



## Vehicle Dynamics

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Technical Specialist – Steering and Handling Analysis

- What is a Simulator?
- JLRs Driving Simulator
- Vehicle Models
- Subjective tuning of the vehicle model
- Improving driver cues (motion and others)
- Development of the driving experience with simple tricks
- Future Potential Development Activities

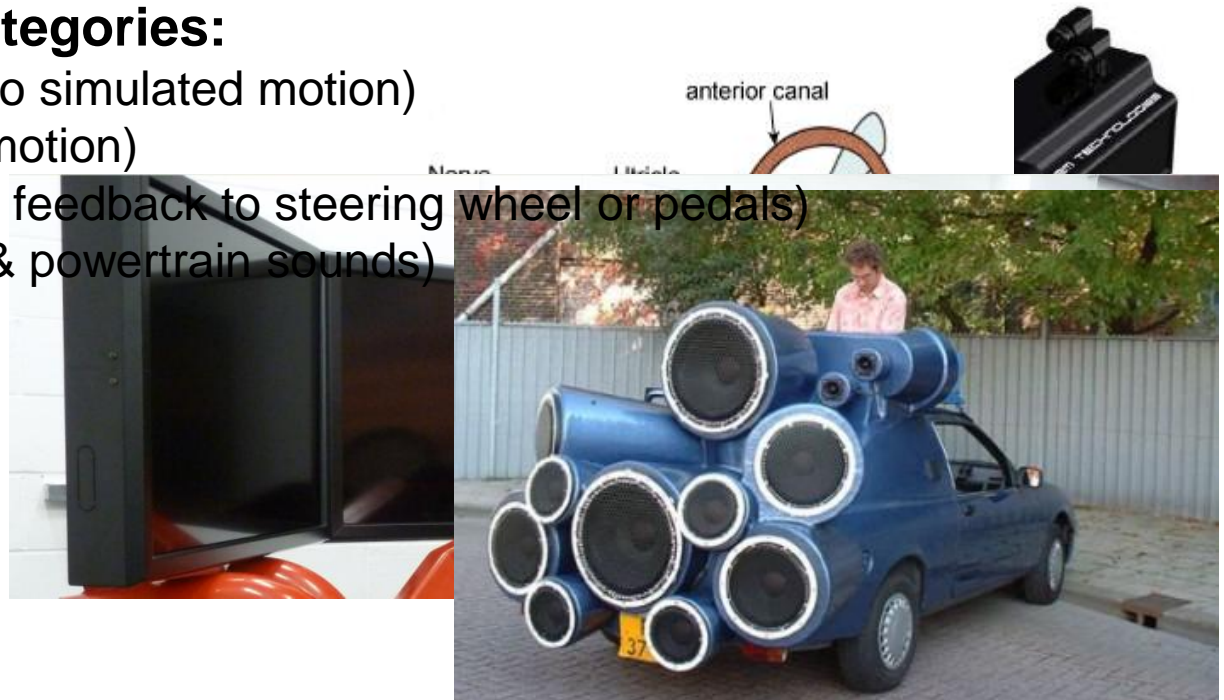
## Oxford Dictionary Definition:

“a machine designed to provide a realistic imitation of the controls and operation of a vehicle, aircraft, or other complex system, used for training *and research* purposes”

Implicit function is the need to provide sufficient sensory feedback to allow the driver to control the vehicle.

## Sensory feedback categories:

- Visual (synchronised to simulated motion)
- Vestibular (simulator motion)
- Somatosensory (force feedback to steering wheel or pedals)
- Auditory (road, wind, & powertrain sounds)



## Collaborative effort between Cruden / IPG / NoViSim

### Cruden:

- Simulator Hardware
- 2 Phase Deployment
- Integration of JLR:
  - Seat
  - Wheel
  - Pedals
- Rendering Software
- Software Integration

### IPG

- Carmaker Office Package
- Custom Simulink blocks

### NoViSim

- SimSound software



## Data Communication

1. Steering Angle / Torque
2. Pedals / Gear Shift
3. Audio (NoViSim)
4. Visualisation (Racer)
5. Platform Motion (IPG / Cruden)
6. Telemetry & Operator



Spectator  
View

### Computer Rack 1

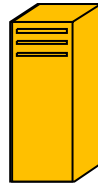


Audio  
Screens  
Left - Centre - Right

### Computer Rack 2



Telemetry  
&  
Operator Spectator ePhyse



Realtime  
Computer  
(Platform  
+ Wheel)



## IPG Carmaker Pro 3.5.4

- Engine & Powertrain
  - Non-suspended engine currently
  - Internal engine model and JLR
- Suspension System
  - Standard Carmaker
  - JLR generated SKC
- Steering System
  - Pfeffer plus JLR customisation
- Tyres
  - MF5.2 & TNO 6.1
- Brakes
  - Standard Carmaker

## **IPG Supported Tyre Models**

### **IPG RealTime Tire**

- Not evaluated as yet

### **Magic Formula Models**

*(Preferred for commonality with other JLR toolsets)*

- Type : MF5.2 & 6.1
- Data Sources : Calspan & TNO

### **Michelin TameTire**

- Not evaluated as yet
- Promising feature content, especially for SCS

## **Implemented**

Simple ABS (IPG demo model)

Continuously Variable Damping (CVD)

Electronically Actuated Differentials (EDIFF)

Active Roll Control (ARC)

Electronic Power Assistance Systems (EPAS)

## **Available but not yet implemented**

Bosch Electronic Stability Program (ESP)

Continental Teves Electronic Stability Control (ESC)

Air Suspension



## Only 4 months development so far!

### Steering Model

Effort levels

- Sensor calibration, wheel diameter, wheel mass / mass offset, boost curves, pump flow on test.....

Pfeffer model complex, but requires careful parameter choice

E.g. Friction, damping, stiffness etc.

### Tyres

- Correction for differences between FlatTrac grit paper and Tarmac
- Low vs. High angle slip data

### Controls

- Pedal Feel
- Pedal sensitivity

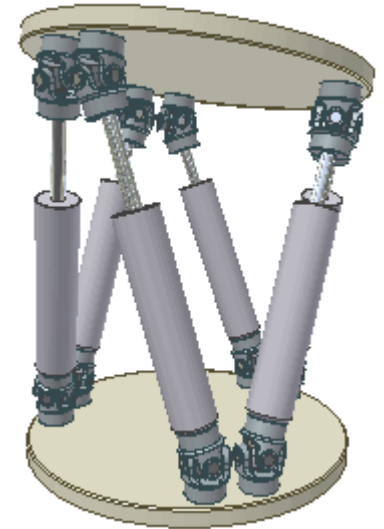
We're using a 'Stewart Platform' to provide the vestibular motion-cues to the driver

Bad News first : however good we make these, they'll never be able to replicate the real vehicle's displacements, velocities, and accelerations, however....

They can provide useful information

We can use quirks of perception to fool the driver.

For example, a 10% acceleration can be synthesized by a roll or pitch angle to the platform.



angle + a  
more

Roll Angle

With a limited envelope of motion we cannot provide limitless cues  
E.g. Large bump in a bend

We need to prioritise cues depending on

Steering

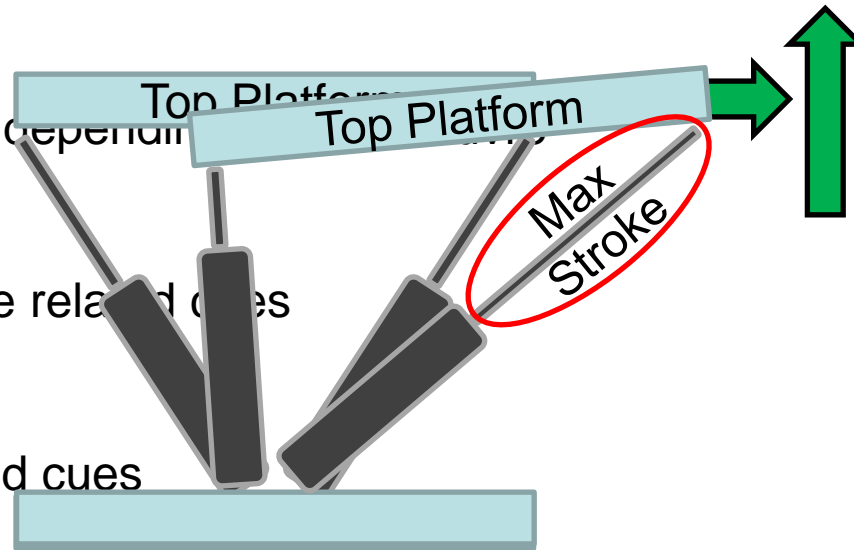
- Prioritise initial response related cues

Handling

- Prioritise stability related cues

Ride

- Prioritise vertical and roll motions



## **Great benefits of higher fidelity audio**

NoViSim allows us to place sound sources in their correct position  
Markedly increases sense of immersion  
Should allow assessor to determine origin of noise, e.g. tyre squeal

## **Less obvious benefits**

Synthesised from real test data (road noise includes stone flicks)  
Engine note allows driver to pre-empt vehicle response

## **Room Environment**

### Wall Colour

- Sides and back in white
- Front wall and sides within peripheral view in black

### Diming the Lights

## **Simulator Environment**

Carpet under heel

Road roughness inclusion

## Further Controllers

ESP / ESC

More extensive plug-in models

Engine

Driveline



Vehicle Dynamics

# Questions