Technology Work Session for the South African Army; Hosted by the CSIR

Mobility

Trends in Vehicle Mobility

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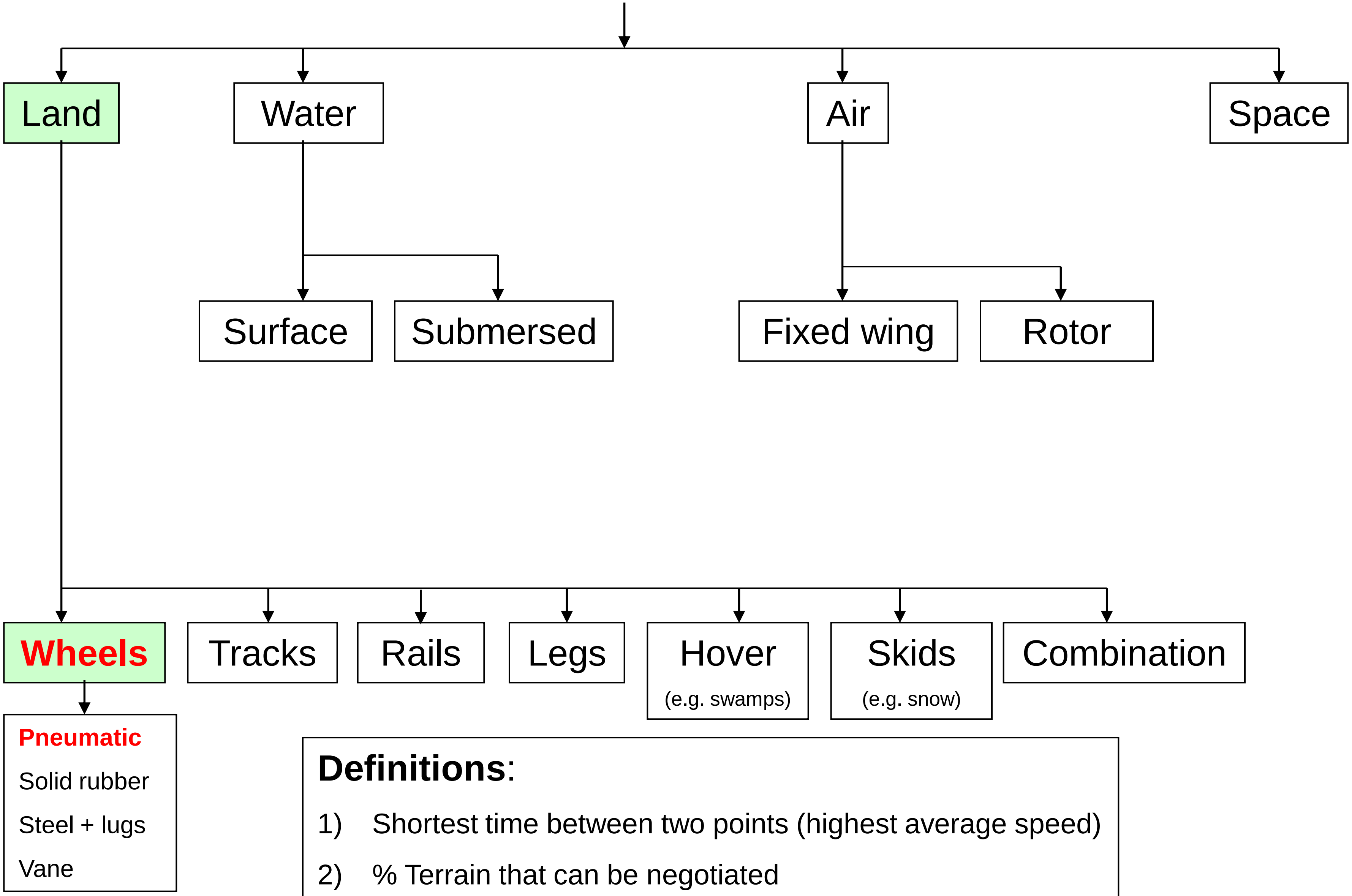
CSIR
our future through science

For vehicles of all types and sizes…

The mobility landscape



Land

Water

Air

Space

Surface

Submersed

Fixed wing

Rotor

Wheels

Tracks

Rails

Legs

Hover

(e.g. swamps)

Skids

(e.g. snow)

Combination

Pneumatic

Solid rubber

Steel + lugs

Vane

Definitions:

1) Shortest time between two points (highest average speed)

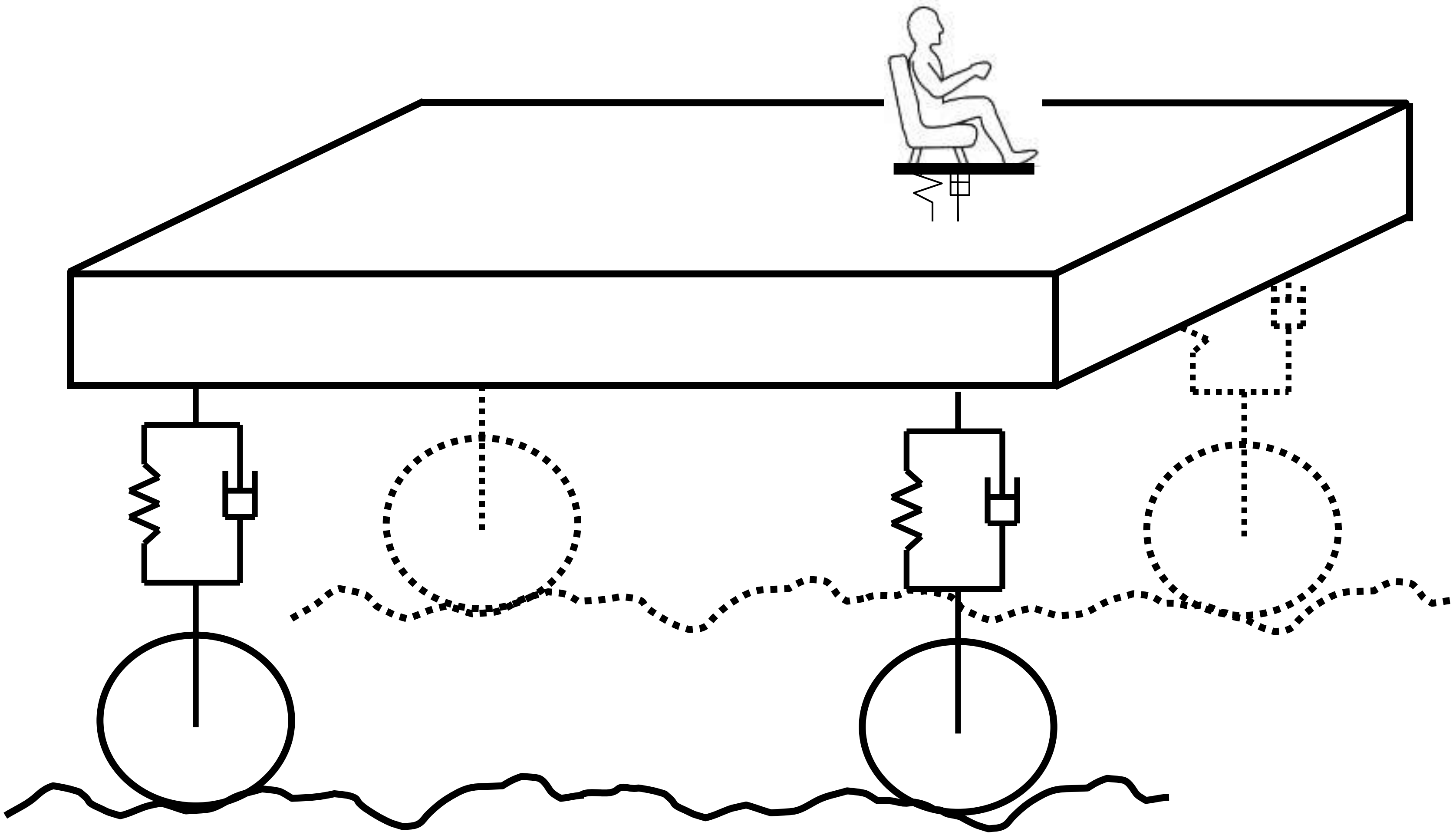
2) % Terrain that can be negotiated

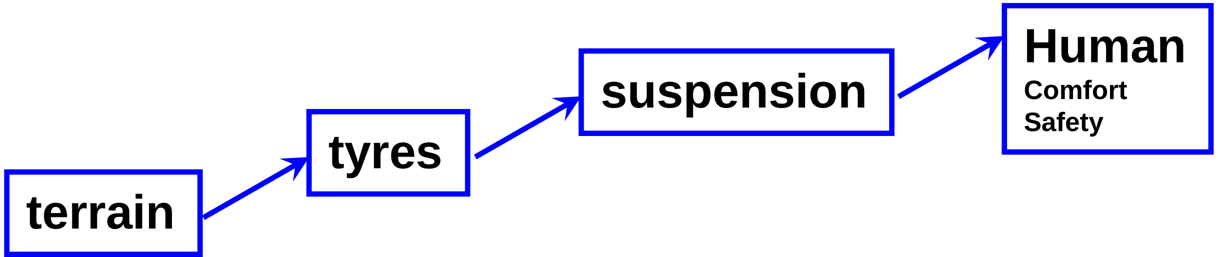
3) Efficiency

Mobility parameters

Mobility parameter:	**Ride** Human resp. to vibration Comfort/Motion sickness Health / Injury / Damage Performance degradation	**Handling** Path following Stability	**Performance**	**Terramechanics** (Deformable terrain) Sand Mud Snow Organic Gravel / Rocks General: contact between environment and vehicle	**Transportability** "External mobility" **Power** Power source Energy storage Regeneration Efficiency Pollution / Environment
Degrees of freedom:	***Vertical DOF***	***Lateral DOF***	***Longitudinal DOF***		
Important aspects:	acceleration Occupants Equipment Discrete obstacles (e.g. speed bump) Random terrain Specific terrain (e.g. washboard)	Kinematics + Dynamics Specific manoeuvres (e.g. parking) Steady state (over-, neutral-, understeer) Dynamic Rollover On-road Off-road	Power source Energy storage Transmission Braking Regeneration Max speed Min speed Acceleration Braking Hill-climb Fuel consumption Towing (drawbar pull)	Traction Slip Towing (Drawbar pull) Tractive efficiency Profile (undeformed / deformed) Rolling resistance	Design issues
Technologies aimed at improving mobility:	Seats Controllable suspension **Tyres / tyre models** **Terrain profiles** Platform stability (also applied to sensor platform)	Controllable suspension Ride (c.g.) height **Tyres / tyre models** Stability control All wheel steering Platform stability (also applied to sensor platform)	Electric drive Hybrid Fuel cells Alternative fuels Batteries / Magneto-dynamic storage / capacitors / accumulators	**Tyres / tyre models / 3D contact** **Soil models** **Terrain properties** Traction control Torque distribution **Tyre inflation** **Test methodologies**	**Potential R&D areas**

Vehicle dynamics and mobility overview





terrain

tyres

suspension

Human

Comfort

Safety

On-road vs. off-road mobility

Suspension characteristics Driving conditions	Springs	Dampers	Ride height (centre of mass position)
On-road	Stiff for good handling, control and safety	High for good handling, control and safety	As low as possible for improved handling, reduced rollover propensity and reduced frontal area and thus aerodynamic drag
Off-road	Soft for good ride comfort, articulation and terrain contact	Low for good ride comfort	High for good ground clearance
Fully laden	Stiff to keep constant natural frequency	High to control wheel and body movement	Maintain constant irrespective of load
Empty	Soft to keep constant natural frequency	Low to keep ride acceptable	Maintain constant irrespective of load

Driver assist systems

- ABS brakes
- Electronic stability control systems
- Traction control
- Cruise control
- Autonomous systems
- Ride vs. handling vs. rollover control
- Ride height control
- Central Tyre Inflation Systems

Mobility Research Focus Areas

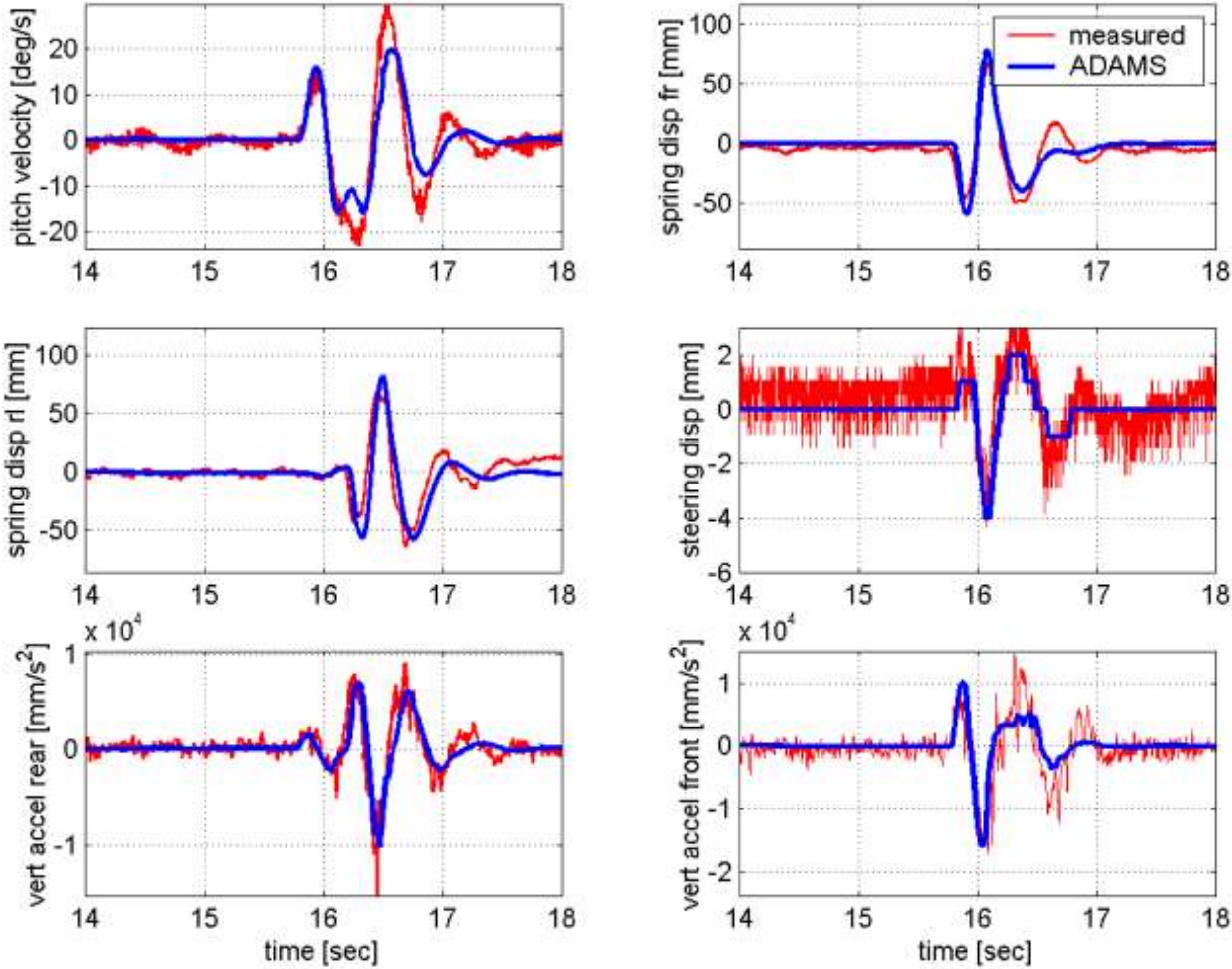
- Vehicle dynamics and mobility modelling
- Roll-over stability of protected military vehicles
- Tyre characterisation and modelling
- Terrain profile measurement and modelling
- Controllable suspension research
- The ride comfort vs. handling compromise
- Dynamic control of autonomous vehicles.

Vehicle dynamics and mobility modelling

Model validation results

Discrete obstacles

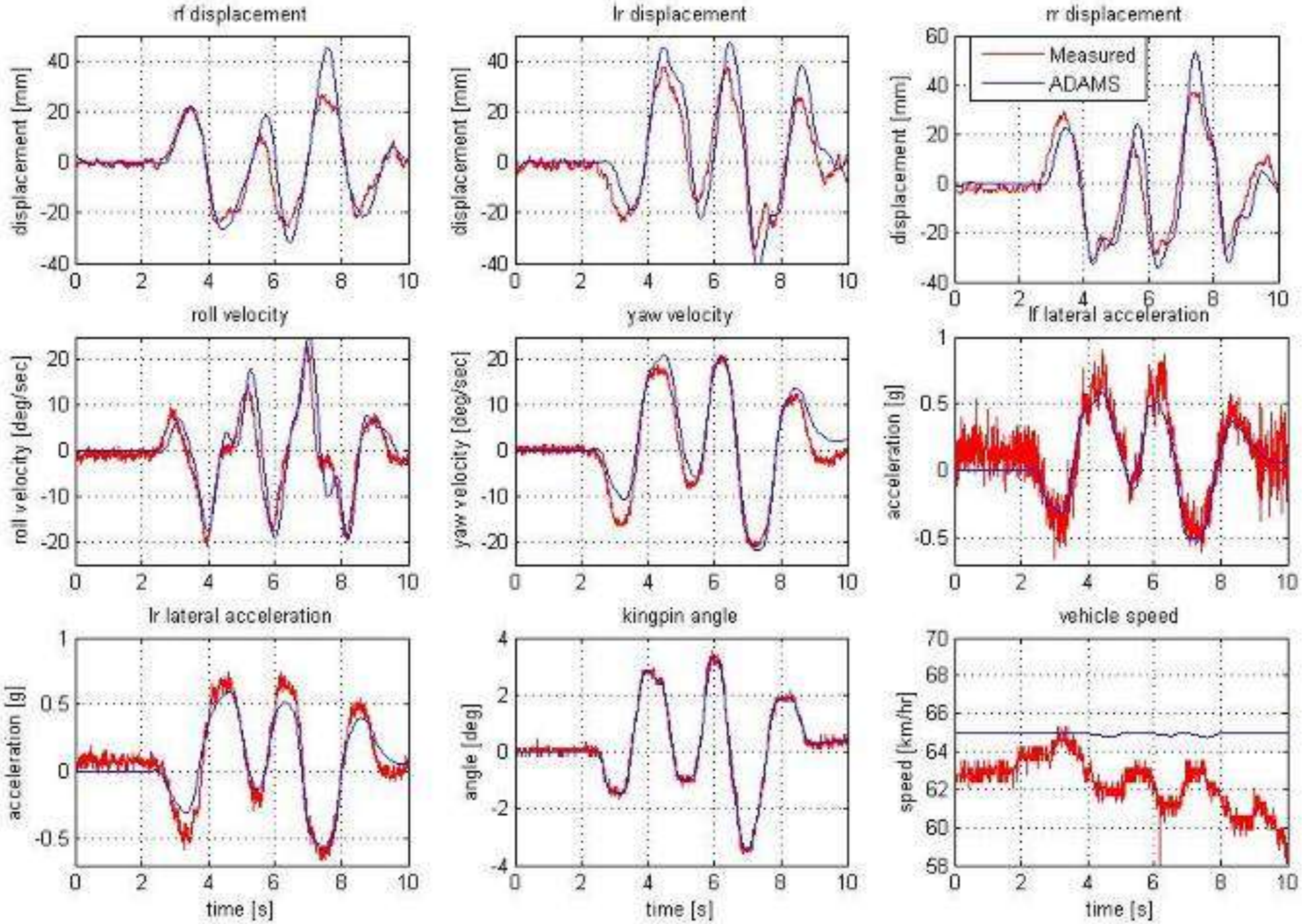
100 mm trapezoidal (APG) bump at 25 km/h.



Model validation results

Handling

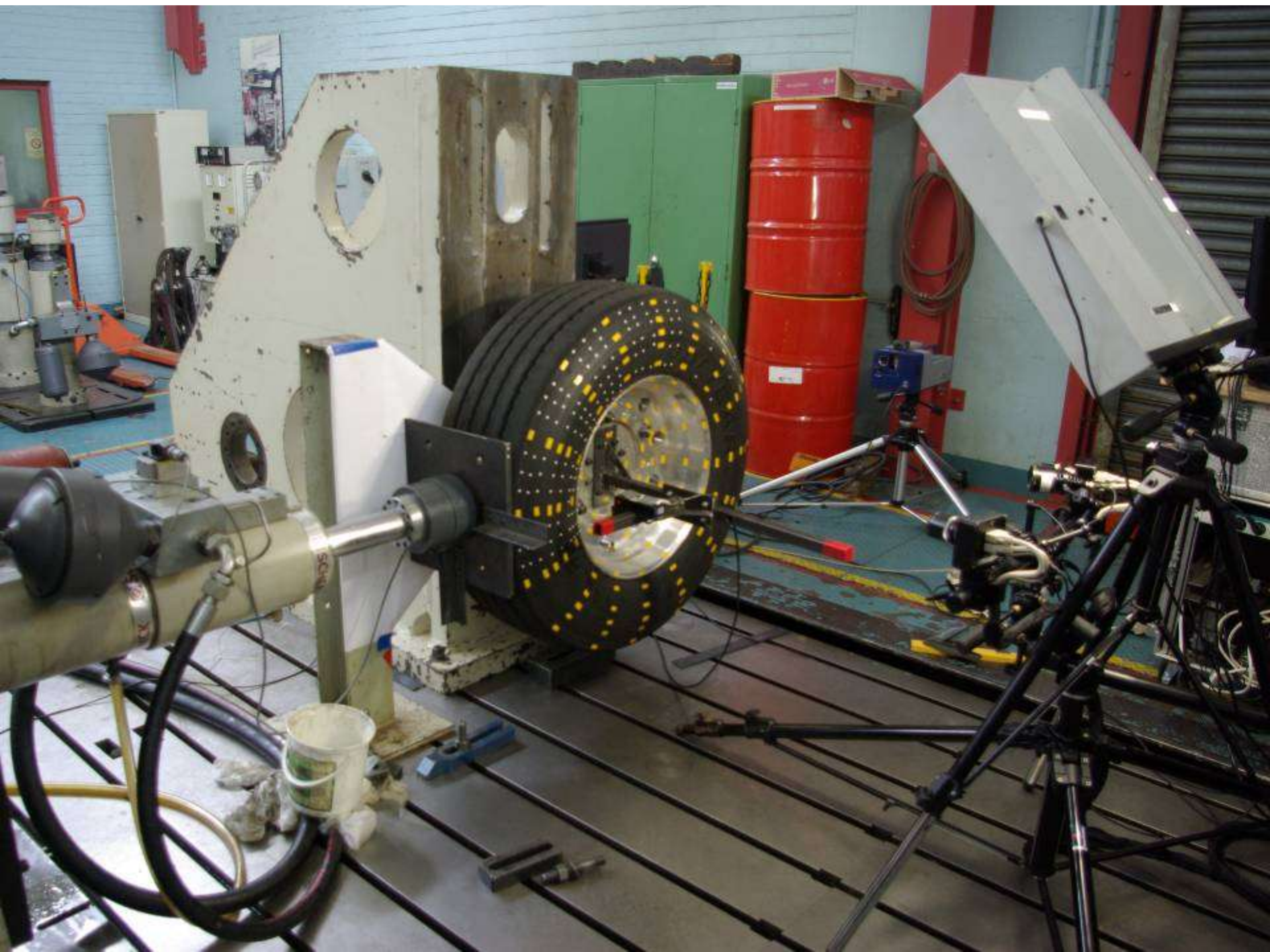
double lane change manoeuvre at 65km/h



Roll-over stability

Why more tyre research ?

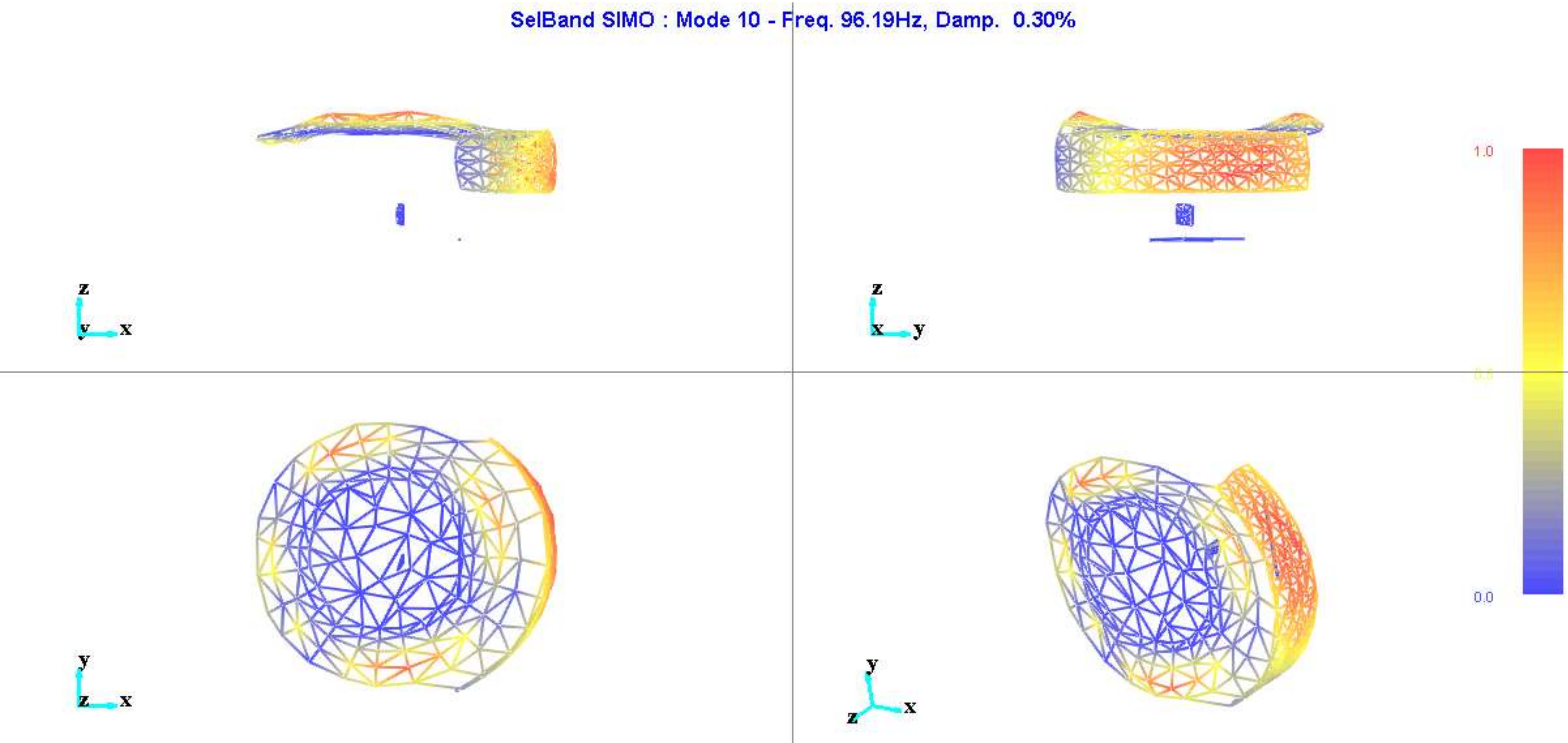
- Unsatisfactory model validation
- Problems on rough terrain
- Tyre data still “unobtainable”
- Questions over local measuring equipment
- Differences between carcass construction of passenger car tyres vs. off-road tyres



Continental Conti-Trac AT

Mode 6

6



SelBand SIMO : Mode 10 - Freq. 96.19Hz, Damp. 0.30%

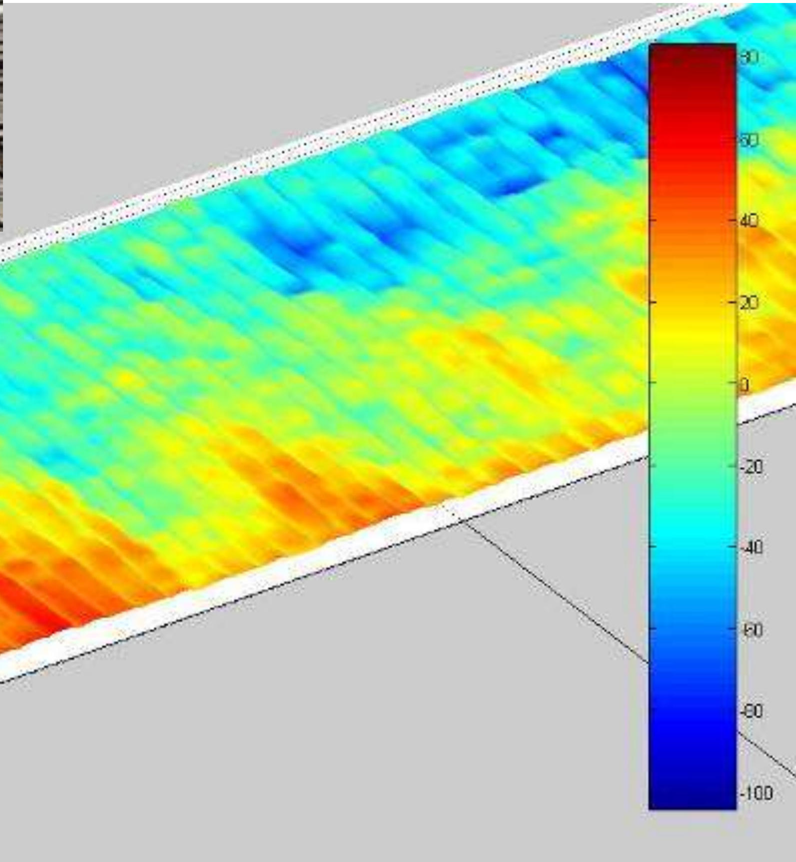
Tyre test equipment

Tyre testing - handling

Wheel load cell

Terrain profile measurement and modelling

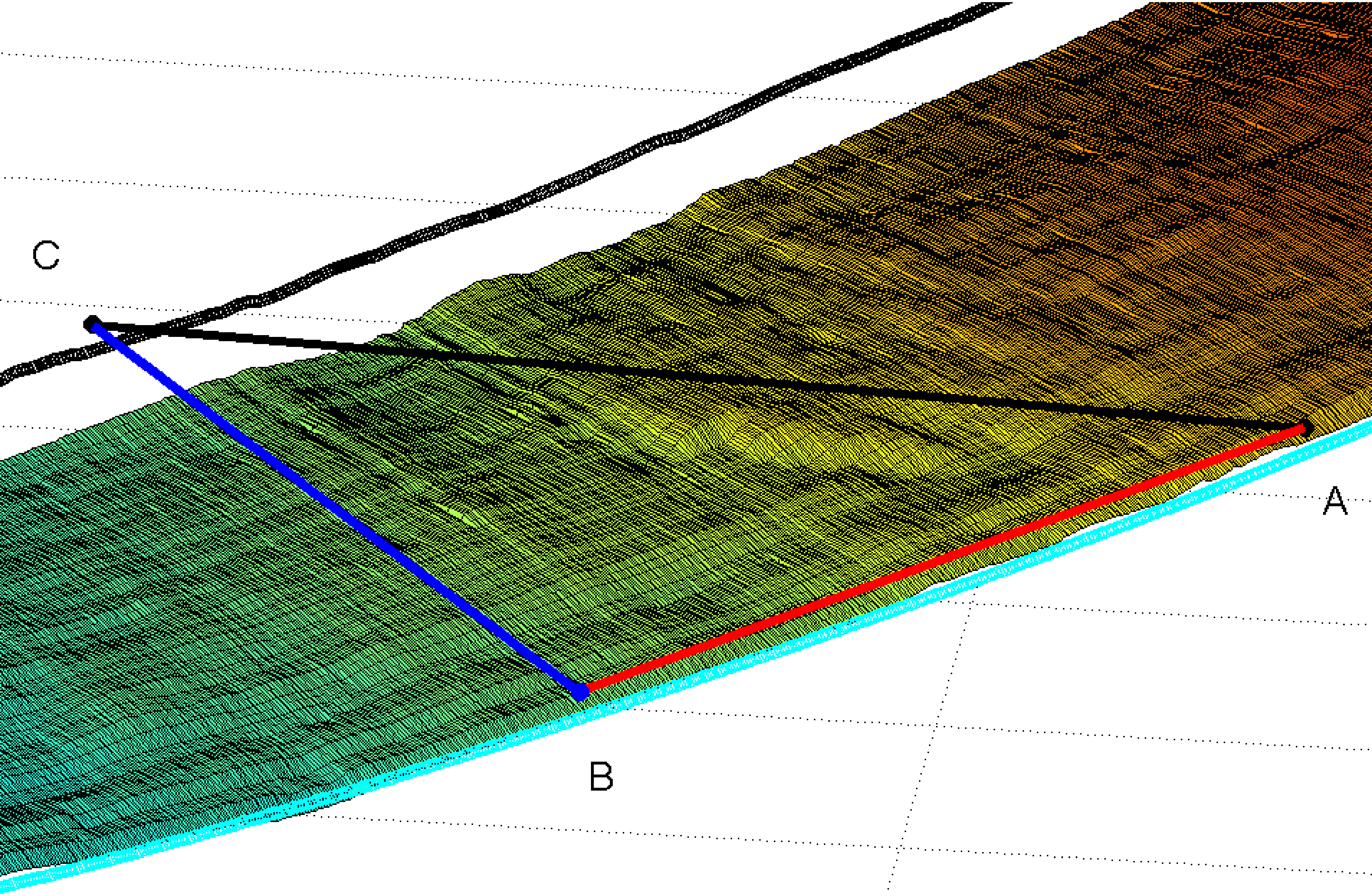
Belgian paving



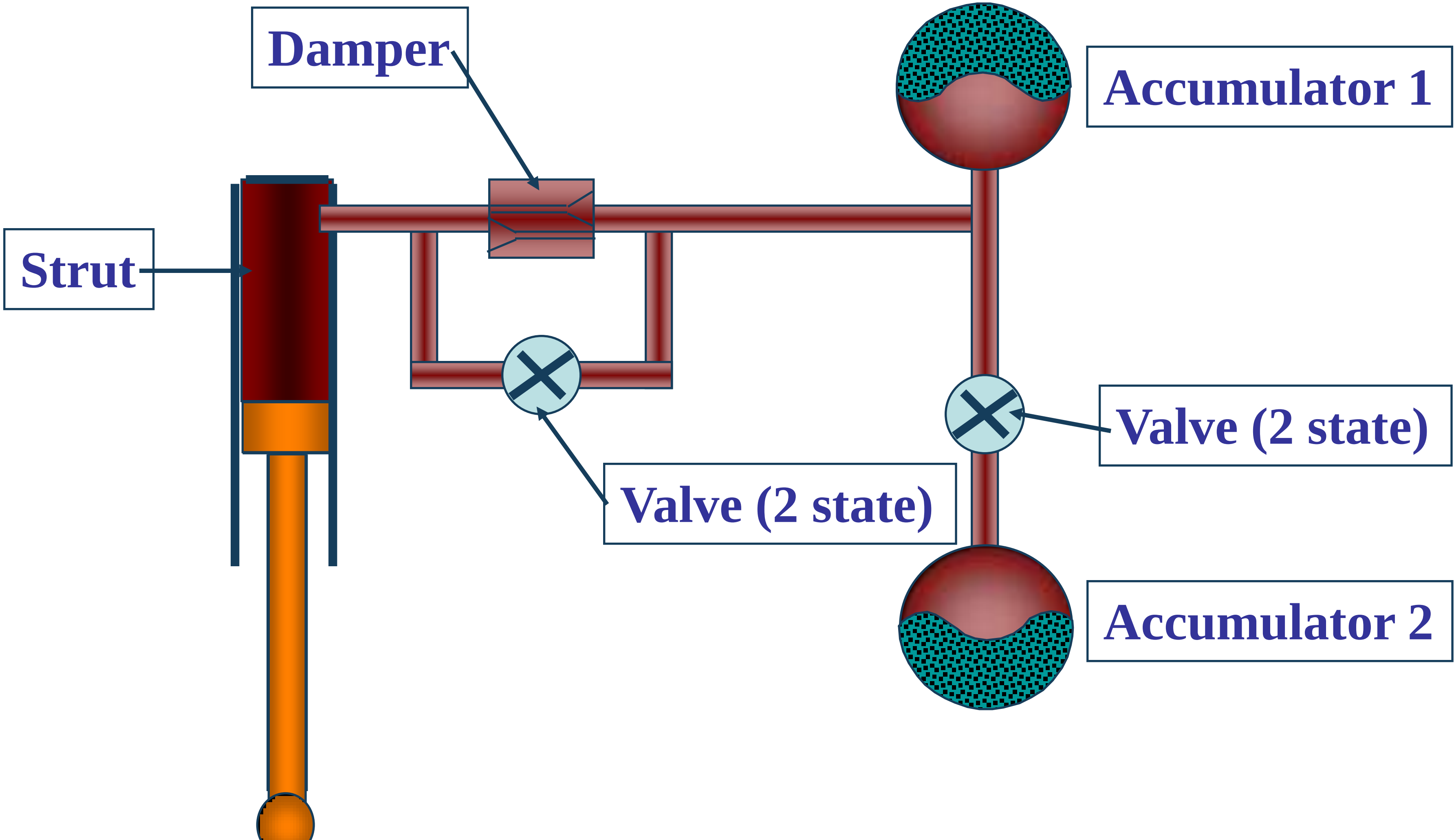
Measurement grid:

100mm lateral
10 mm longitudinal

Rough track



Controllable suspension research



Damper

Accumulator 1

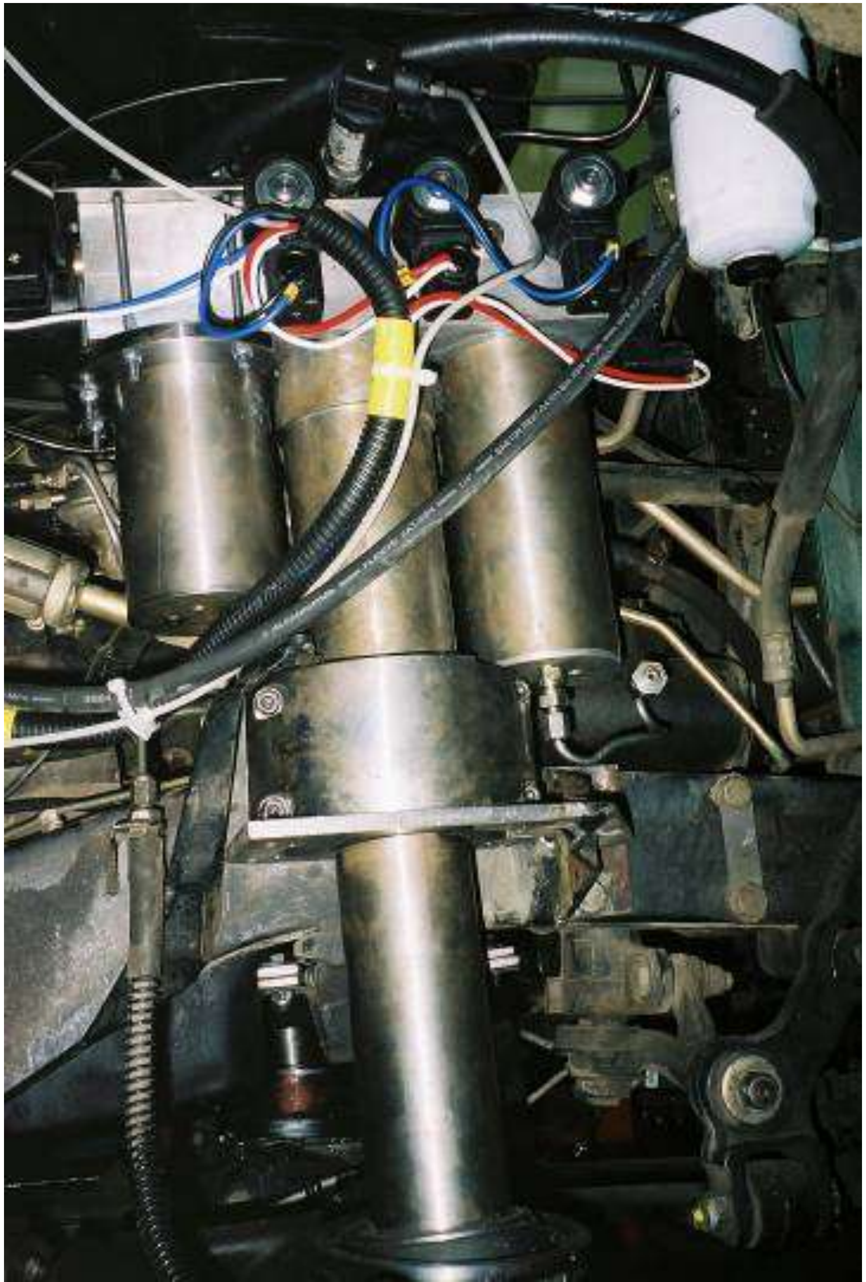
Strut

Valve (2 state)

Valve (2 state)

Accumulator 2

$4S_4$ (4 State Semi-active Suspension System)



$4S_4$ (4 State Semi-active Suspension System)

Ride Comfort mode

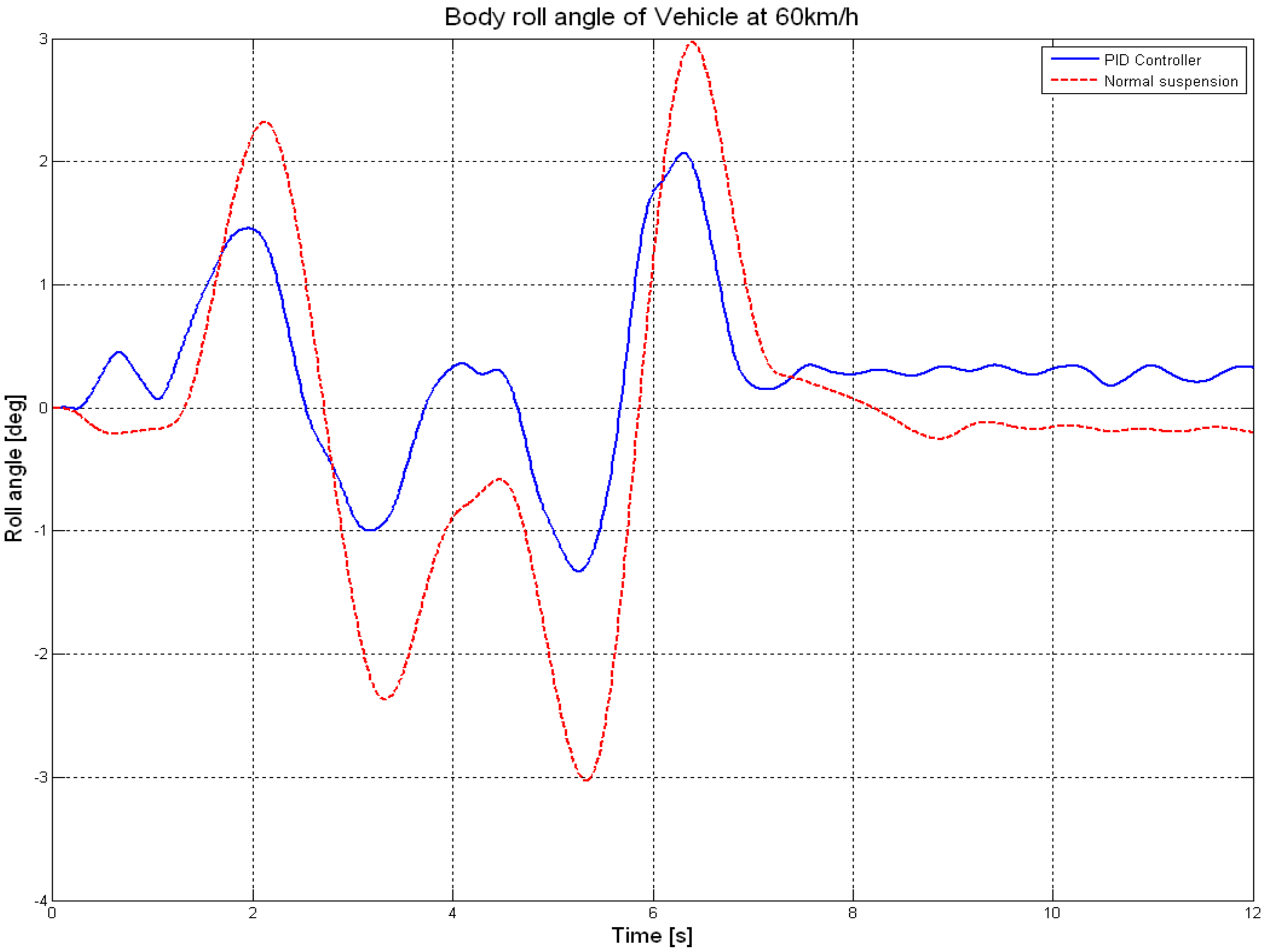
Handling mode

4S$_4$ (4 State Semi-active Suspension System)

Ride Comfort mode

Handling mode

Slow Active Roll Control

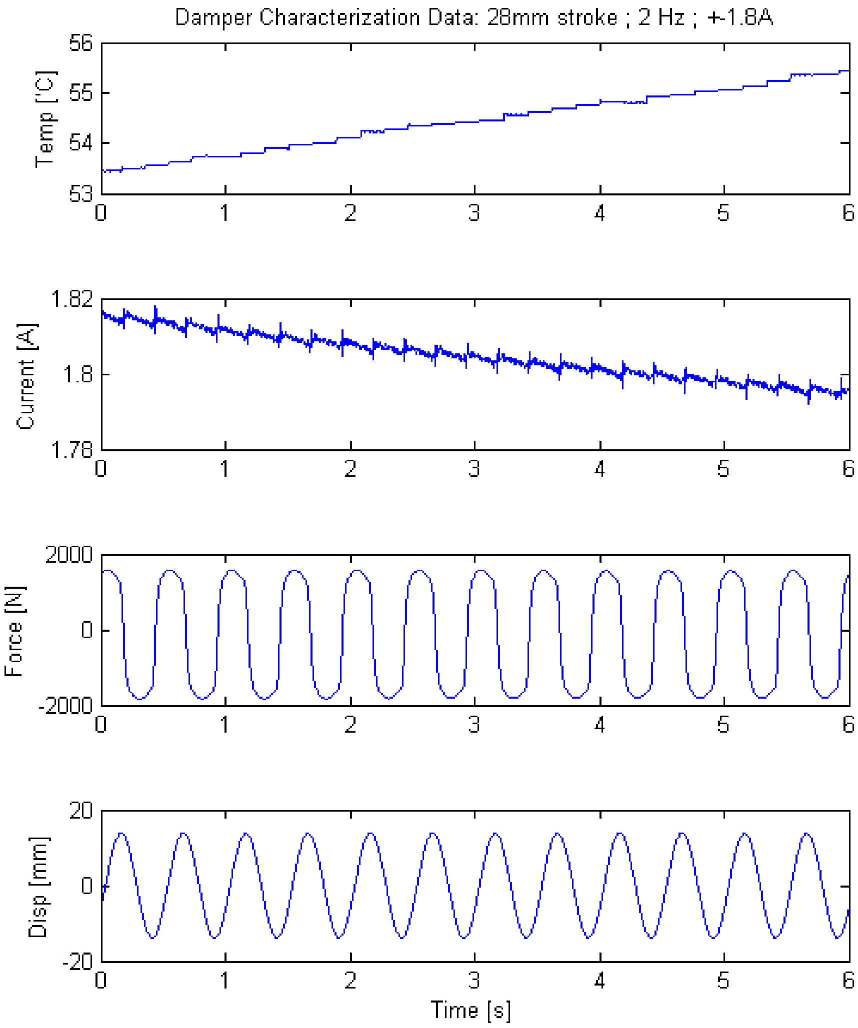


Controllable Suspension Using Magneto-Rheological (MR) Fluids

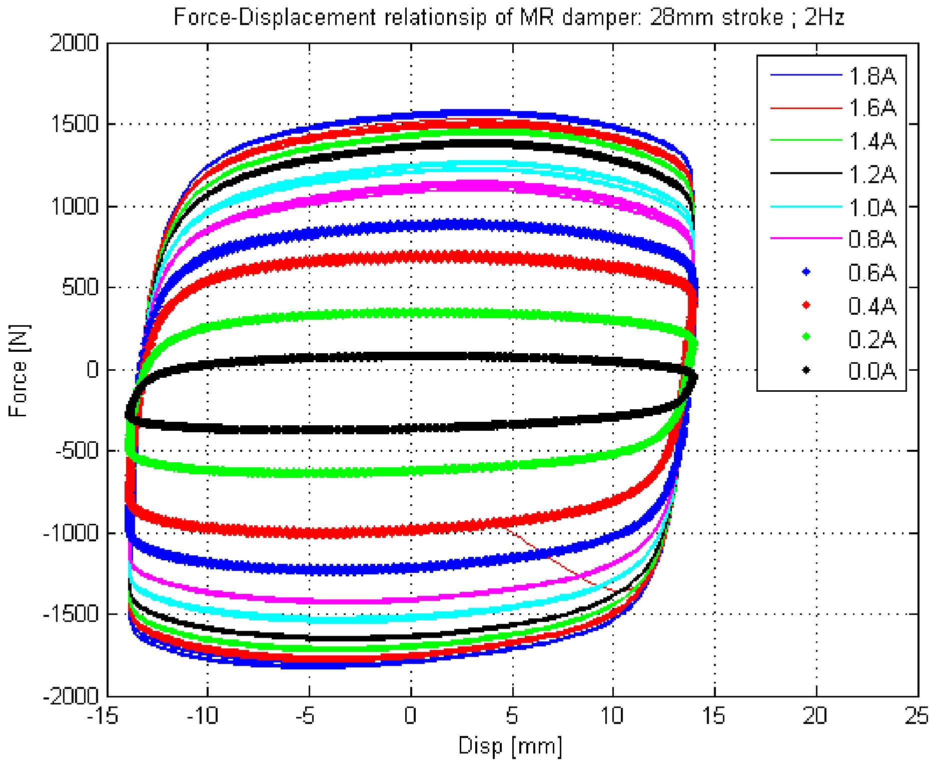
Use Baja as test-vehicle

- Develop model
- Instrument
- Test
- Validate Model
- Implement damper control
- Optimise control
- Quantify improvement

Characterisation



Damper Characterization Data: 28mm stroke ; 2 Hz ; +-1.8A



Force-Displacement relationsip of MR damper: 28mm stroke ; 2Hz

Vehicle control

Dynamic Control of Autonomous Vehicles

Driver drives vehicle
to record desired path

Vehicle follows path
without driver input

Taking vehicle dynamics to new heights

Thank You

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