Extending CarMaker for Multiple Variable Analysis.
IPG Apply and Innovate

Robert Neilson
Chassis
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Introduction

- Background to the CarMaker extension
- Overview of TestWare tool functionality
- Current State and Developments
Use of active systems means that current vehicles have increasing influences on vehicle dynamic behaviour:

• Systems reacting to environmental conditions
• Systems changing behaviour based on driver request

JLR needed an approach for integrated vehicle dynamic system development.

• Switchable Systems
  > Air Suspension
  > Active Roll Control
  > Adaptive Damping
  > Terrain Response
  > Gearbox Modes
  > ...

• Varying Environmental Conditions
  > Vary Mu conditions
  > Driving Styles
Investigate system interactions at vehicle level:

- Objective data to measure system capability.
- Understand system interactions
  > Both expected and Unforeseen

Define requirements for:

- System Architecture
- System communications
- Limitations on system state transitions
- Allowable combinations of states
Background
Tool Choice

• CAE allows large number of different configurations to be run easily.
  > Increased scope of testing when compared to physical is possible.
  > Reduced cost
  > Results can be produced more quickly

• Requirements can be developed much earlier in the vehicle development process, before physical prototypes exist.
Example 1:
Lift Off Turn in Test – 384 states.
• 70 Runs per day
• 30 Runs per set of tyres.
• 3 Repeat Runs
• 23.3 States per day

16.5 days testing, 39 sets of tyres

Example 2:
Sine with Dwell – 64800 states.

5555 days testing, 12960 sets of tyres
JLR set out to work with IPG to produce a tool that:

- Automates the generation of a large number of test runs with systems set in varying states.
- Controlled by a simple GUI for use by non-expert CarMaker users.
- Automated data analysis based on pre-defined criteria for initial feedback.
- The tool would be suitably generic that it can be used by any group in JLR analysing large groups of variables.
Tool Overview

Structure

CarMaker Power User

Test Run / Variable Definition

TestWare GUI

Test Manager

CarMaker

Systems Engineer

Post-processing
Tool Operation
System Models

- Compiled Simulink Models
  > Custom interface to compile suspension systems independently
    - Independent version control
    - Secure model exchange
  > Different configurations of systems can be used from within one executable.
  > Improved simulation performance over co-simulation
    - In the order of 10x
Tool Operation
Test Definition File

Function:

Define all the project and manoeuvre specific features.

Including:

• Variables to be included in analysis
  > Naming for GUI linked to actual variable name in the model.
• .tcl scripts
  > Post-processing
  > Manoeuvre Specific
• Driver adaption (if required).
• Definition of any pre-tests to set vehicle speed etc.
Multiple vehicle variations can be set up. Including different tyres/loads etc.

Individual parameters can be modified.
Tool Operation
GUI - Features

Test Procedures to be Run
Tool Operation

GUI - Features

![Tool Operation GUI Features](image)

Variable input
Tool Operation
GUI - Features

Filter tool to remove ‘illegal’ combinations.
Tool Operation
GUI - Features

Configurable Trigger
Tool Operation

GUI - Features
Any number of vehicles can be selected for each test. e.g. cross check all variants in a vehicle line.
Test runs are split into groups of 1000 runs to make debugging and data storage more manageable.

Customisable feedback for Pylon hit etc.
Function

Provide initial feedback to the systems engineer about which tests require further investigation.

Operation:

• Compares signals against predefined Criteria
  
  > Eg Vehicle hits a pylon, simulation does not complete, yaw rate exceeds a limit.

• Runtime data stored to CarMaker Scratchpad.

• .tcl script then processes and exports the data to excel
Current State and Developments

• Tool is still under development.
  > Tool not production ready at IPG
  > Other groups in JLR looking at expanding the tool for their work.
    • E.g. model based calibration by automating the creation of the definition files.

• Other aspects of the model can become the limiting factor
  > The quality of correlation will improve as individual system/component CAE models improve.

• Opportunity to develop more complex post processing utilities.
Current State and Developments

- Phased introduction
  - Decrease in vehicle test work will increase as confidence is built in the predictions.
  - Incorporation into JLR development process.

- Meets JLR corporate strategy
  - Information available earlier in development cycle
  - Reduction in prototype usage (reduced cost to vehicle programs)
  - Reduced CO$_2$ output (both in prototype manufacture and testing)