





Extending CarMaker for Multiple Variable Analysis.

IPG Apply and Innovate

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Chassis
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Introduction



- Background to the CarMaker extension
- Overview of TestWare tool functionality
- Current State and Developments

Background



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 μ conditions
 - > Driving Styles

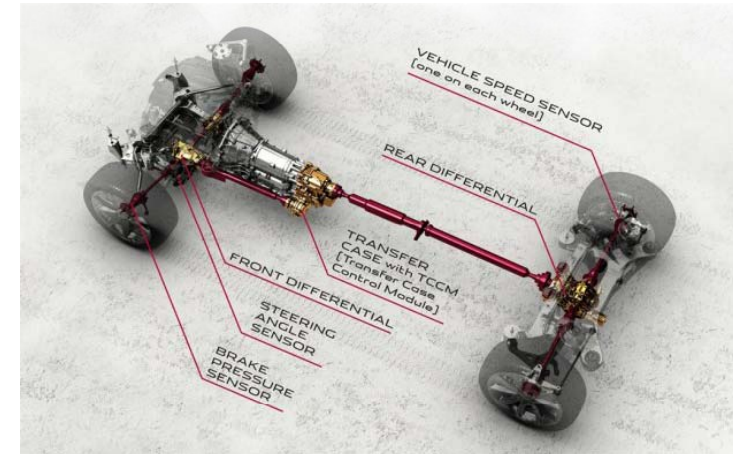
Background

System Development



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.

Background

Tool Choice - Justification



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**

Project Scope

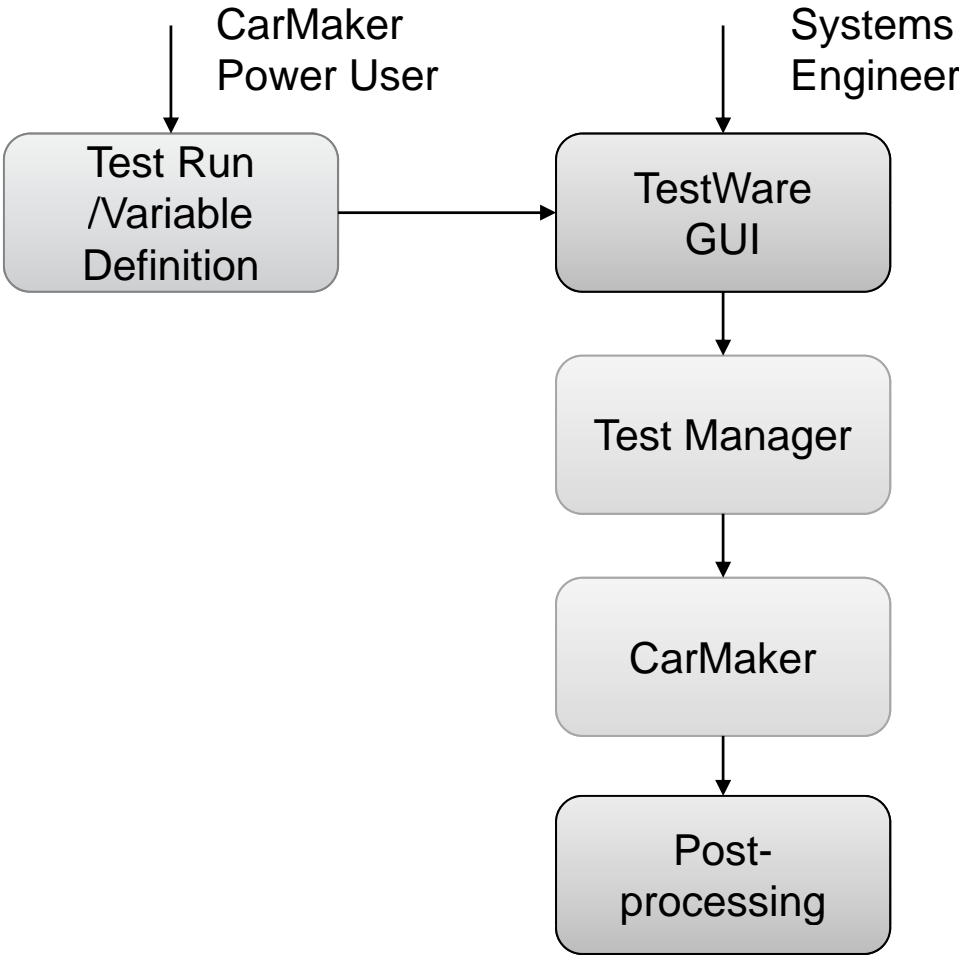


JLR set out to work with IPG to produce a tool that:

- 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



Tool Operation

Test Definition File



Function:

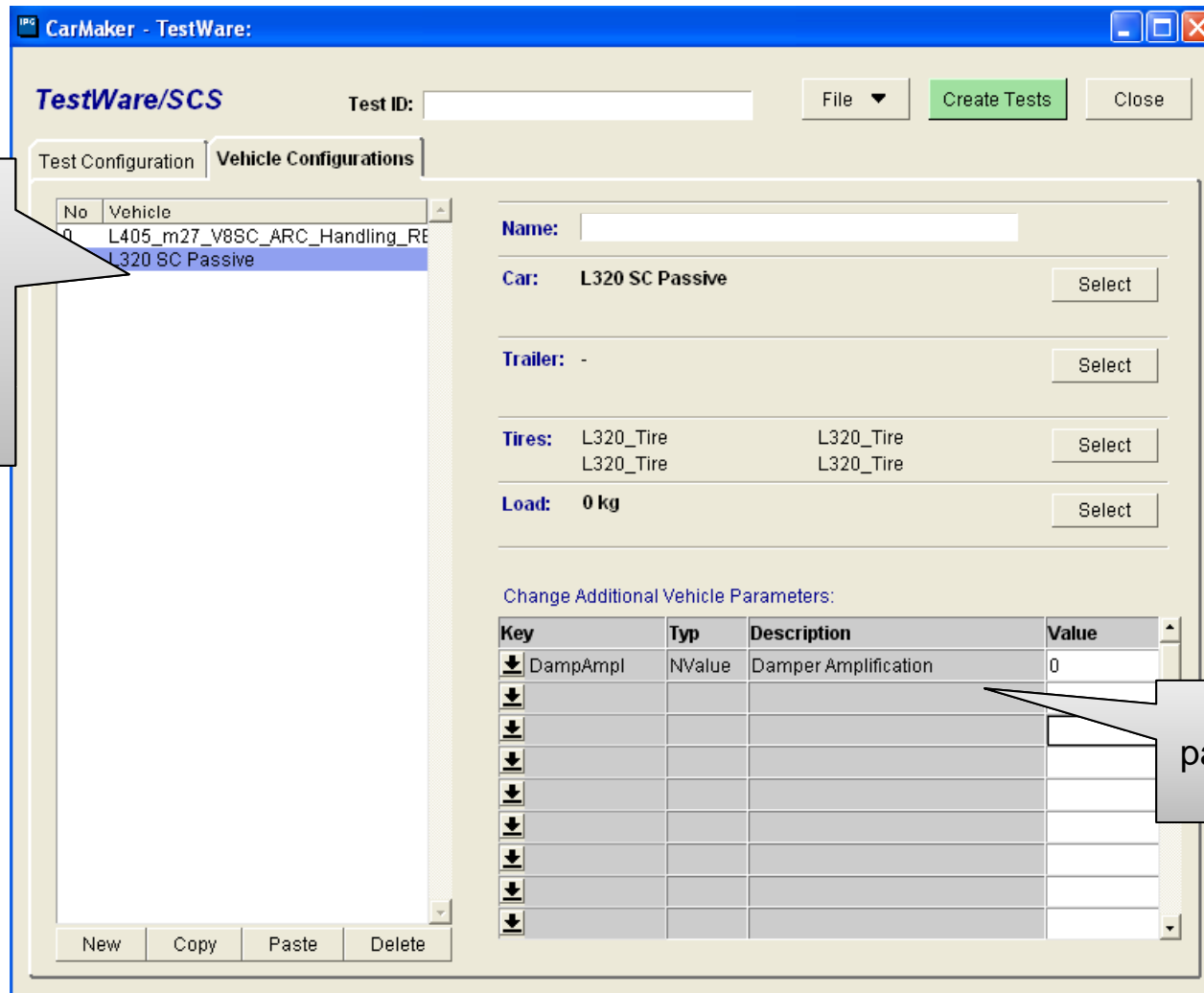
Define all the project and manoeuvre specific features.

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.

Tool Operation

GUI - Features

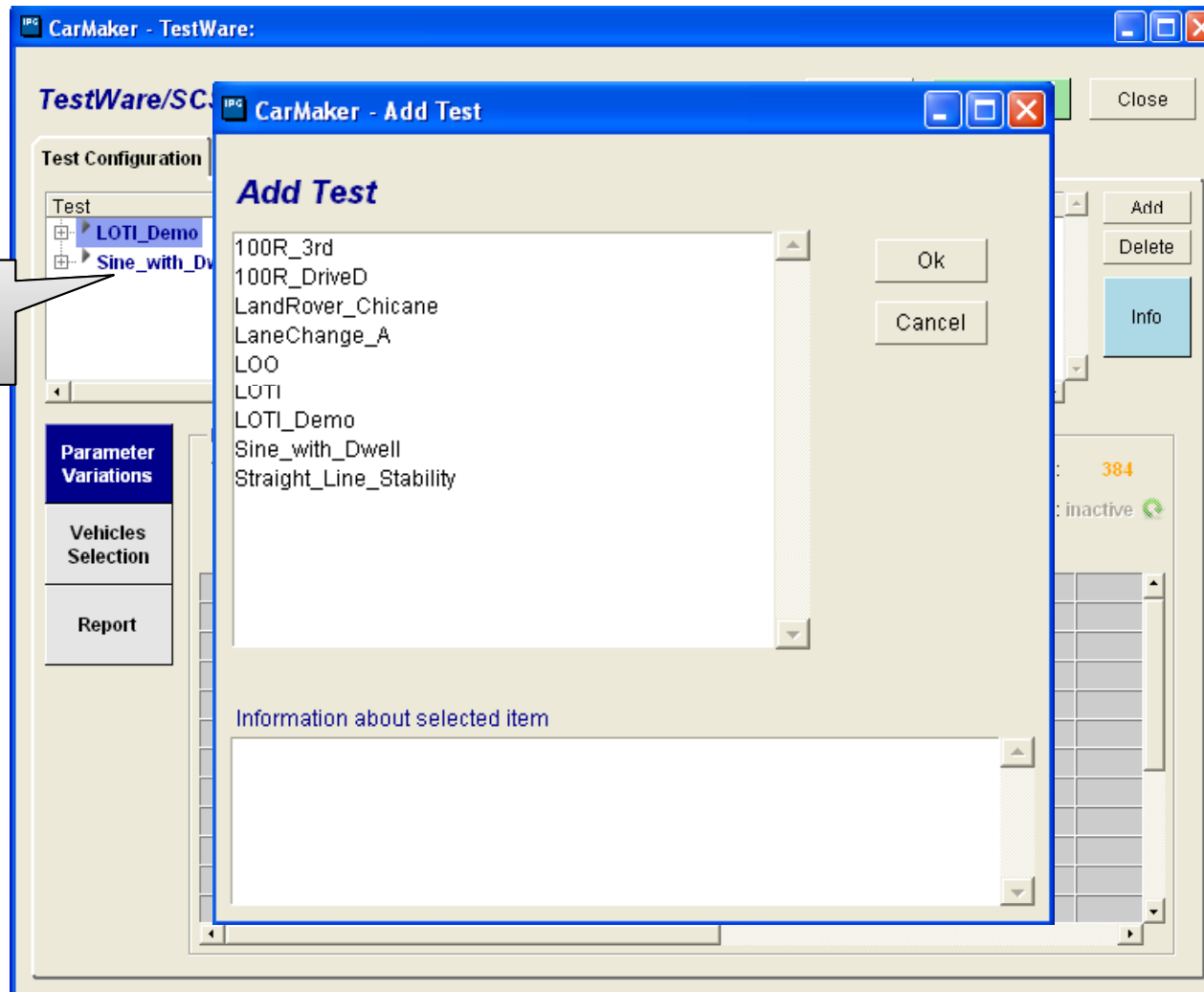


Multiple vehicle variations can be set up. Including different tyres/loads etc

Individual parameters can be modified.

Tool Operation

GUI - Features



Test Procedures
to be Run

Tool Operation

GUI - Features



CarMaker - TestWare:

TestWare/SCS Test ID: File

Test Configuration Vehicle Configurations

Test	Results	Vehicles	Variations	
LOTI_Demo	384	1	384	<input type="button" value="Add"/>
Sine_with_Dwell	129600	2	64800	<input type="button" value="Delete"/>

Parameter Variations

Trigger Condition: After Simulation Start s Number of Variations: 384

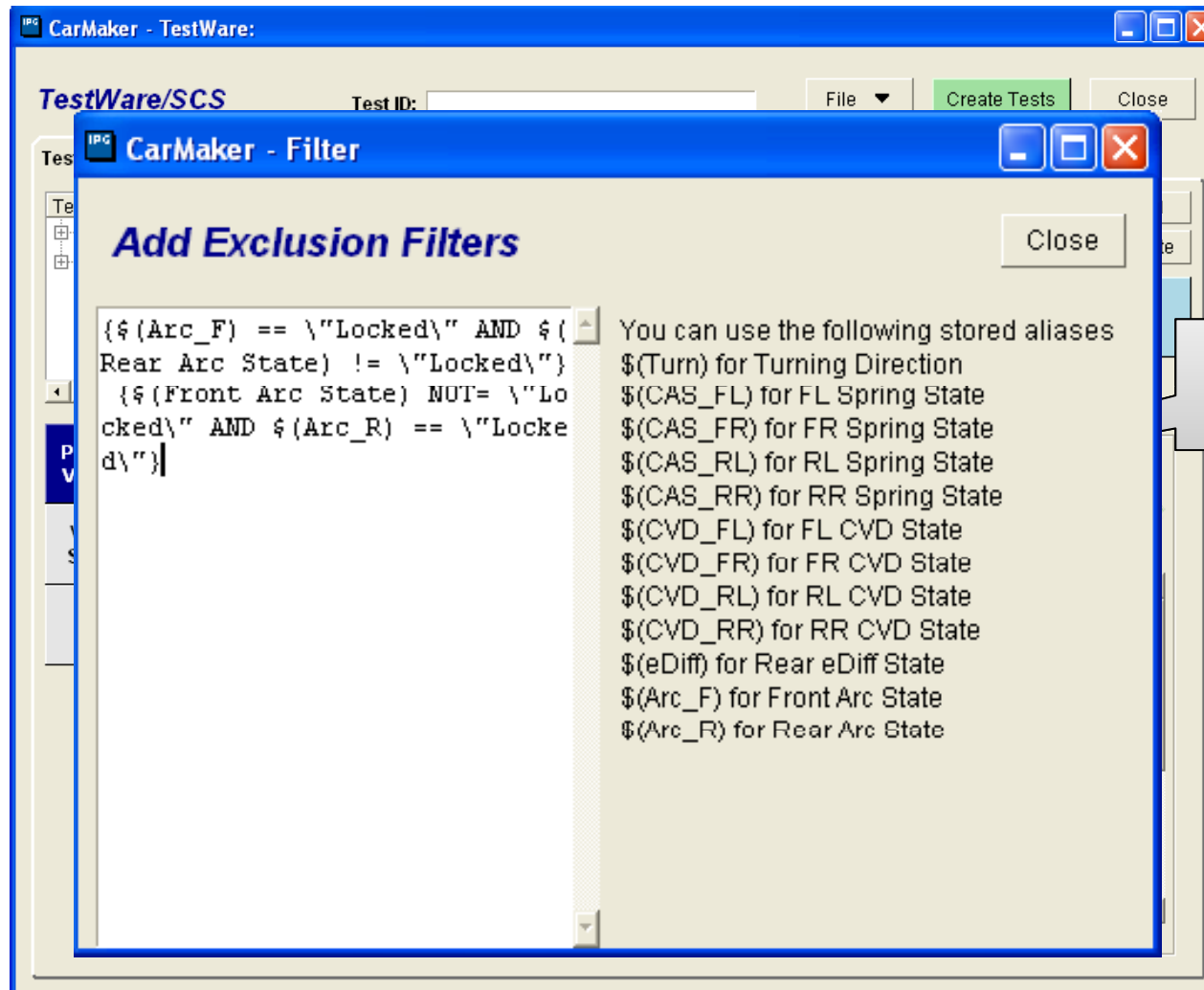
Variations: Combinatorial After filtering: inactive

Parameter	Unit				
Turning Direction	-	Left	Right		
Target Ride Height		Access	Normal	OffRoad	25
Terrain Response					
Gearbox	-	Drive	Sport		
Dynamic Mode	-	Off	On		
Mu Split Mu	-	Yes	No		
Steer Rate	-	1200	1800		

Variable input

Tool Operation

GUI - Features



Filter tool to remove 'illegal' combinations.

Tool Operation

GUI - Features



CarMaker - TestWare:

TestWare/SCS Test ID: File Create Tests Close

Test Configuration Vehicle Configurations

Test	Results	Vehicles	Variations	
LOTI_Demo	384	1	384	Add
Sine_with_Dwell	129600	2	64800	Delete

Info

Parameter Variations

Trigger Condition: After Simulation Start 0 s Number of Variations: 384

Variations: After Simulation Start After Main Focus Start After Distance After filtering: inactive

Parameter	Access	Normal	OffRoad						
Turning Direct									
Target Ride Height	-	Access	Normal	OffRoad					
Terrain Response	-	Ruts	elSnow	Sand	ckCrawl				
Gearbox	-	Drive	Sport						
Dynamic Mode	-	Off	On						
Mu Split Mu	-	Yes	No						
Steer Rate	-	1200	1800						

Configurable Trigger

Tool Operation

GUI - Features



TestWare: L00_full.ware

TestWare/SCS Test ID: MyL00 File Create Tests Close

Test Configuration Vehicle Configurations

Test	Results	Vehicles	Variations
LOTI_Demo	4	1	4
Sine_with_Dwell	129600	2	64800

Parameter Variations

Trigger Condition: After Simulation Start 0 s Number of Variations: 4

Variations: Separate Tests Filter After filtering: inactive

Parameter	Unit	1	2	3	4	5	6	7	8	9	10
Turning Direction	-	Left	Left	Left	Left						
Target Ride Height	-	Access	Access	Access	Access						
Terrain Response	-	Ruts	Grass	Grass	Ruts						
Gearbox	-	Drive	Drive	Drive	Drive						
Dynamic Mode	-	Off	Off	On	On						
Mu Split Mu	-	Yes	Yes	Yes	Yes						
Steer Rate	-	1200	1200	1200	1200						

Parameter Variations

Vehicles Selection

Report

Tool Operation

GUI - Features



The screenshot displays the 'CarMaker - TestWare' interface. At the top, there is a 'TestWare/SCS' header with a 'Test ID:' field, a 'File' dropdown, and 'Create Tests' and 'Close' buttons. Below this, the 'Test Configuration' tab is active, showing a table of test configurations:

Test	Results	Vehicles	Variations
LOTI_Demo	384	1	384
Sine_with_Dwell	129600	2	64800

Buttons for 'Add', 'Delete', and 'Info' are located to the right of the table. Below the table, the 'Vehicle Selection' tab is active, showing a table with columns 'Sel.', 'No.', and 'Vehicle':

Sel.	No.	Vehicle
<input checked="" type="checkbox"/>	0	L405_m27_V88C_ARC_Handling_REV1_1_AllActive
<input type="checkbox"/>	1	L320 8C Passive

Buttons for 'Select All' and 'Unselect All' are at the bottom left, and a 'Vehicle Configuration' button is at the bottom right. A 'Parameter' tab is also visible on the left side of the interface.

Any number of vehicles can be selected for each test. eg cross check all variants in a vehicle line

Vehicles Selection

Report

Tool Operation

Test Manager



Item	Description	Par1	Par2	Par3	Par4	Par5	Par6	Par7	Pa	Res.Date	Result
Global Settings											
T1: LOTI_Demo											
V1: L405_m27_V8SC_ARC_Handling_REV1_1_AllActive											
Info											
L405_m27_V8SC_ARC_Hand											
Settings											
Read Info Block	ReadInfoBlock set TS::MainRun 0...										
LO_PreTest											
Initialize Run	set TS::SCS_Channels "" set TS::SCS_ChannelValues ""...										
Group 0											
Export Results to Excel	if (\$?platform(platform) == "windows") {Fill_Excel_Table [GetExc										
T2: Sine_with_Dwell											

TestRun	Type	Name	Value
LO_PreTest			

Test runs are split into groups of 1000 runs to make debugging and data storage more manageable

Customisable feedback for Pylon hit etc

Tool Operation

Data Analysis



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 CO₂ output (both in prototype manufacture and testing)

Q & A



