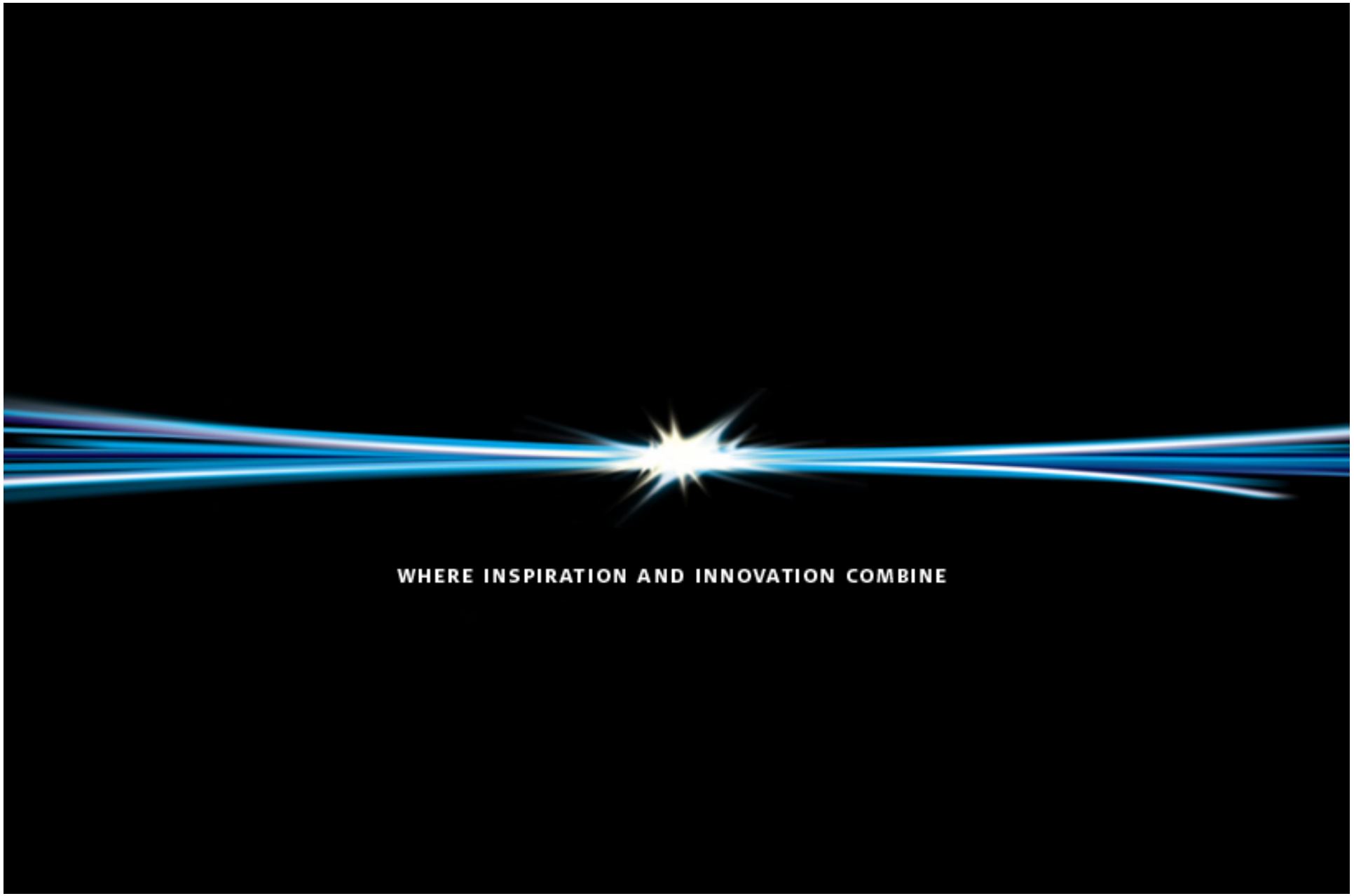


prodrive

NORTH AMERICAN PICK-UP RIDE ANALYSIS

Matthew Taylor - Principal Engineer Vehicle Dynamics

Contribution by Ricardo Prado of Metalsa

INTRODUCTION

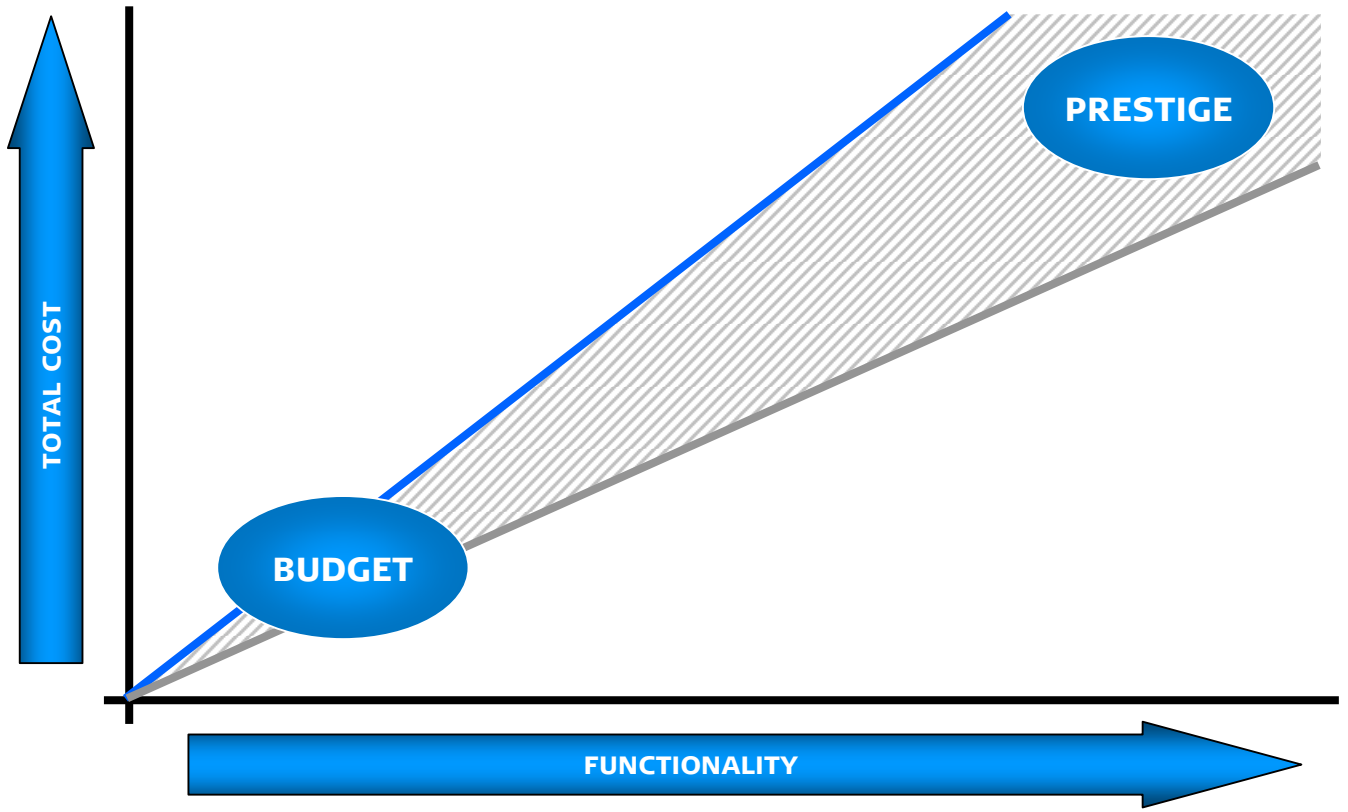
- Requirement to understand ride limitation of large US pick-up trucks
- High volume strong selling vehicle – competitive market place
  - domestic product
  - imported vehicles
- Do we understand the cause of the ride deficiencies

INTRODUCTION

- Decision drivers for truck chassis
  - direction from suppliers
  - perception of consumer
  - performance

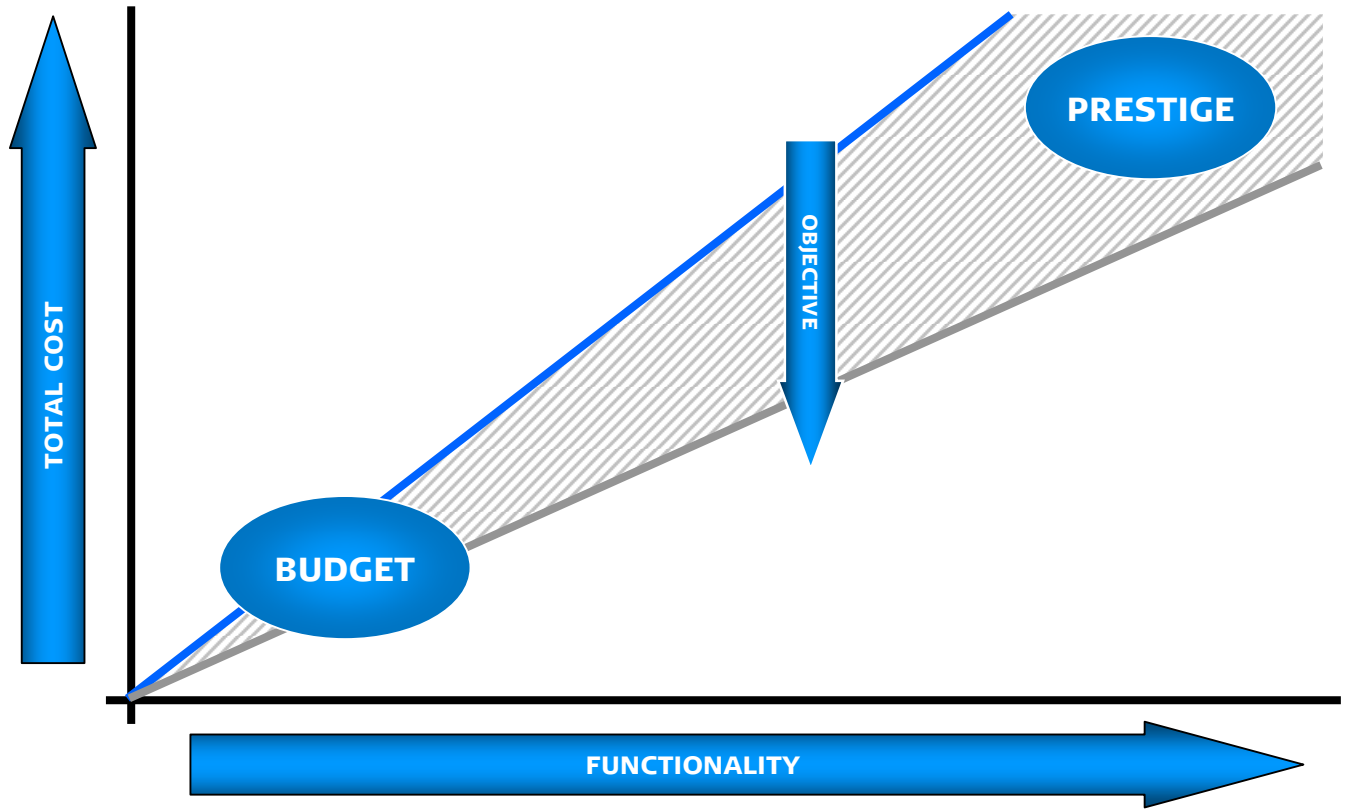
WHERE ARE THE OPPORTUNITIES?

- Two ways to gain a financial advantage
  - better product for same money (less than competition)
  - same product for less money (less than competition)



WHAT IS OUR DIRECTION?

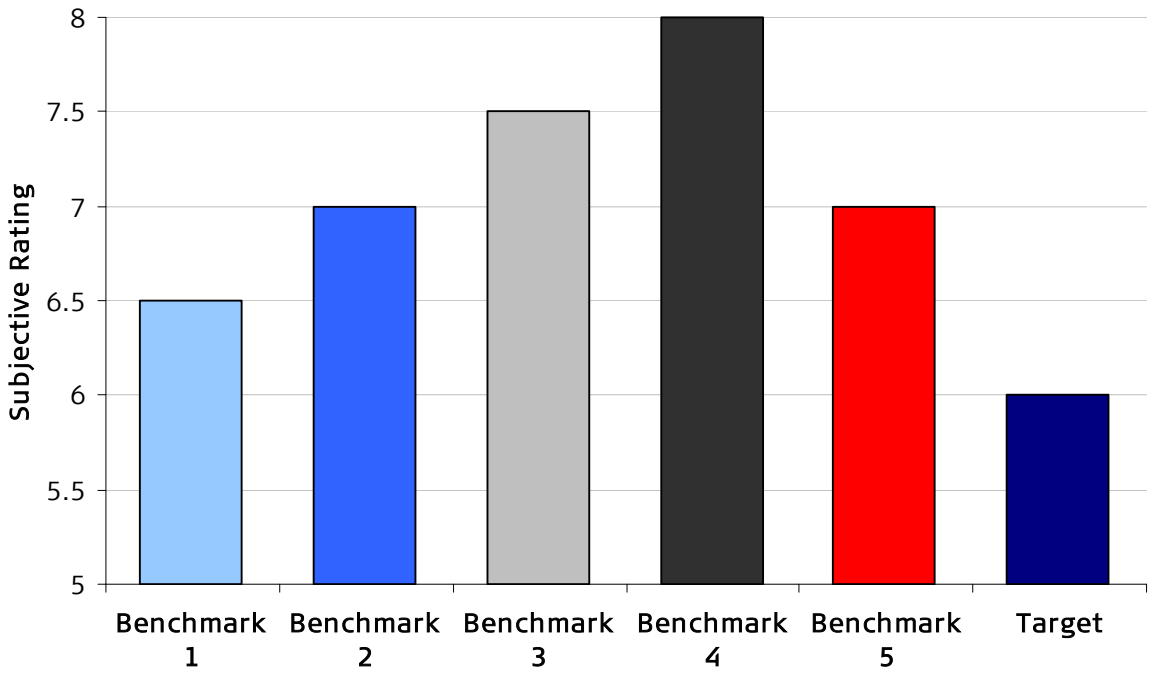
- Our aim was to match the competition for less money
  - understand the system
  - do not just follow the crowd



BENCHMARK

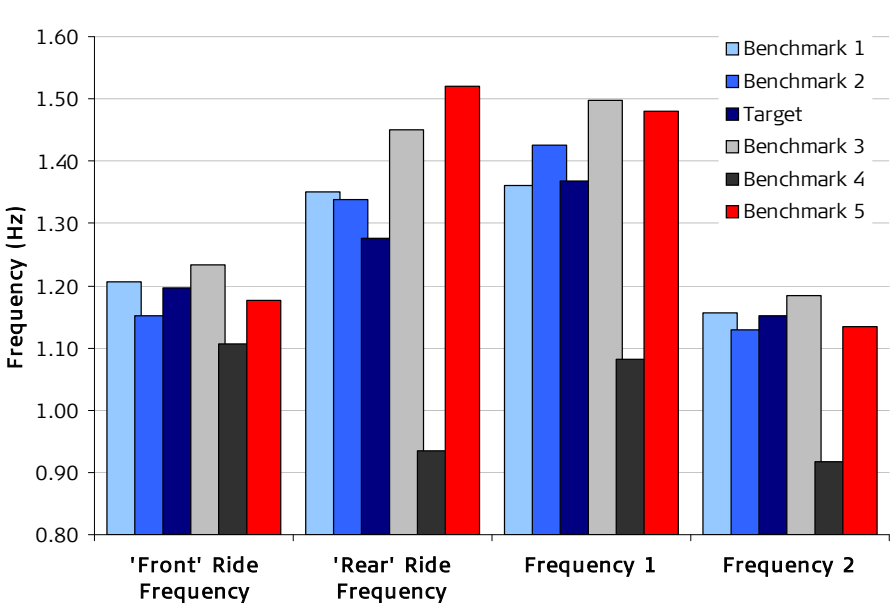
- Ride and handling comparison of six trucks
  - three domestic market, three imported

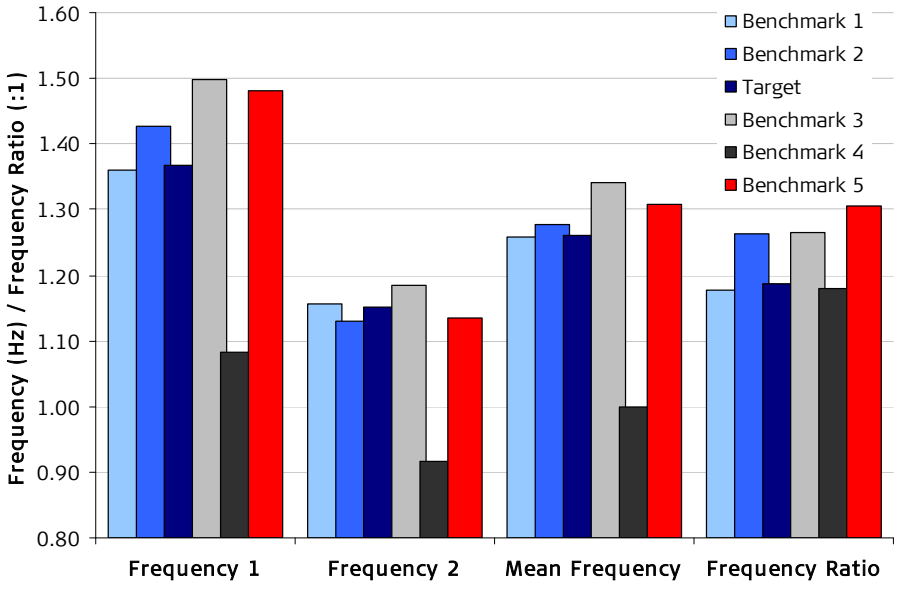
- Goal of this report – ride performance
  - target vehicle perceived worse primary ride
  - target vehicle perceived worse secondary ride



PRIMARY RIDE COMPARISON

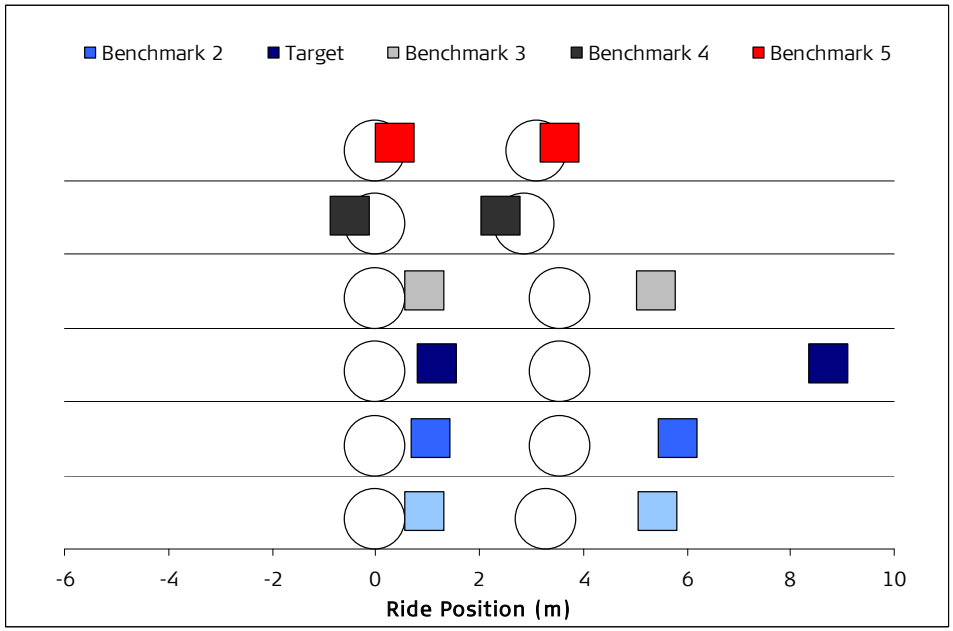
- Benchmarks 4 and 5 were thought to have car-like ride when unladen
- Ride centres of most US trucks were not axle aligned
  - significant spread of ride frequencies
  - axle centred strategy improves accuracy of front / rear type ride frequency calculation

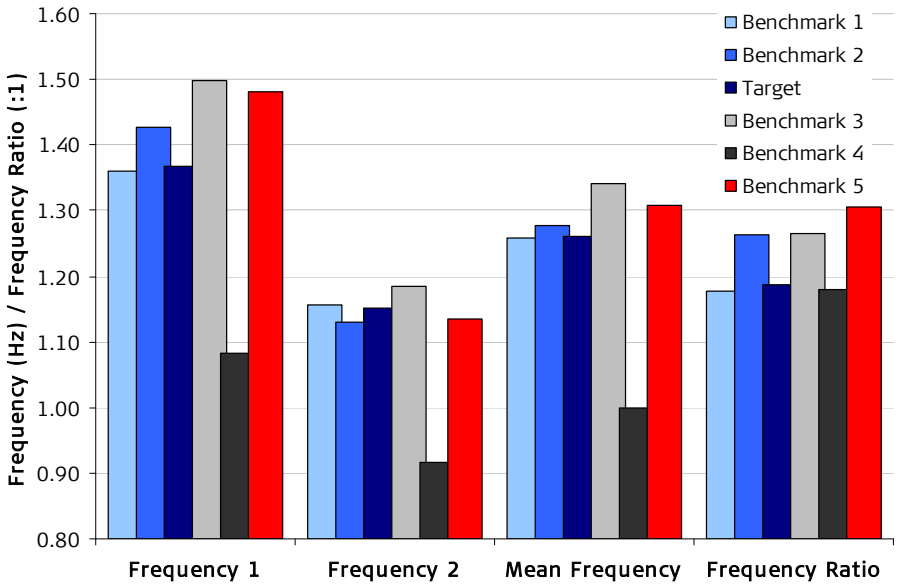




PRIMARY RIDE COMPARISON

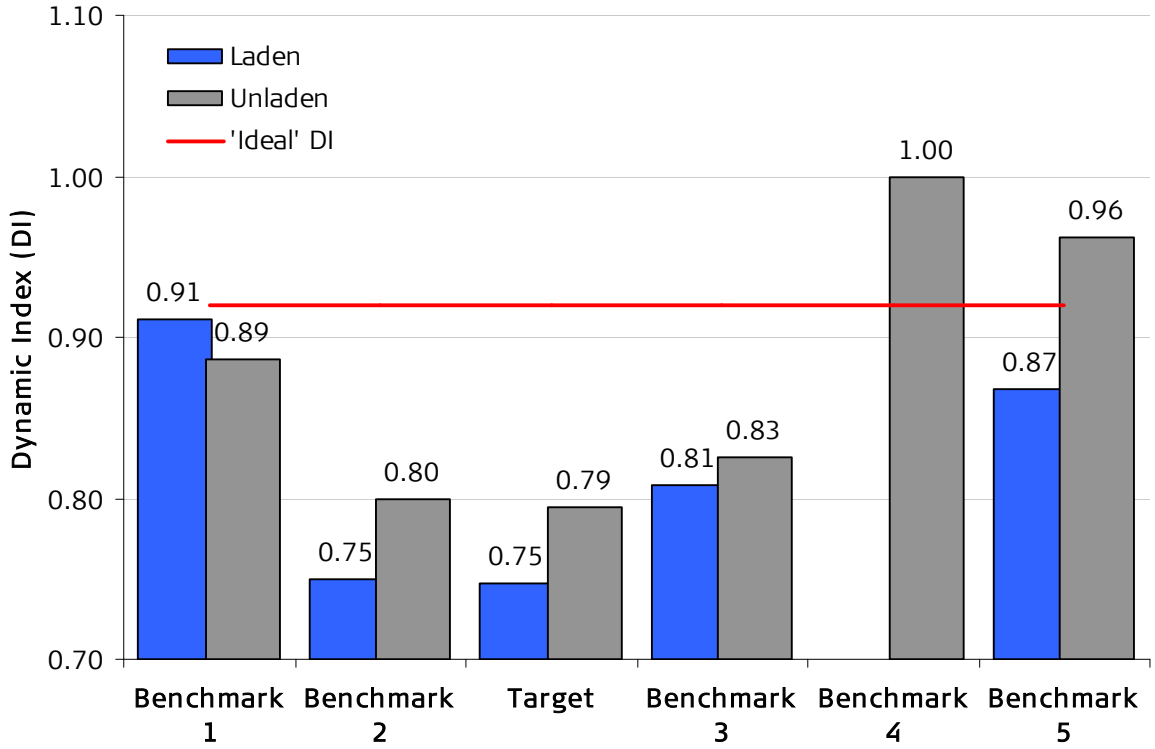
- Benchmarks 4 and 5 were thought to have car-like ride when unladen
- Ride centres of most US trucks were not axle aligned
  - significant spread of ride frequencies
  - axle centred strategy improves accuracy of front / rear type ride frequency calculation
  - problems with primary ride strategy of target vehicle apparent





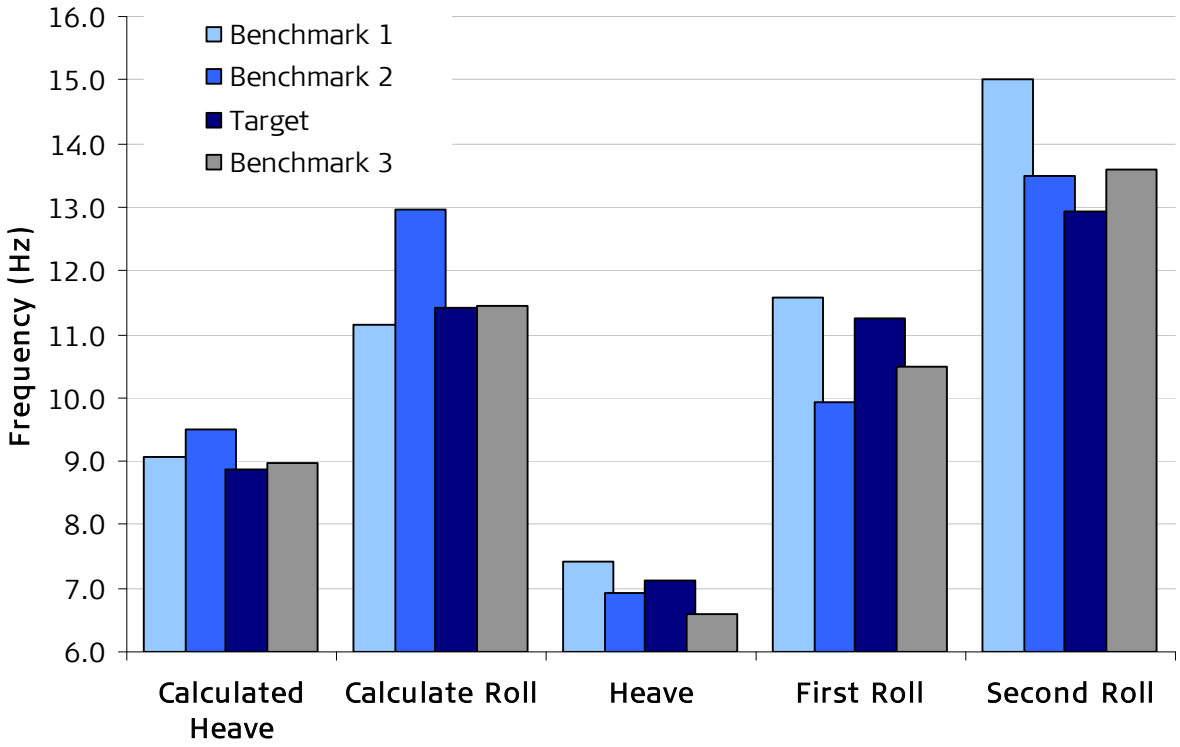
PRIMARY RIDE CONCLUSION

- Potential to improve axle centre strategy limited by vehicle's mass, inertia and wheelbase ratio (dynamic index)
- Modification of wheelbase outside scope of project
  - modification of spring tune
  - significant recalibration of dampers



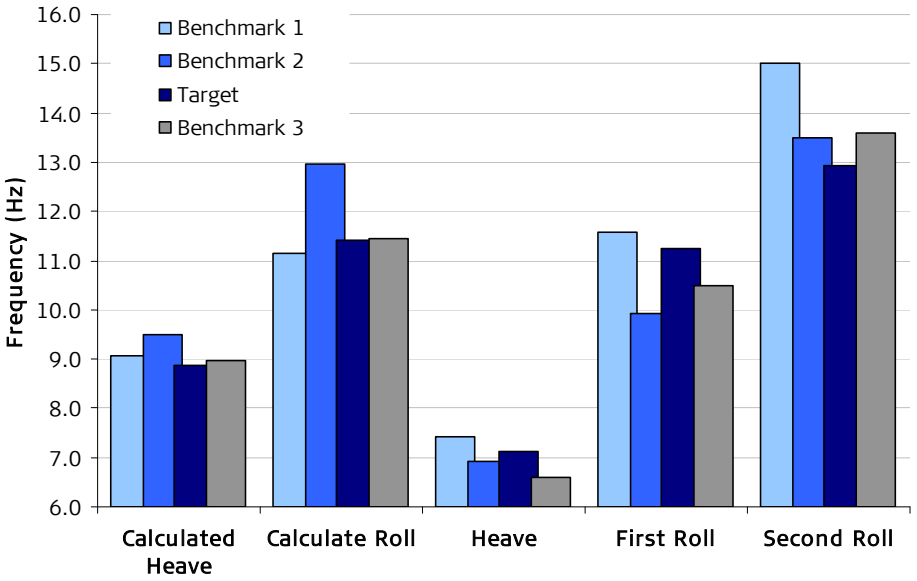
SECONDARY RIDE – OVERVIEW OF CONCERN

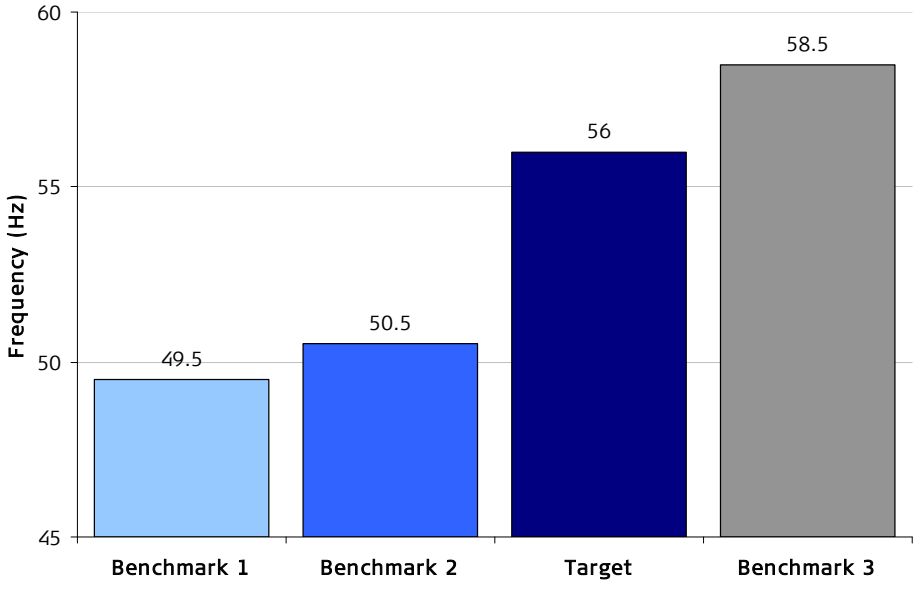
- Secondary ride (shake) identified as much more significant problem
  - dominated by axle roll and hop (in- and out- of phase wheel hop)
  - in phase of particular problem
- Strong couple to vehicle chassis – common to all beam axle trucks tested



SECONDARY RIDE – MODAL STRATEGY

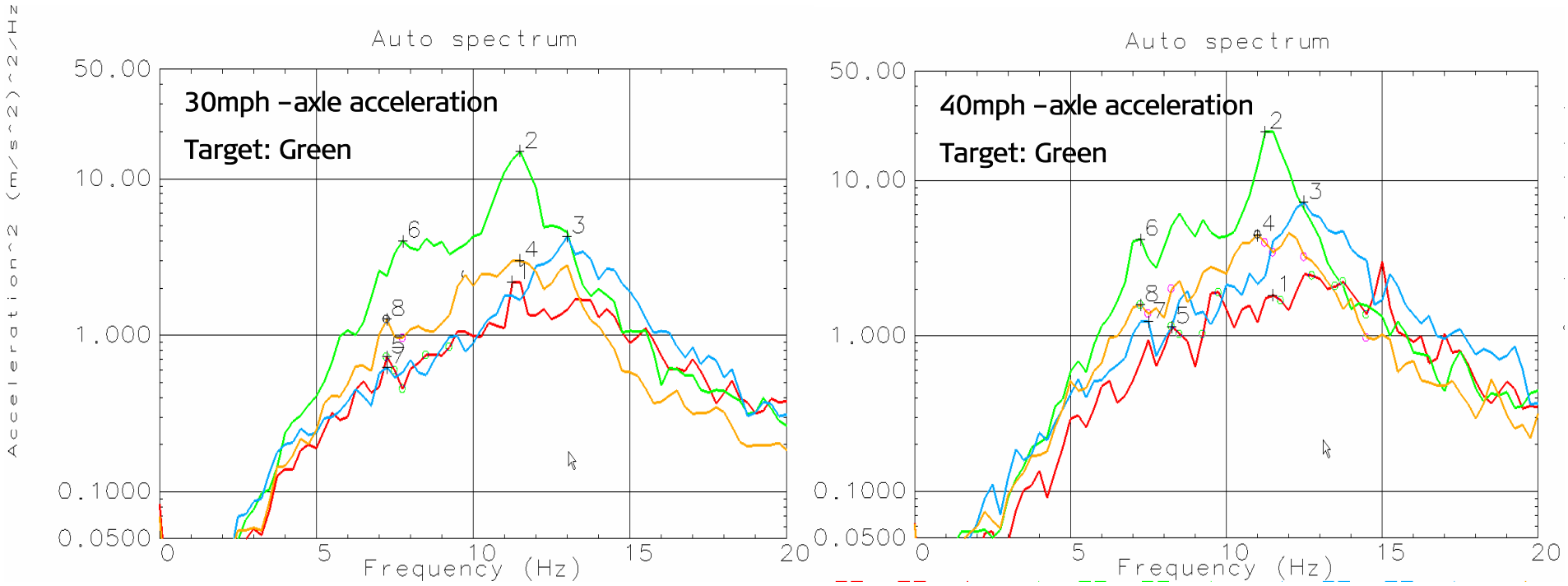
- Axle bending frequency clearly not contributory
- Repositioning of chassis modal behaviour impractical
  - below 6Hz to separate from axle heave
  - above 13Hz to separate from axle bounce
- One vehicle attempted to lower chassis frequency
  - subjective appraisal notes persistent shake





SECONDARY RIDE – OPERATING SHAPES

- Operating shape analysis confirms similarity
  - modal positioning of vehicles very similar
  - amplitude of target vehicle significantly greater than benchmark



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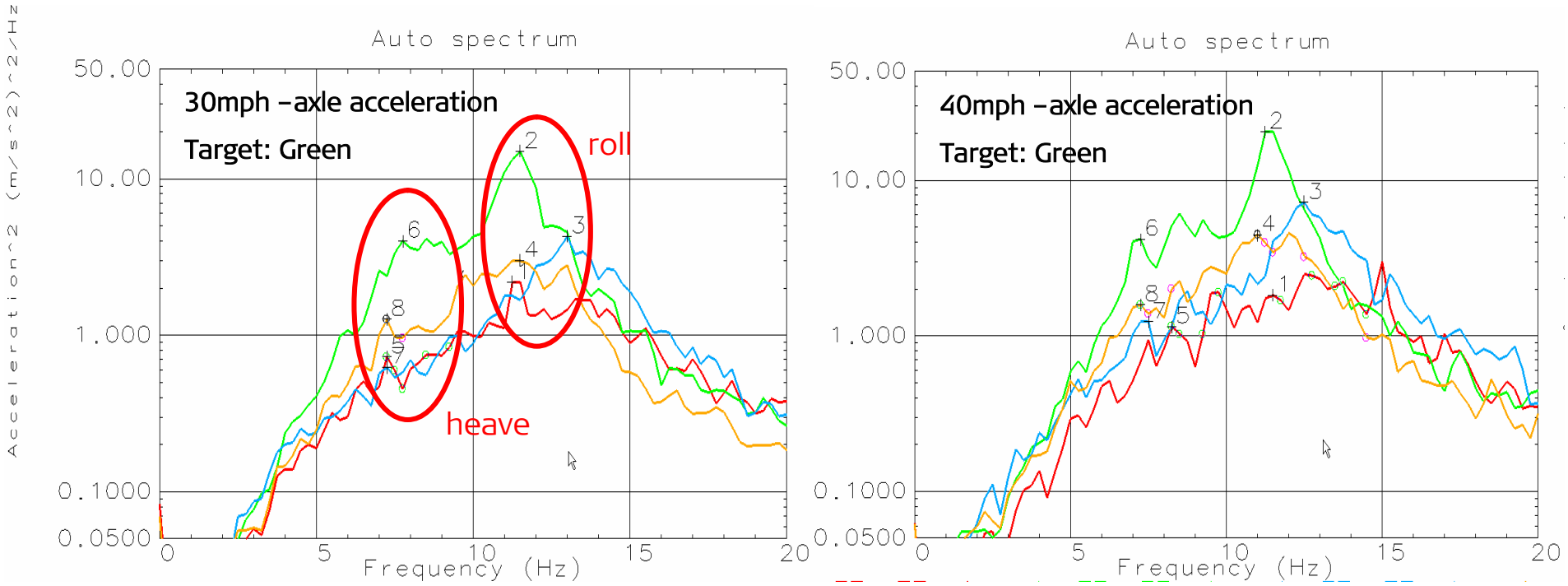
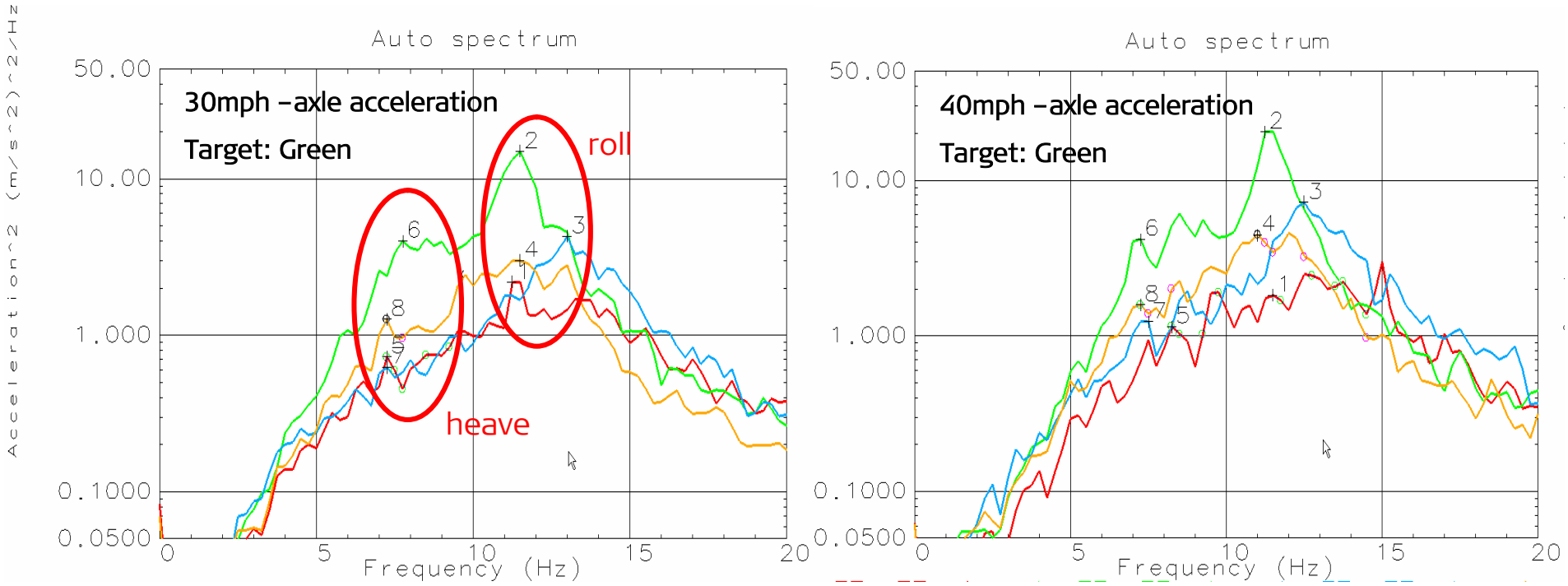


SECONDARY RIDE – OPERATING SHAPES

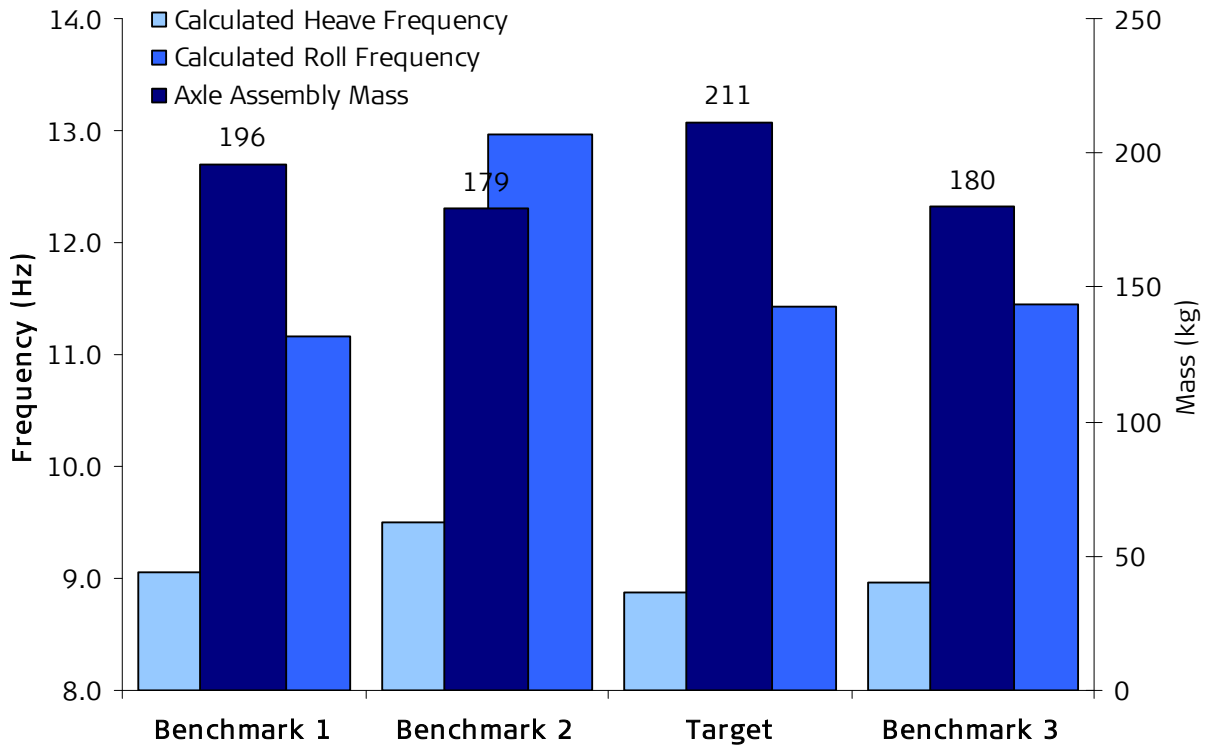
- Operating shape analysis confirms similarity
  - modal positioning of vehicles very similar
  - amplitude of target vehicle significantly greater than benchmark

- Solution is to understand cause of higher amplitude



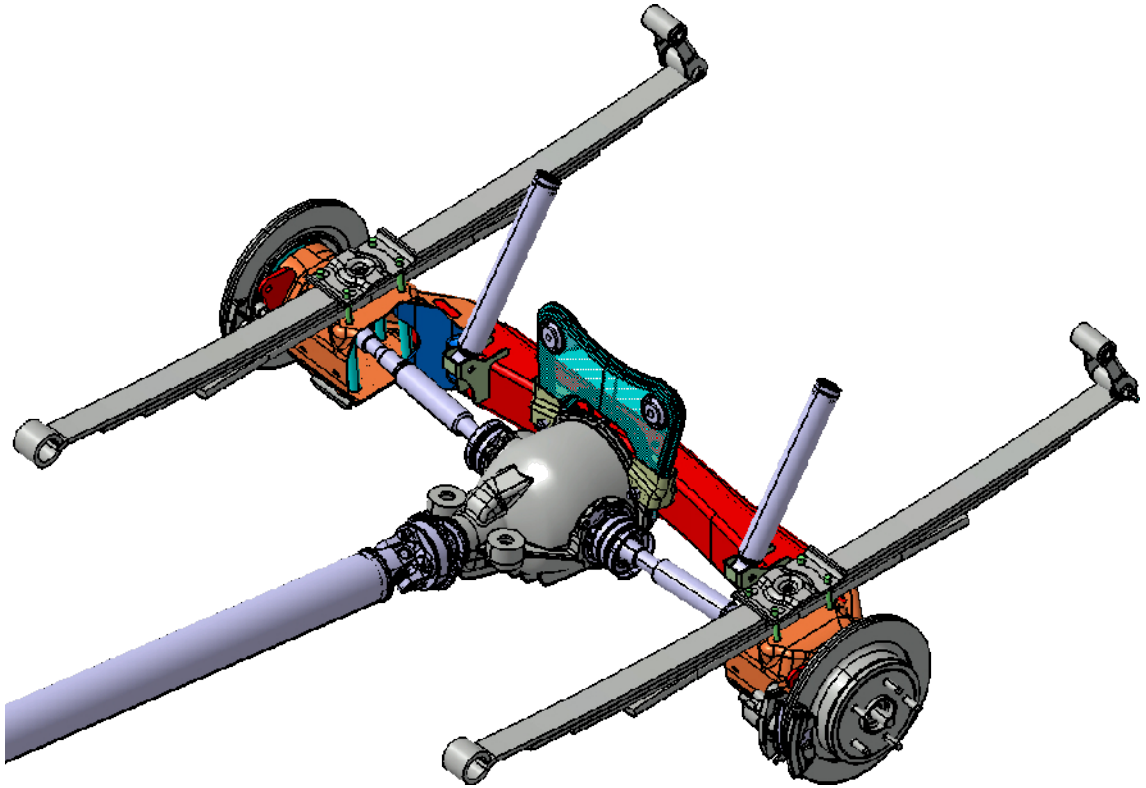
SECONDARY RIDE – DIFFERENCES

- Modal decoupling is not cost effective
  - lower axle mode too low
  - high axle mode too high
- Reduction in target vehicle axle mass will reduce excitation energy



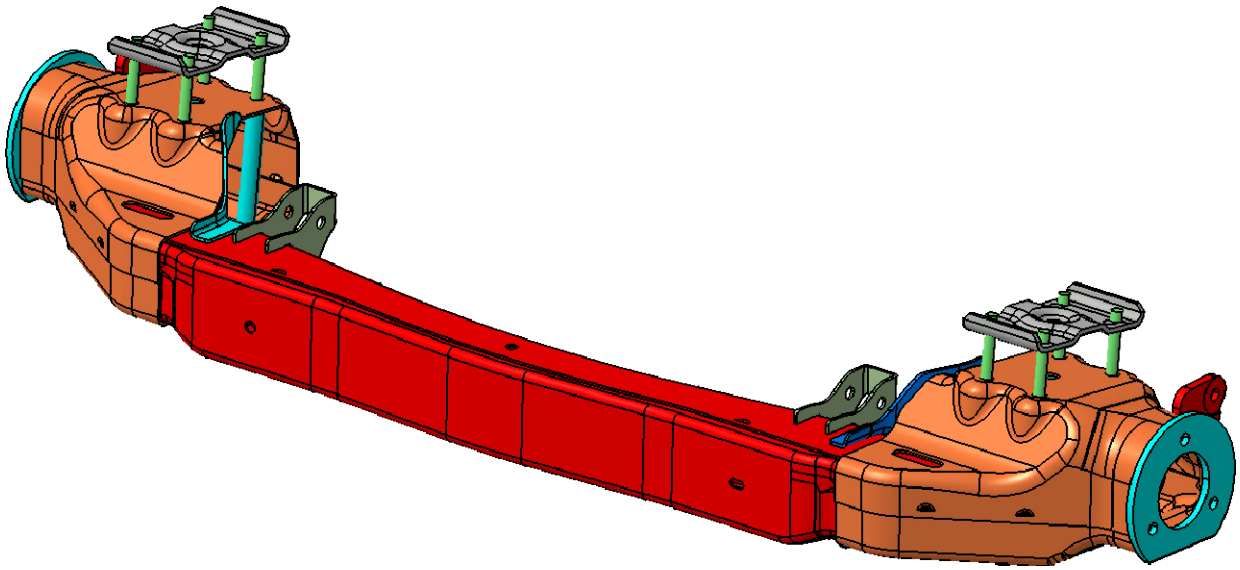
SECONDARY RIDE – REDUCED AXLE WEIGHT

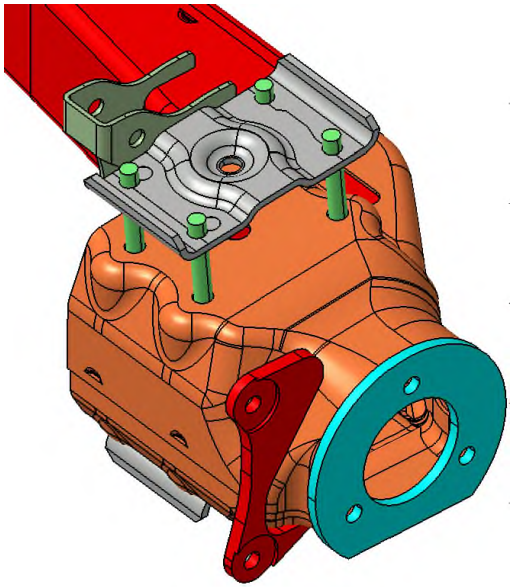
- Nothing in findings to support removal of Hotchkiss system
- Combination of two concepts
  - low cost, low complexity Hotchkiss
  - minimised weight, rigid beam De-Dion



SECONDARY RIDE – REDUCED AXLE WEIGHT

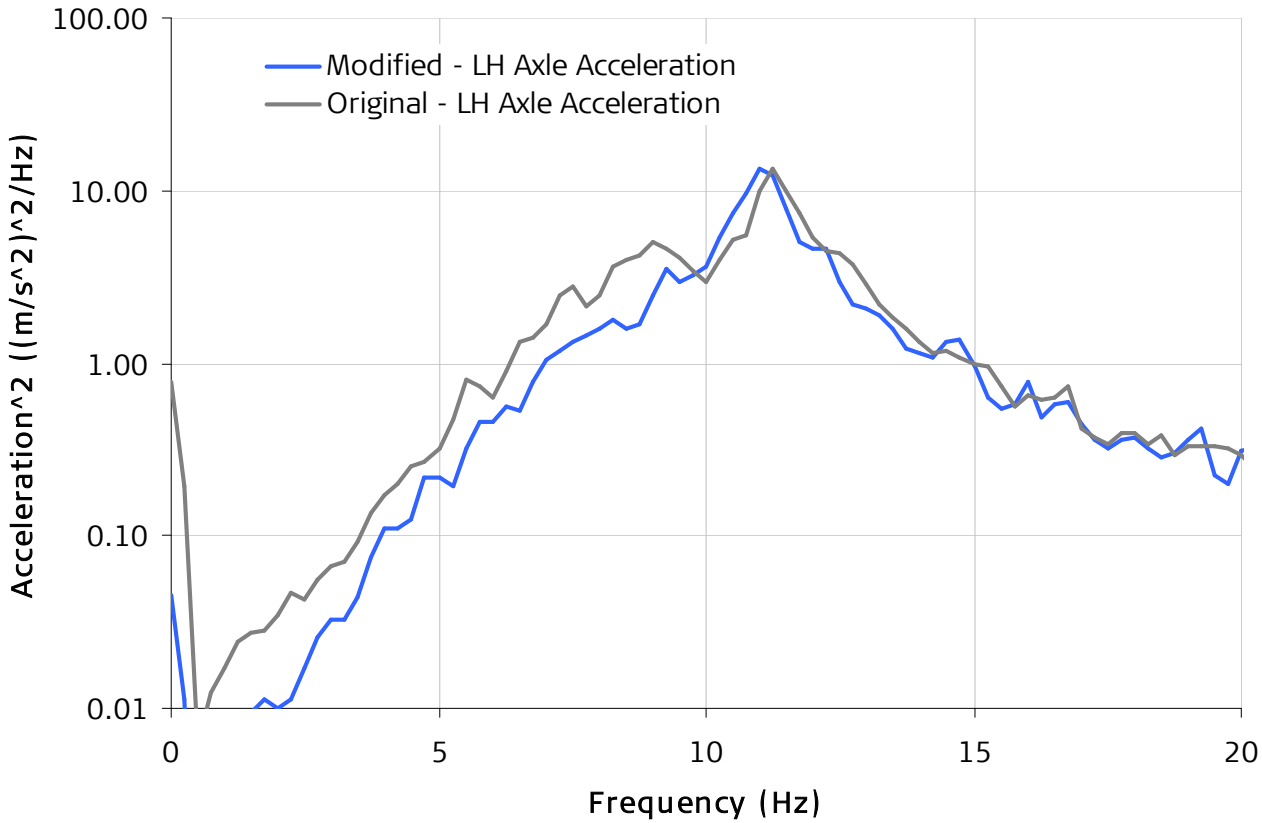
- Beam no longer carries differential device
- Reduced weight, large section beam pressing
- Improved camber and toe stiffness
- 'Unsprung' mass reduced by 25%
- Excitation energy reduced by 3dB





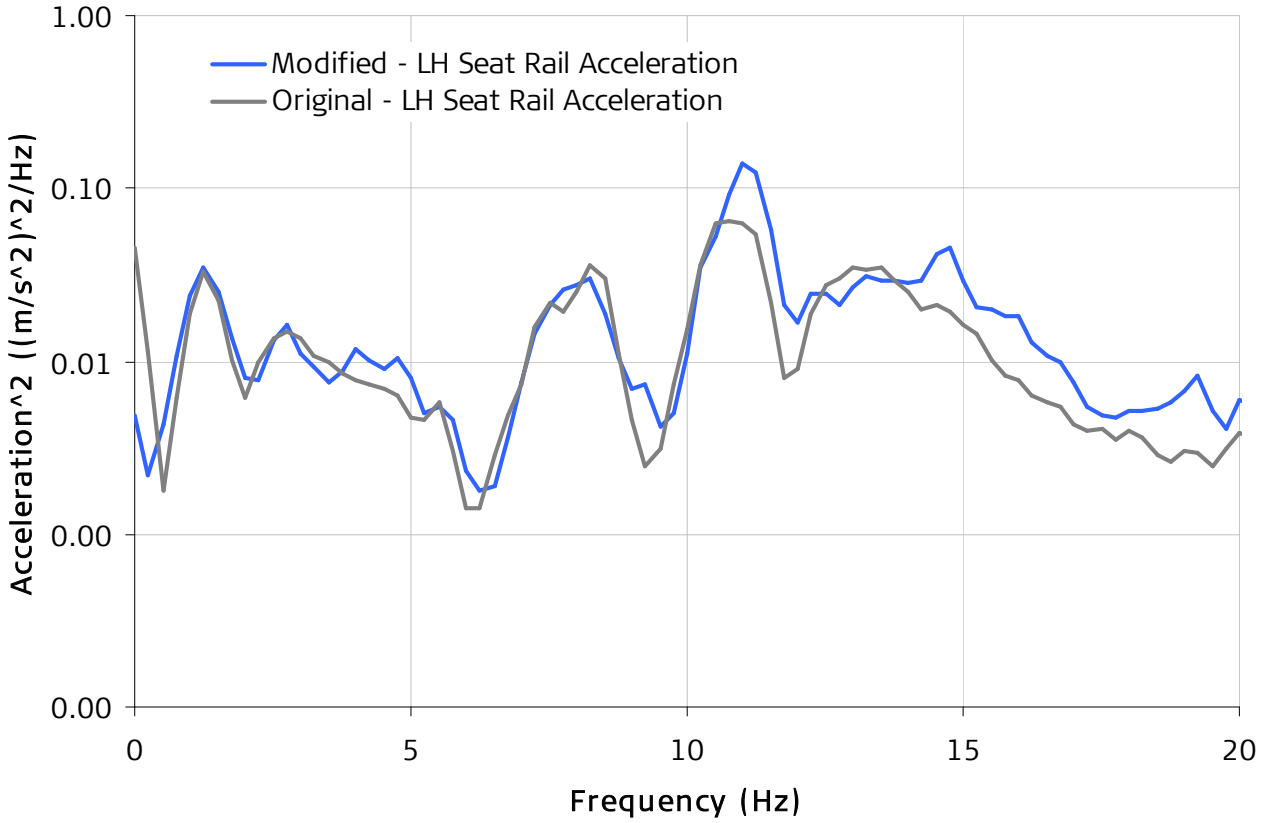
RESULT OF MODIFICATION

- Subjective ride rating improved by 1.5 points
- Objective results show significant reduction in axle energy
- As anticipated, modal behaviour unaltered



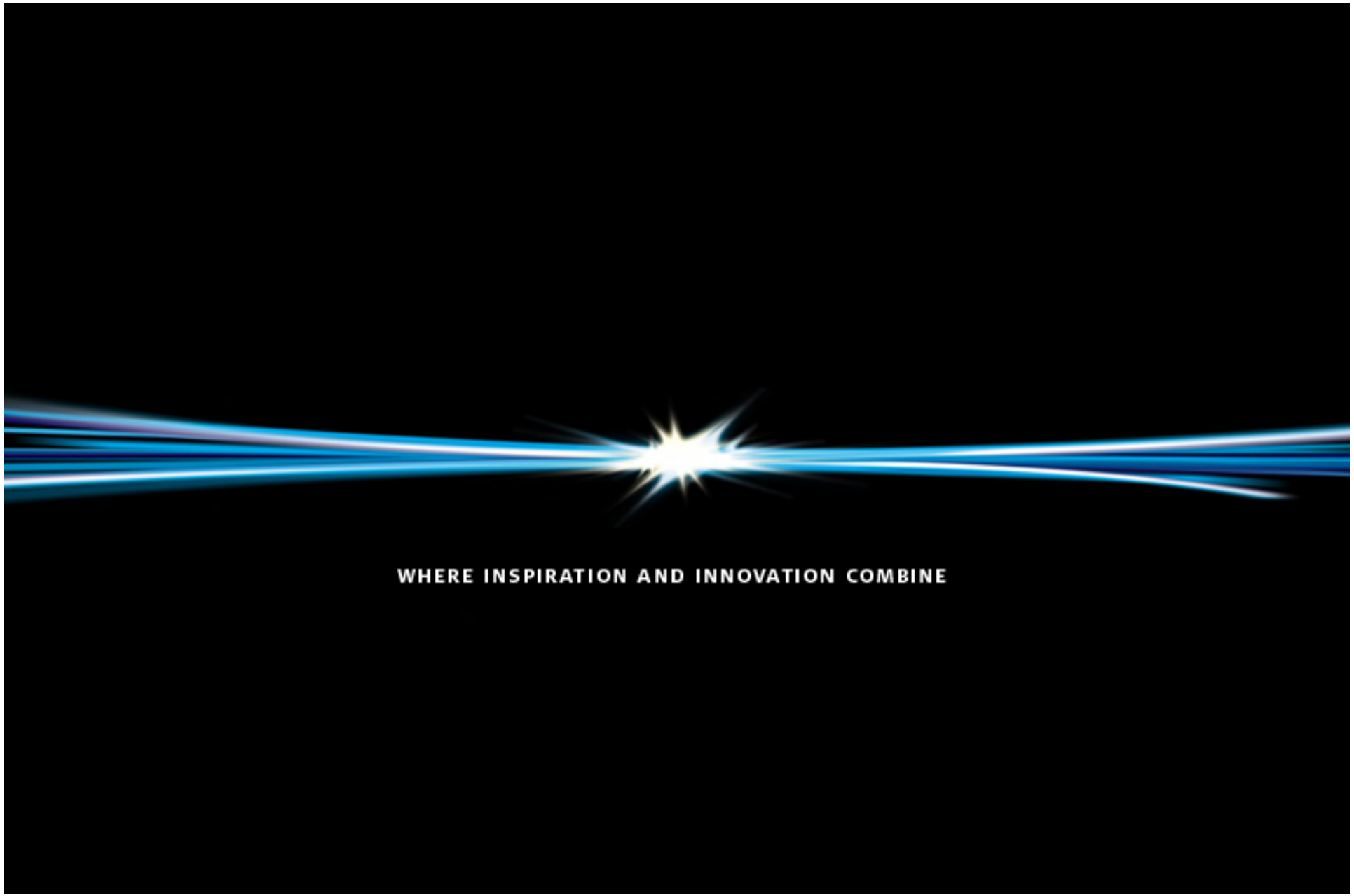
FURTHER WORK

- Increased acceleration response at seat rail dominated by front axle activity
  - modifications to chassis have altered front axle coupling
  - opportunity to re-tune mass damper



CONCLUSIONS

- Primary ride compromised by poor inertia mass relationship
  - can be improved in limited sense by damping
- Axle activity and modal behaviour of chassis not realistically separable
- Secondary ride subjectively improved by reduced mass axle
- Simple solution represents cost effective fix



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