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Vehicle Dynamics CAE within a Development Programme

N.W.Fussey,
P.A. Chappell, J.A. Nicholson, N. McGowan

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Agenda

- **Introduction**
- **Where does CAE fit in?**
- **Applications of Vehicle Dynamics CAE**
- **CAE Tools**
- **Data requirements**
- **Converting Subjective to Objective data**
- **Simulations**
- **Correlation**
- **Conclusions**

Where does CAE fit in?

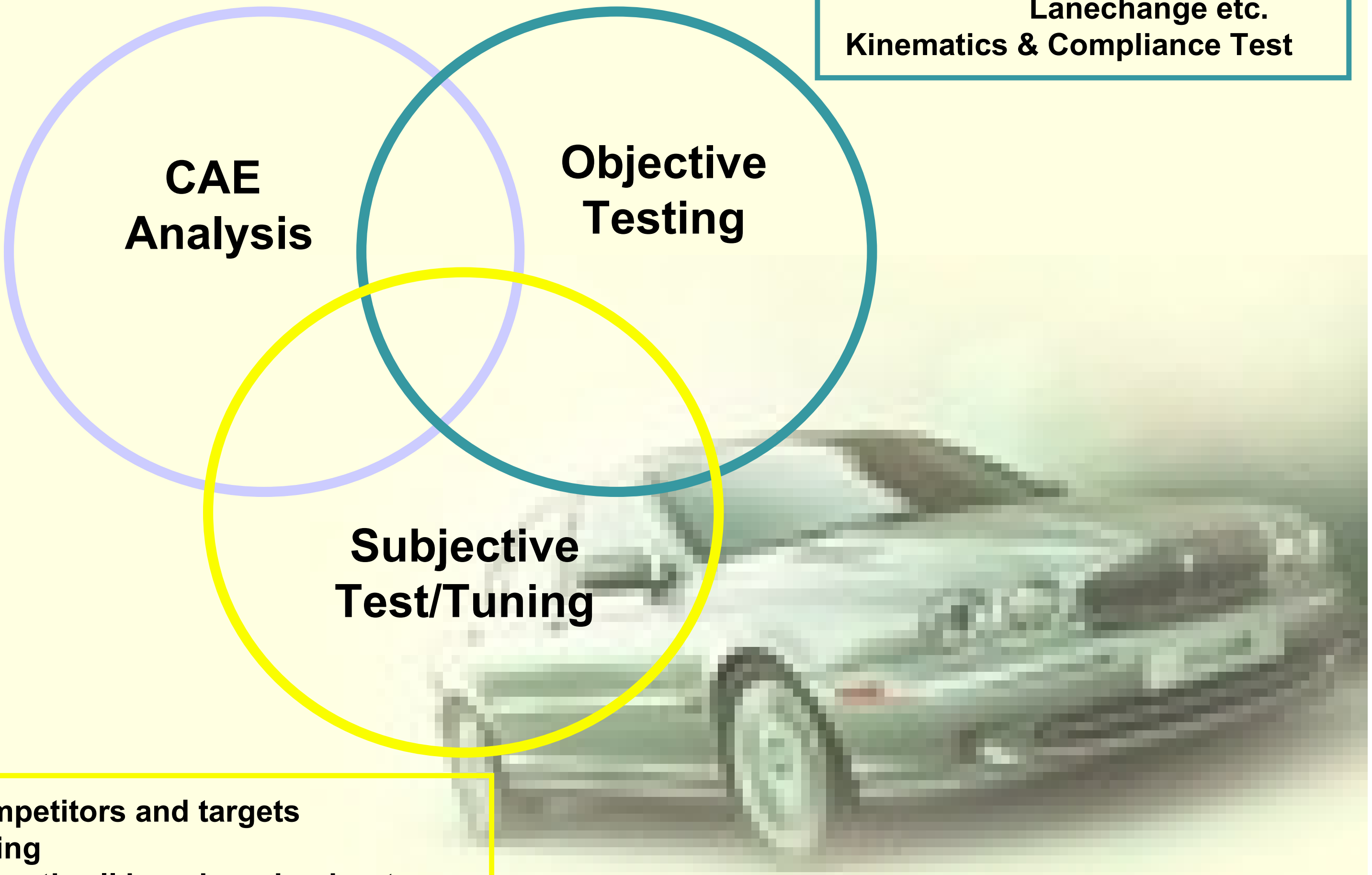
Assists target setting & cascade

System and subsystem selection

Match vehicle to targets

Provide initial setup before final tuning

Vehicle Dynamics Tests
e.g. Constant Radius, Lanechange etc.
Kinematics & Compliance Test



Initial identification of competitors and targets
final component level tuning
e.g. Spring/Damper rates, anti-roll bar sizes, bush rates.

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Main Applications of CAE during Development

- Target assessment with programme assumptions.
- Cascade targets to system/component level.
- Provide system design direction.
- Resolve conflicts & balance targets.
- Assist tuning phase.

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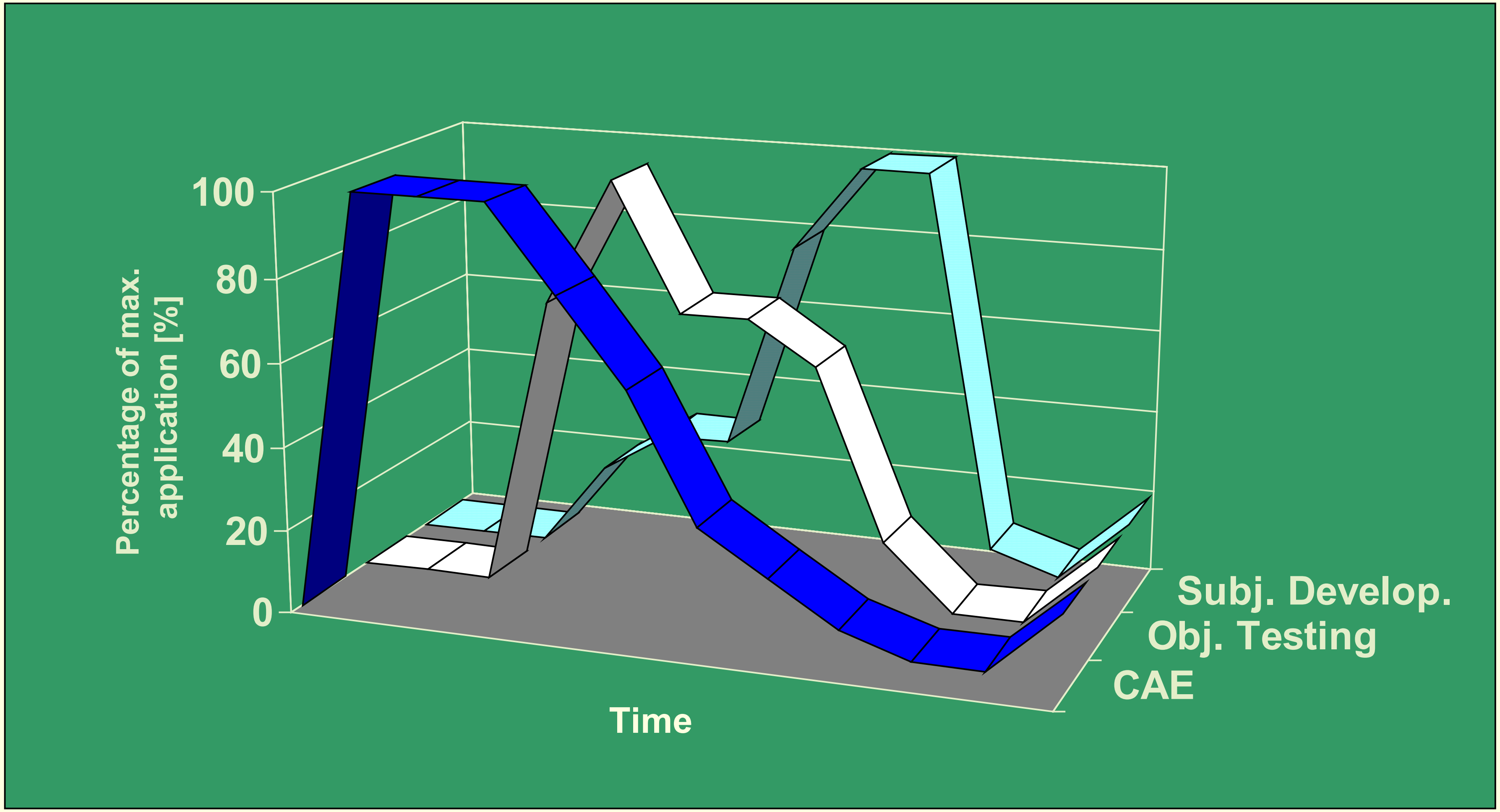
Vehicle Dynamics CAE

- Steering
- Handling
- Low Frequency Ride

Workload distribution during development



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CAE Tools in Vehicle Dynamics

- Excel
- Matlab/Simulink models

} Sanity & high level parameter checks, ADAMS model set up, target cascade.

- ADAMS Full vehicle models & DoE.

Note: Excel and Matlab models may be used before a Suspension and steering system has been selected.

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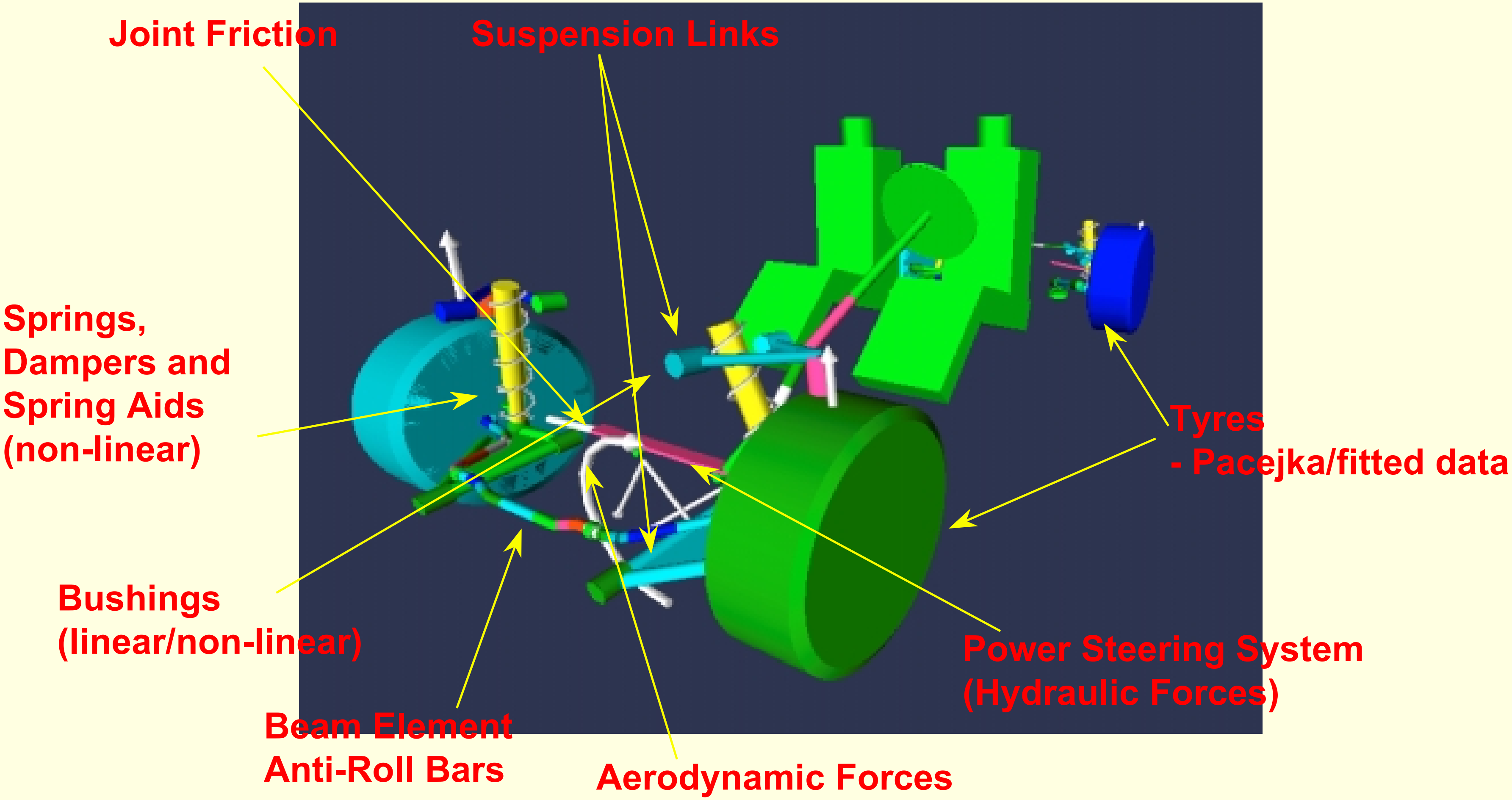
ADAMS Model Detail & Data Requirements



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Converting subjective assessments to objective data

Objective targets are essential if CAE is to be used effectively for vehicle dynamics development.

Example: Straight ahead controllability
– how does the vehicle respond to small steering inputs at different speeds?

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Converting subjective assessments to objective data

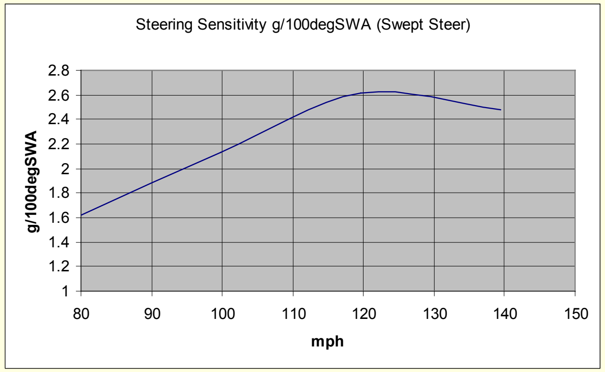
Drive Event
Own products + competitors

Subjective rating (1-10 VER scale)

Subjective rating – too fast/slow, just right.

Objective test – On-centre, swept steer vs. speed

Target Characteristic



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Converting subjective assessments to objective data

Steering Sensitivity= f(speed, wheelbase, understeer, steering ratio)

Usually programme assumptions

Understeer = f(suspension/steering characteristics, weight distribution, tyres, aero etc……)

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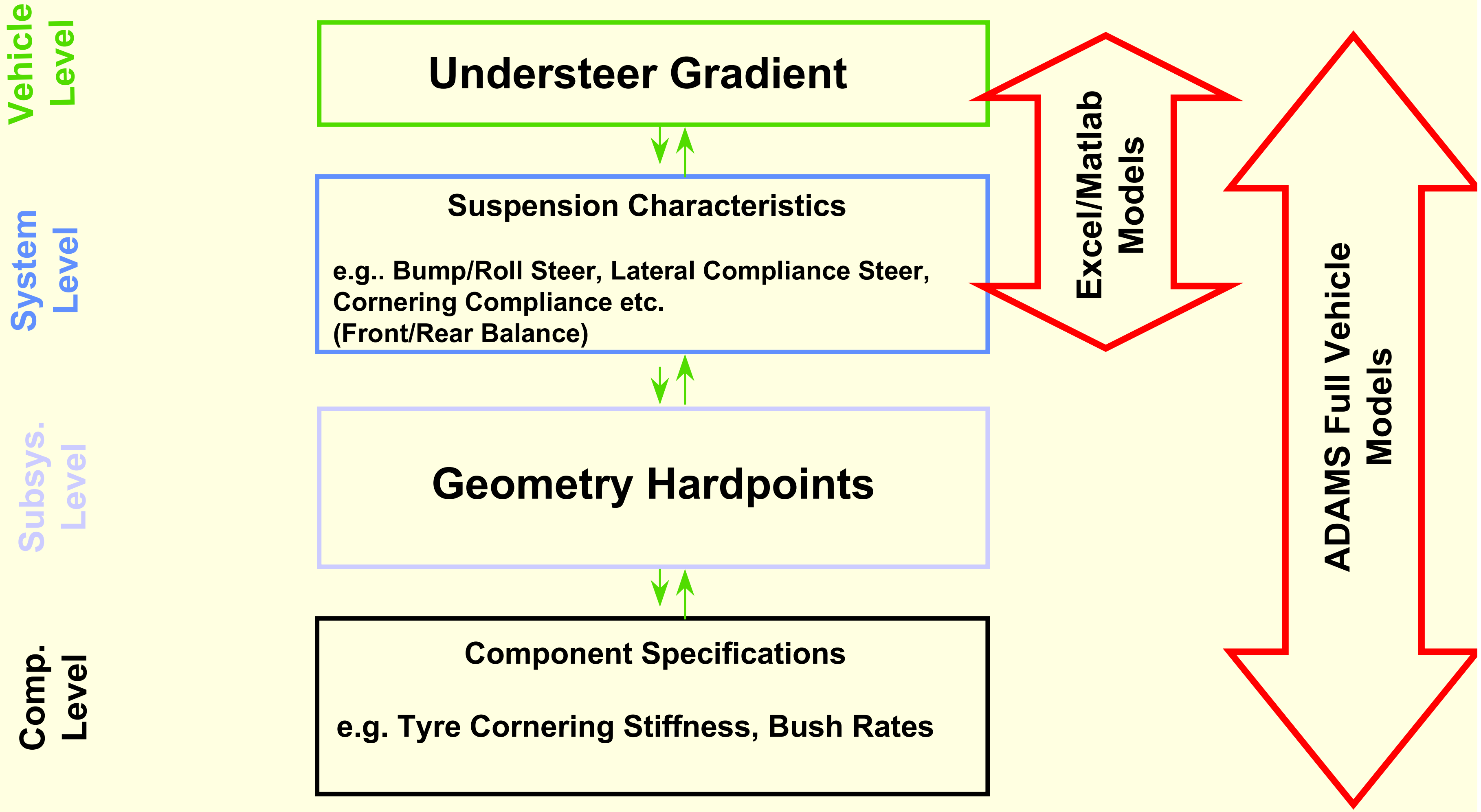
Target Cascade Example



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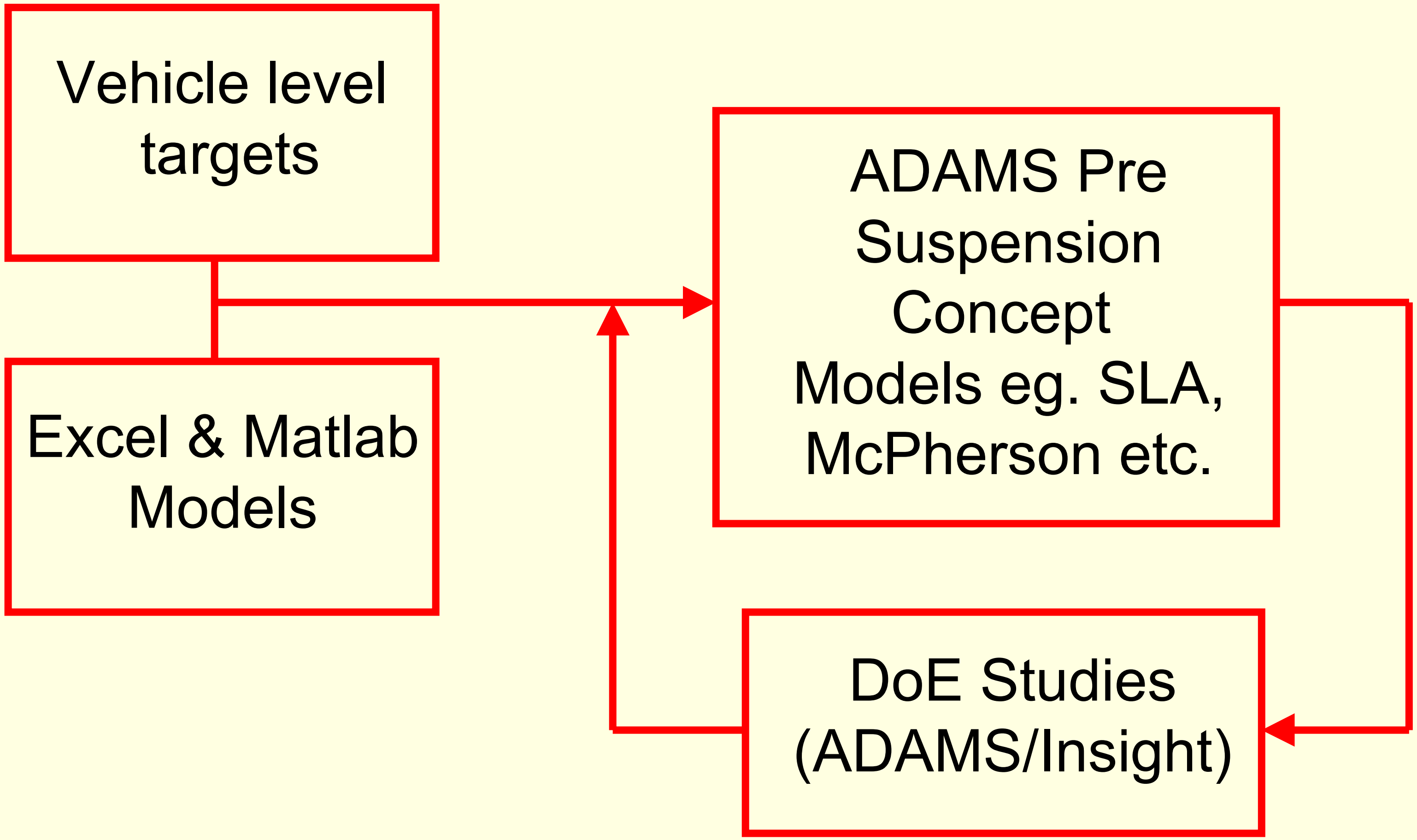
Up Front Concept Selection



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Balancing Targets

Build ADAMS full vehicle model based on programme assumptions

Run full set of simulations to verify targets can be achieved

Use multiple DoE using the same factors and 'linked' response surfaces.

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Full Vehicle Events (1) (steering & handling)

- Acc.controlled stop
- ADAMS/Driver
- Brake Drift
- **Brake in turn**
- **Constant radius**
- Cross wind
- Double lane change
- **Dynamic constant rad.**
- Fishhook
- **Frequency response**
- Hands free (flick test)
- J-Turn
- **Lane change**
- Moderate braking

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Full Vehicle Events (2) (steering & handling)

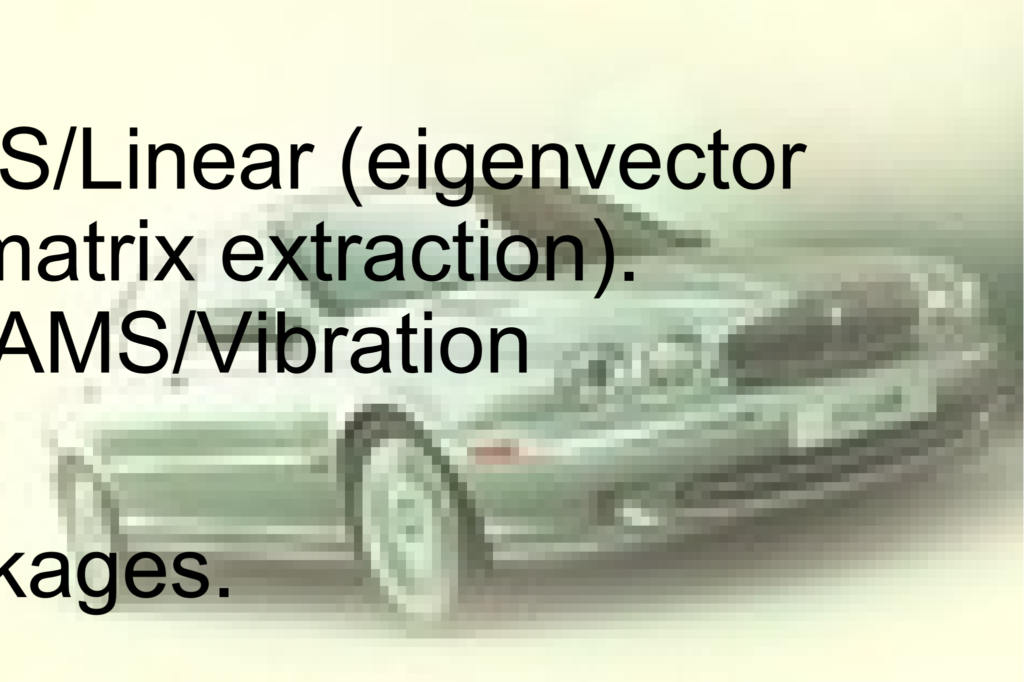
- **On-centre**
- Open loop braking
- **Parking Effort**
- Sine steer
- SDI
- Steady state drift
- Step steer
- **Straight line acc/decel**
- Straight line drive
- **Swept Steer**
- SVC
- **Throttle on/off in a turn**
- Tyre wear
- K&C (MTS Rig)
- **K&C (ABD Rig)**

Low Frequency Ride (<20Hz)

<5 Hz Time domain 3D road modelling.

5 to 20 Hz – ADAMS/Linear (eigenvector and state space matrix extraction). Converting to ADAMS/Vibration

>15 Hz – NVH Packages.



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Low Frequency Ride (5-20Hz)

ADAMS Pre vehicle dynamics model + plant input/outputs

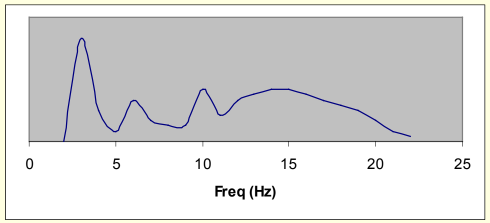
ADAMS /Linear

Eigenvector /value analysis

ABCD Matrices

Matlab Routines

FRFs



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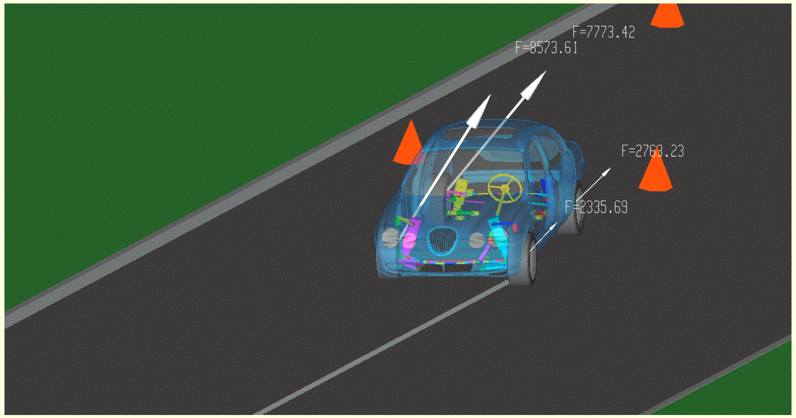
Chassis Control Systems

ADAMS Pre vehicle dynamics model + plant input/outputs



ADAMS /Control

Simulink Controller for ABS, Yaw control, Switchable dampers etc.

Co-simulation

Must have a controller algorithm from the system supplier.

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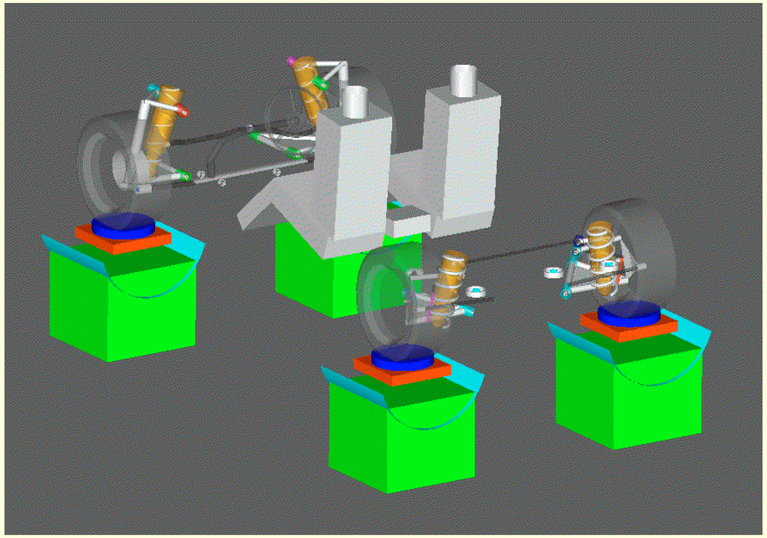
Correlation Methods

Kinematics & Compliance Rig



Objective Vehicle
Dynamics Testing

Plus Mass/Inertia, Tyre & Component Tests

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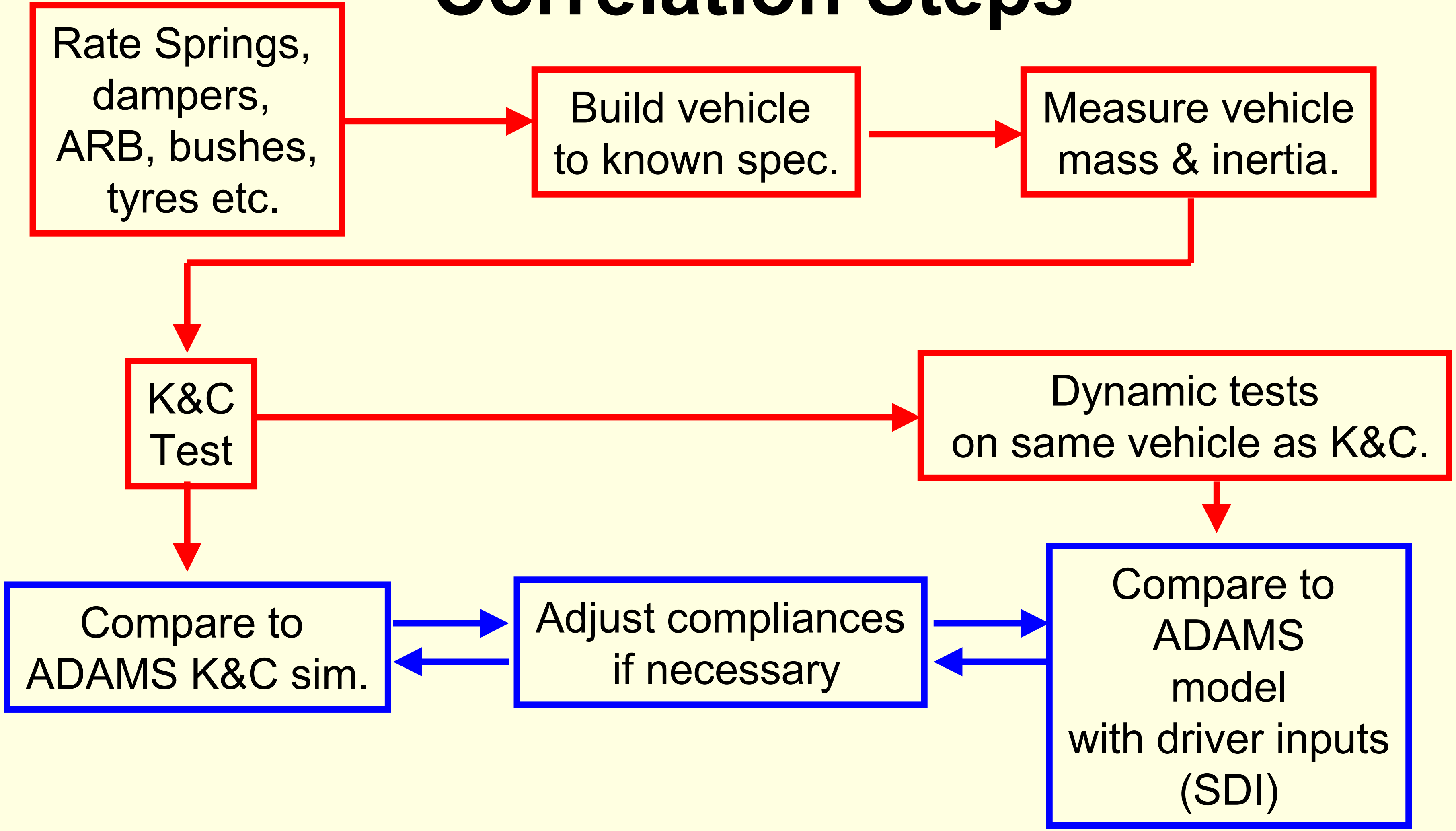
Correlation Steps



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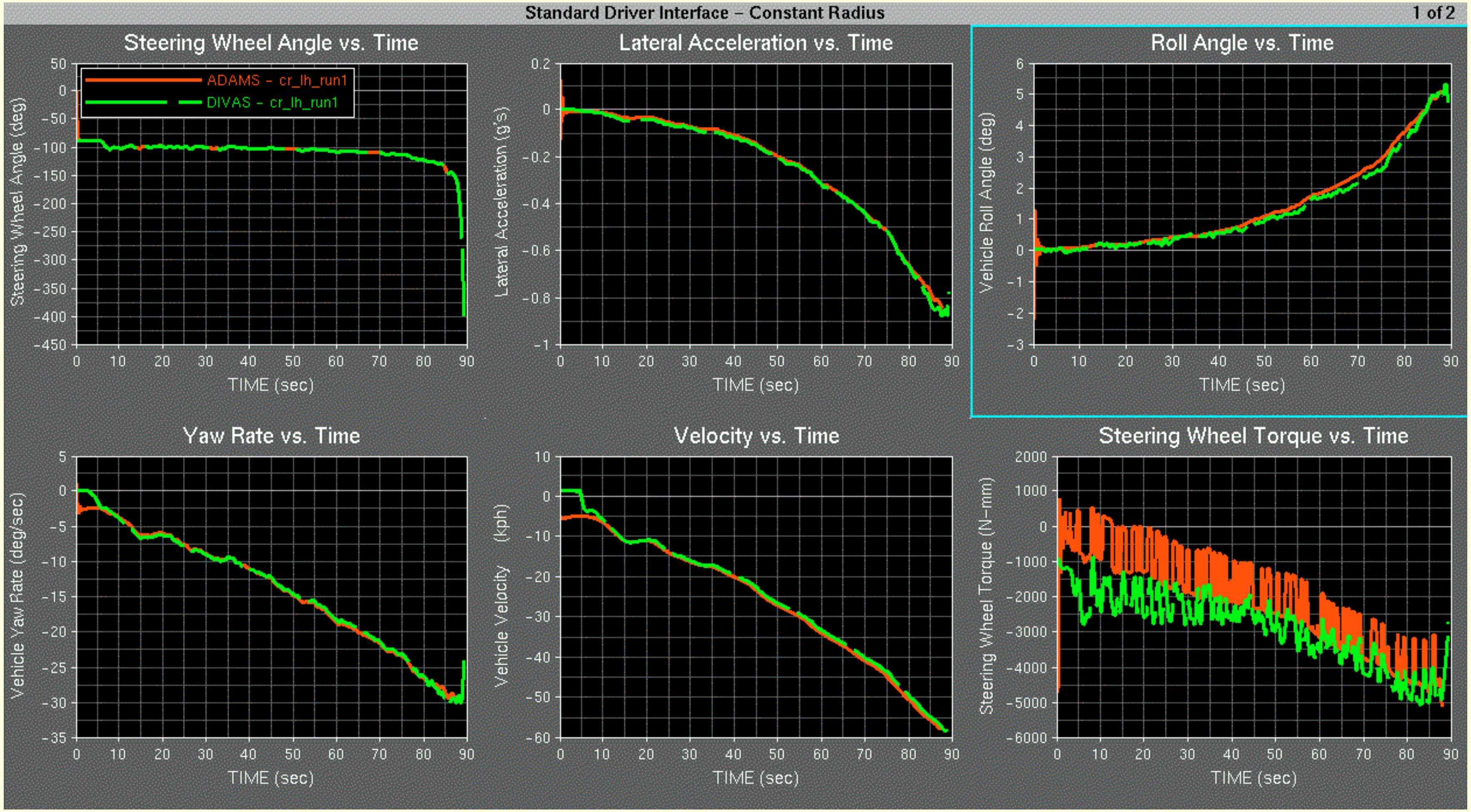
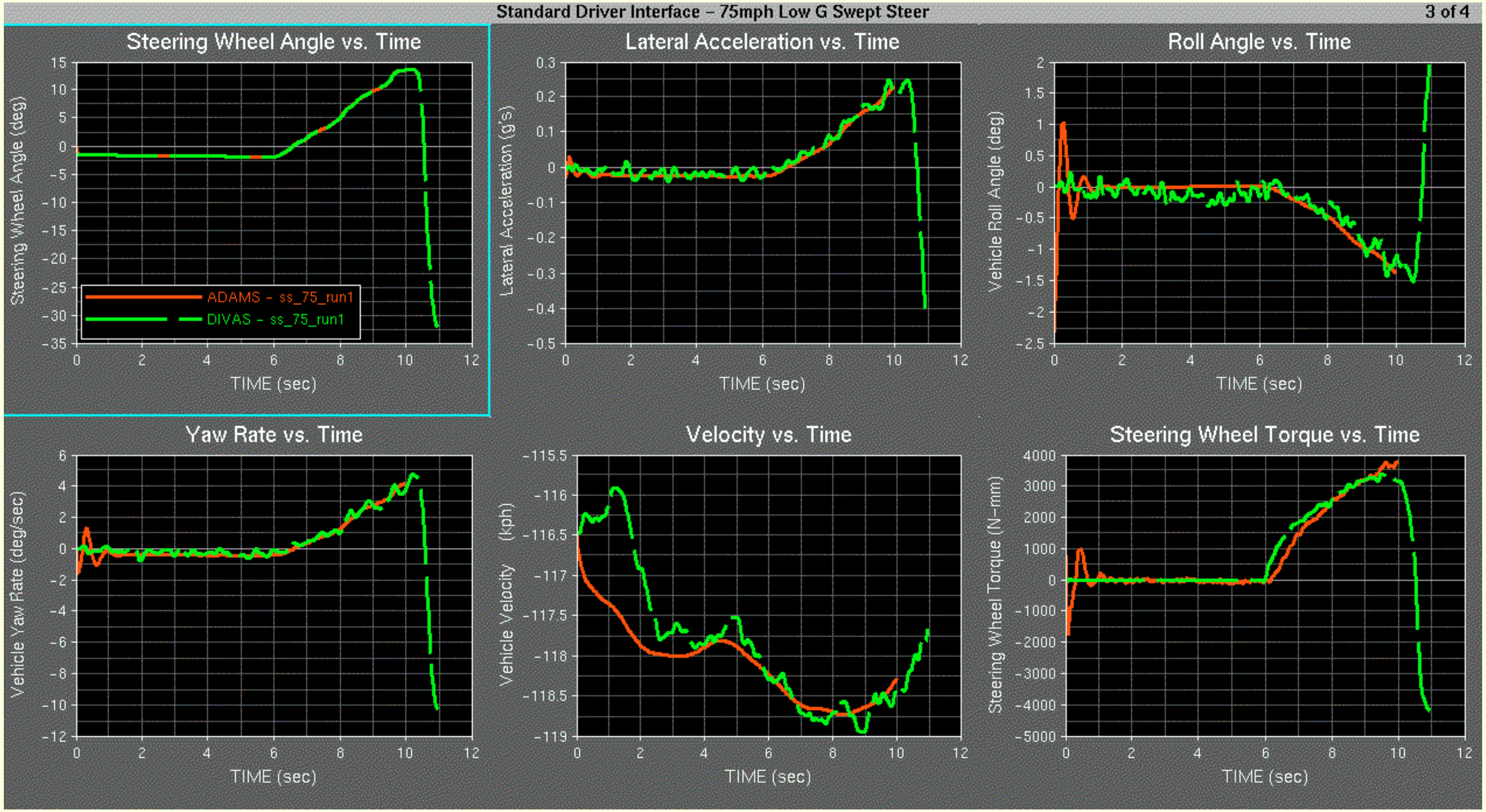
Correlation

30m Constant Radius



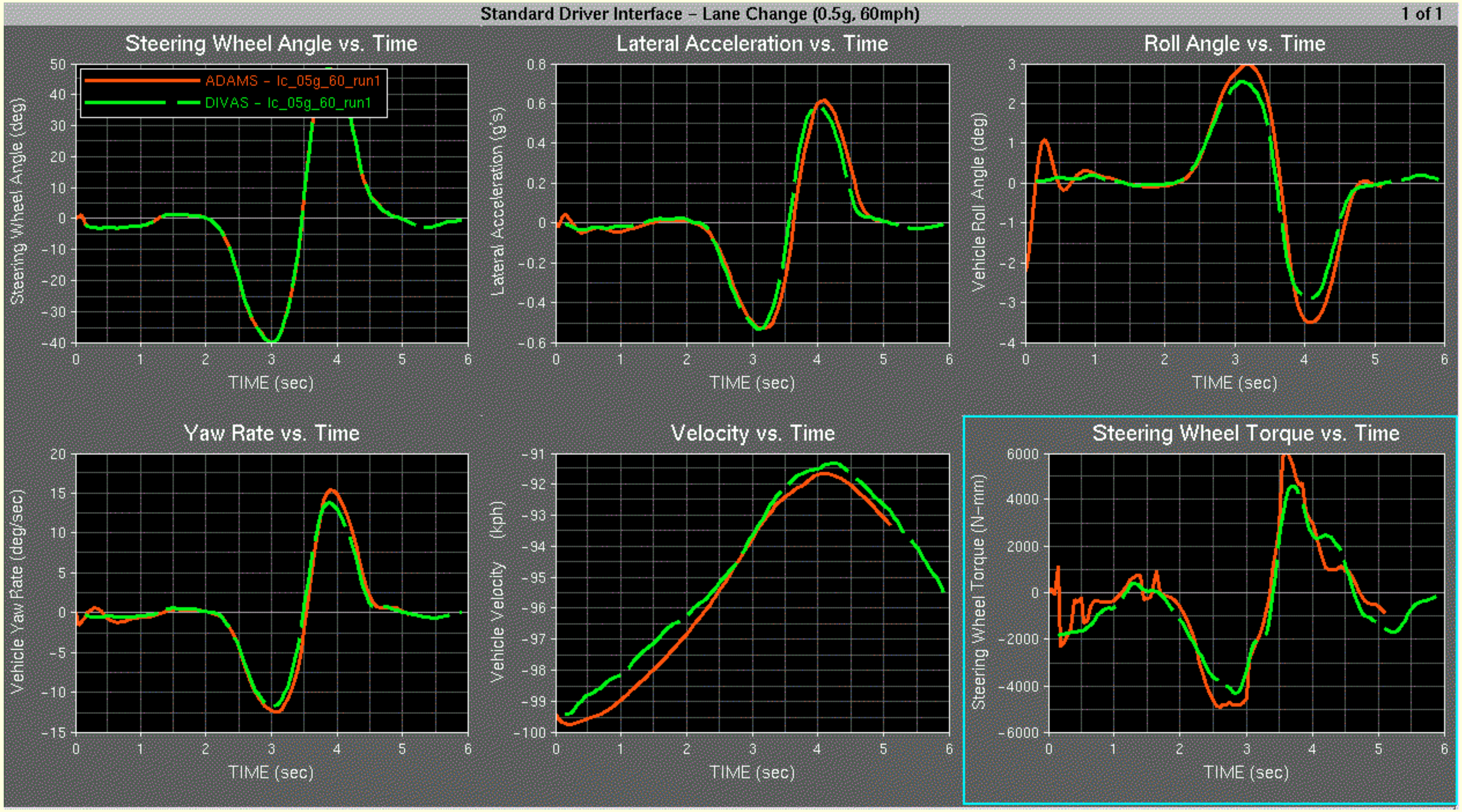
Correlation

75 mph[121km/h] low g swept steer



Correlation

0.5g 62mph [100km/h] lane change



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Correlation Issues

1. Steering wheel torque.

   Lack of hysteresis – Hydraulic, friction and distribution though PAS system. Tyres.

- Frequency Response (higher frequency)

  Roll and yaw gains underdamped – tyres mainly.

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Correlation Issues

- Low frequency time domain analysis – suspension friction (balljoints, dampers etc.) and frequency dependant bushings.

- <u>The models are only as good as the data supplied.</u>

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Conclusions

- Vehicle dynamics CAE is applied in many areas of the programme.

  Target setting & verification.

  Target cascade.

  System & component choice including control systems.

  System design.

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Conclusions (Continued)

- Close links to objective and rig testing are vital for accuracy.
- Close working relationship with subjective development areas to maximise CAE use.
- It is necessary to understand the models’ limitations.