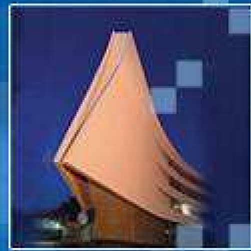
SANRAL:

Simulation of Vehicle Dynamics



Wynand JvdM Steyn

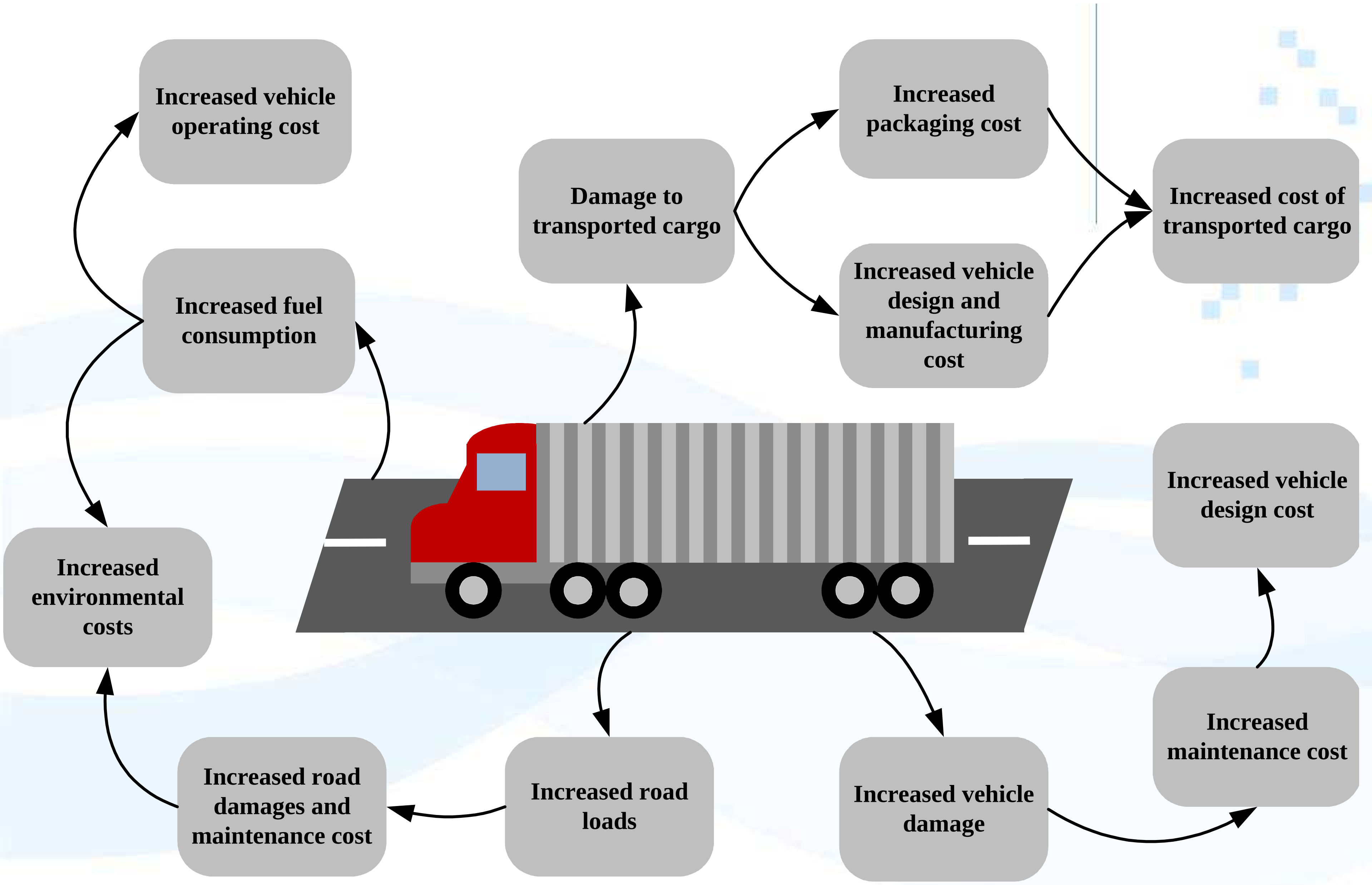
What is the problem

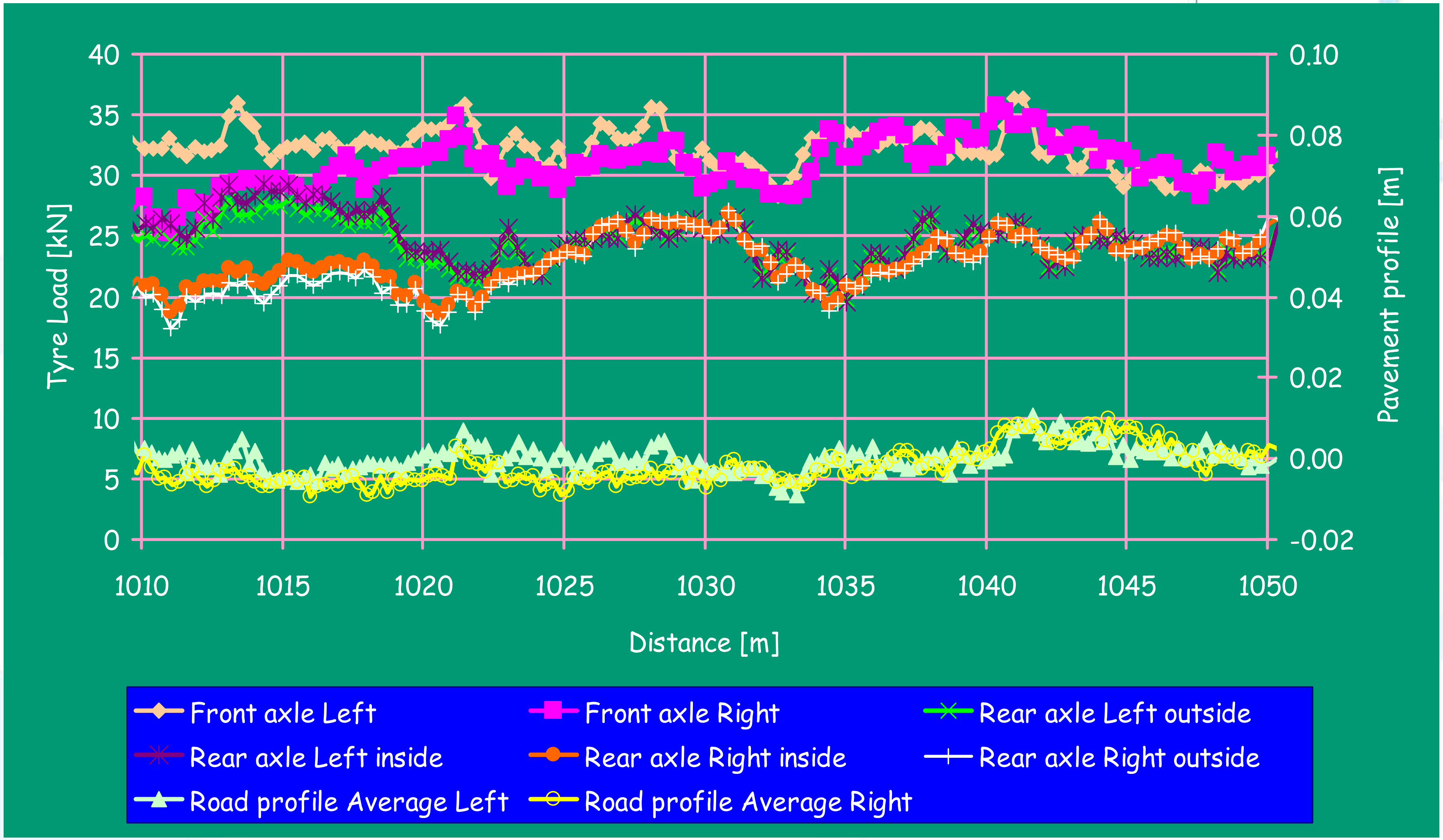
- Roads are not flat
- Uneven roads cause Moving Dynamic Loads (MDL)
- MDL cause range of loads on roads

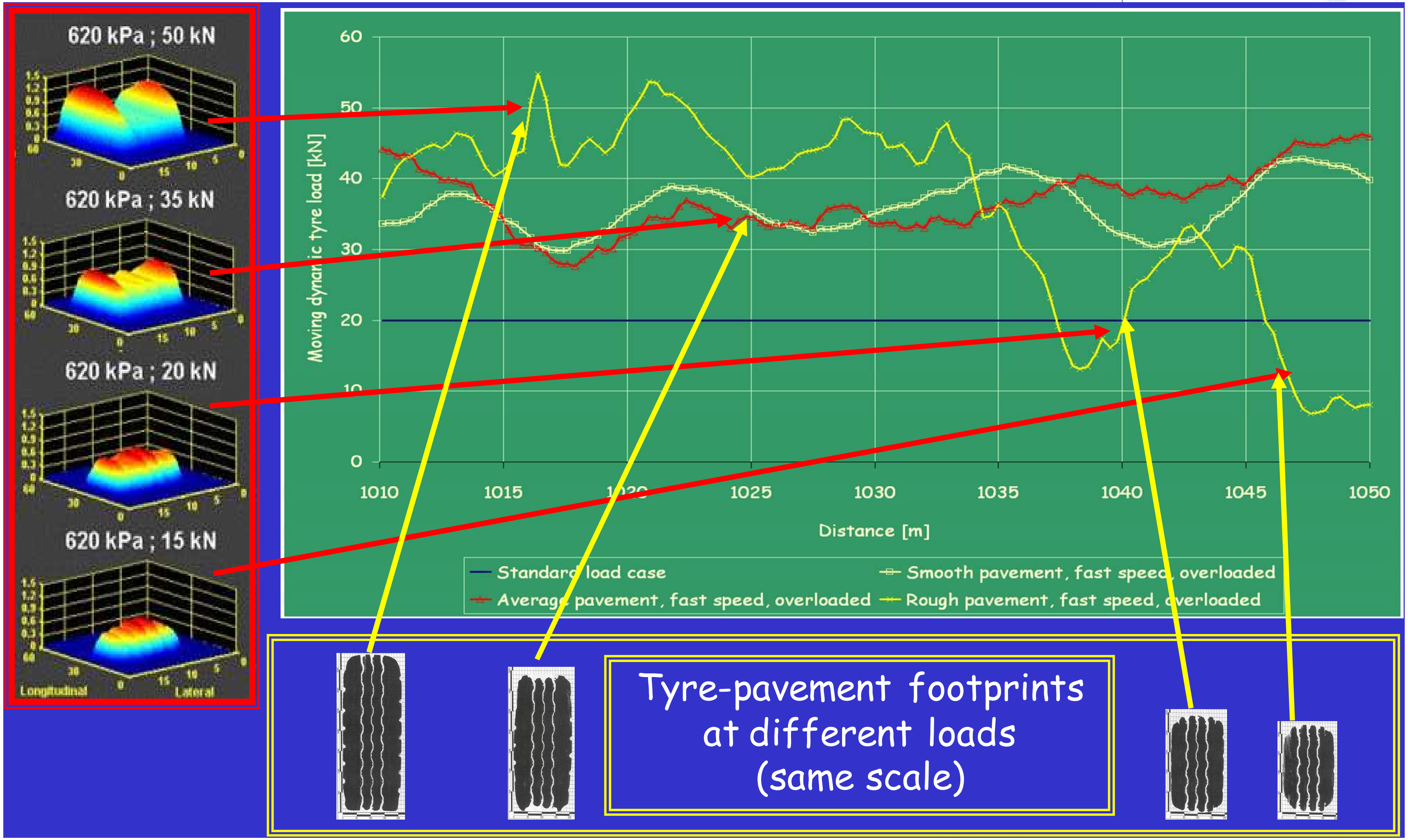
- What do we design for?

SANRAL project focus & background

- Part of overall SANRAL project
- Focus on improved definition of the traffic loads
- Process
  - Simulate trucks on range of roads
  - Analyse outputs
  - Develop relationships
  - Apply in design and analysis
- Outside this presentation scope
  - WIM data, traffic counts, Tyre contact stresses


Increased vehicle operating cost
Damage to transported cargo
Increased packaging cost
Increased cost of transported cargo
Increased vehicle design and manufacturing cost
Increased fuel consumption
Increased vehicle design cost
Increased environmental costs
Increased maintenance cost
Increased road damages and maintenance cost
Increased road loads
Increased vehicle damage


Tyre Load [kN]
Pavement profile [m]
Distance [m]
40
35
30
25
20
15
10
5
0
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
1010
1015
1020
1025
1030
1035
1040
1045
1050
Front axle Left
Front axle Right
Rear axle Left outside
Rear axle Left inside
Rear axle Right inside
Rear axle Right outside
Road profile Average Left
Road profile Average Right



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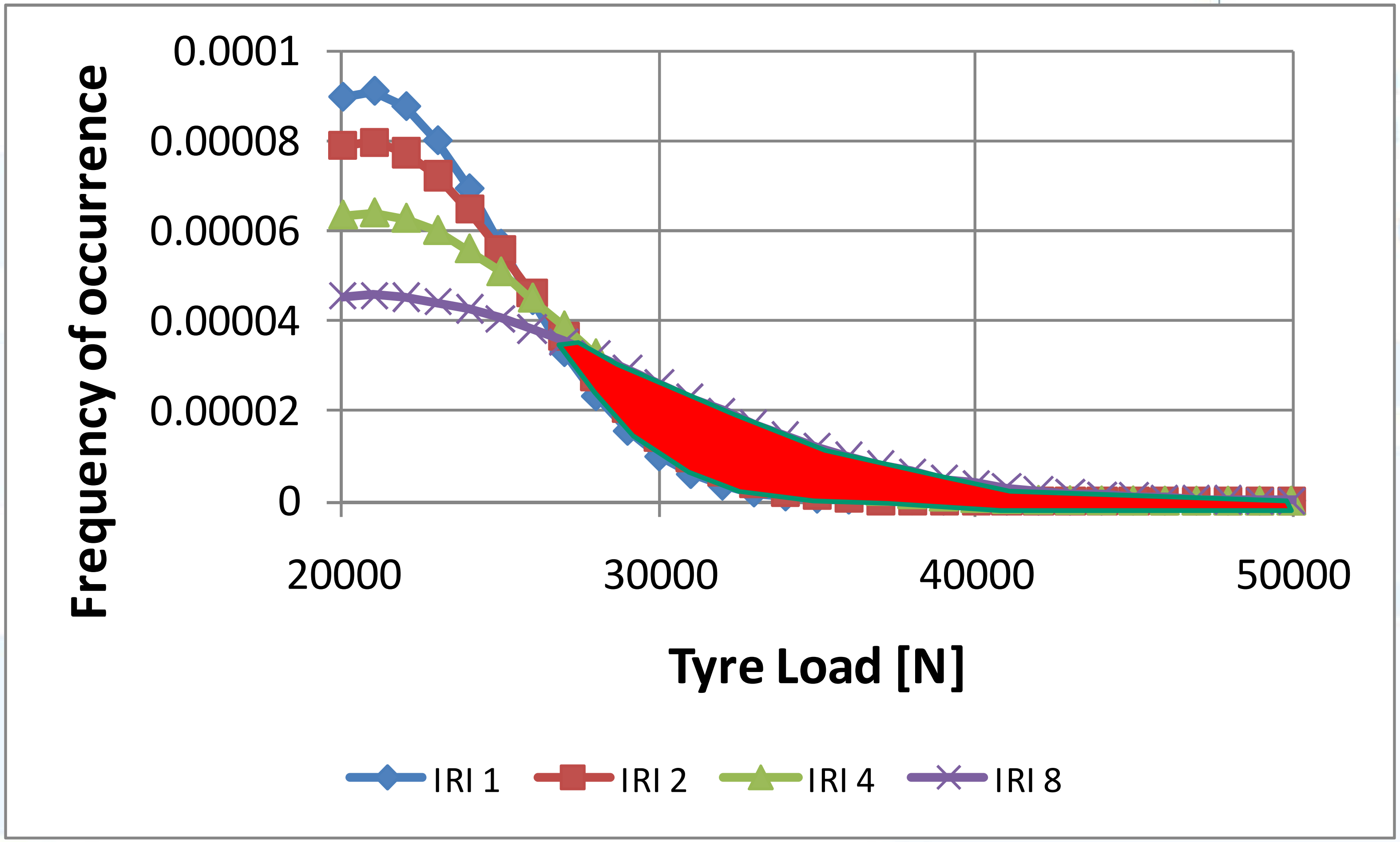
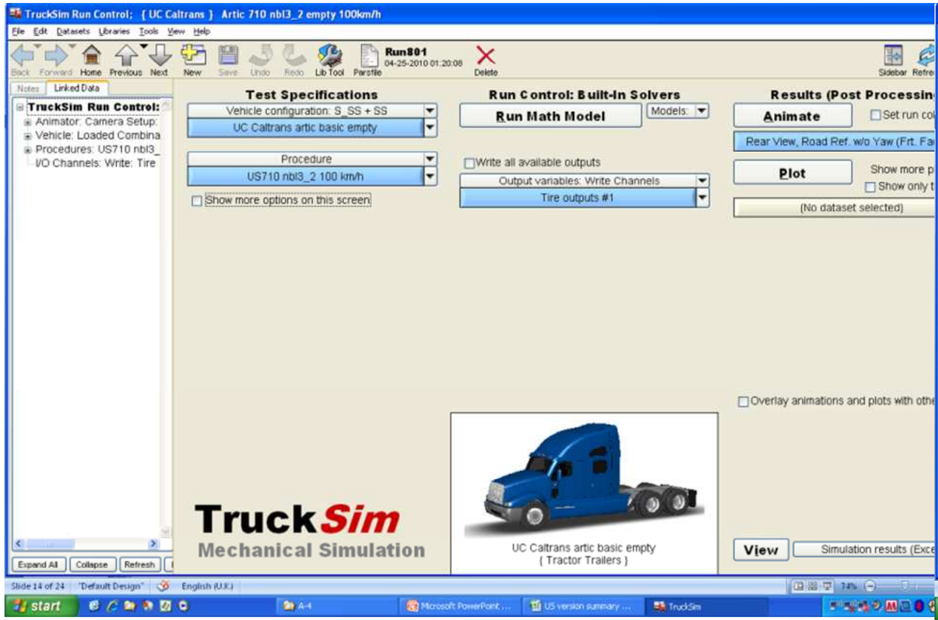
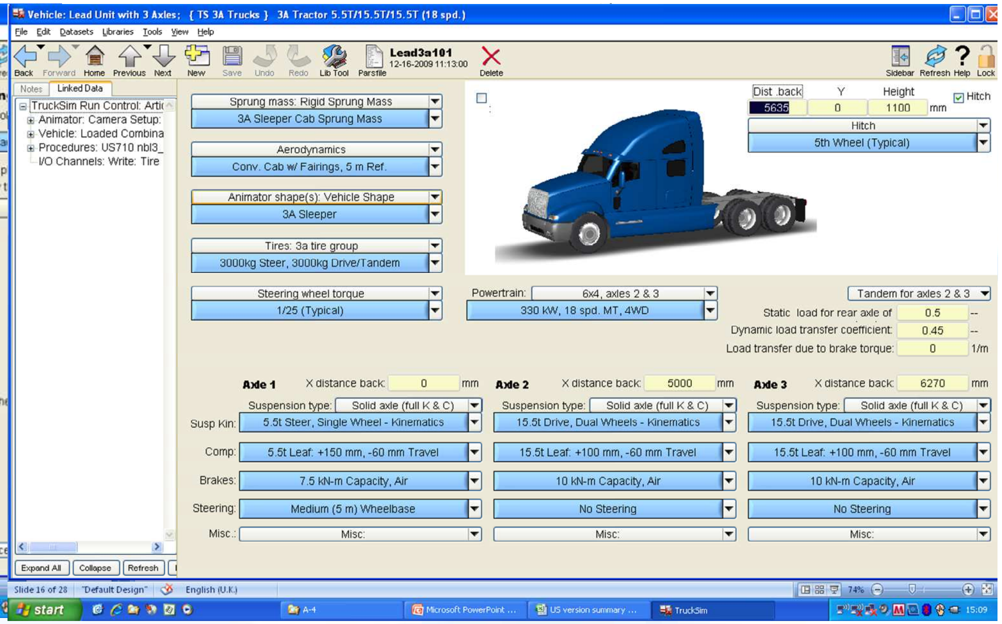
Riding quality vs Tyre loads

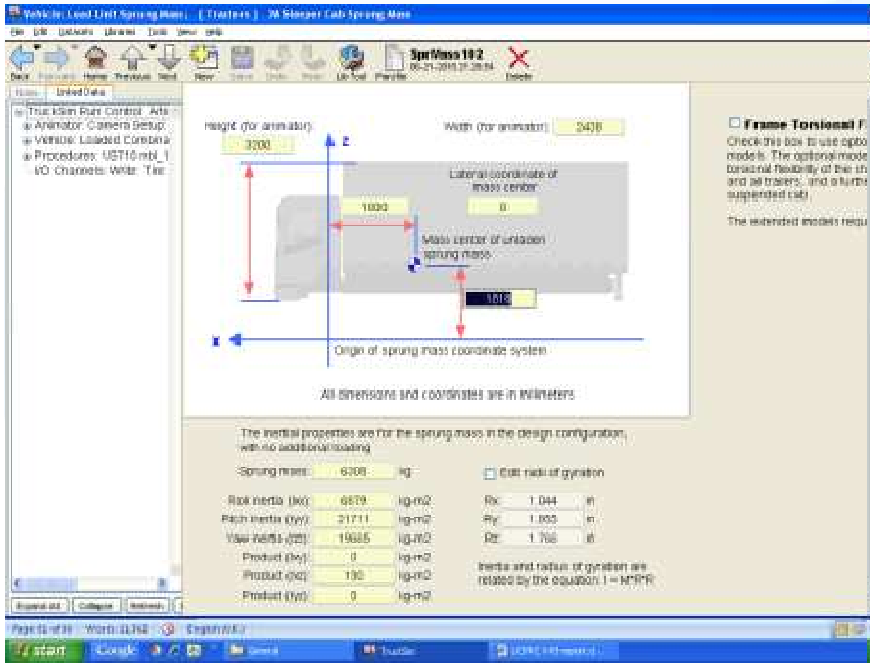


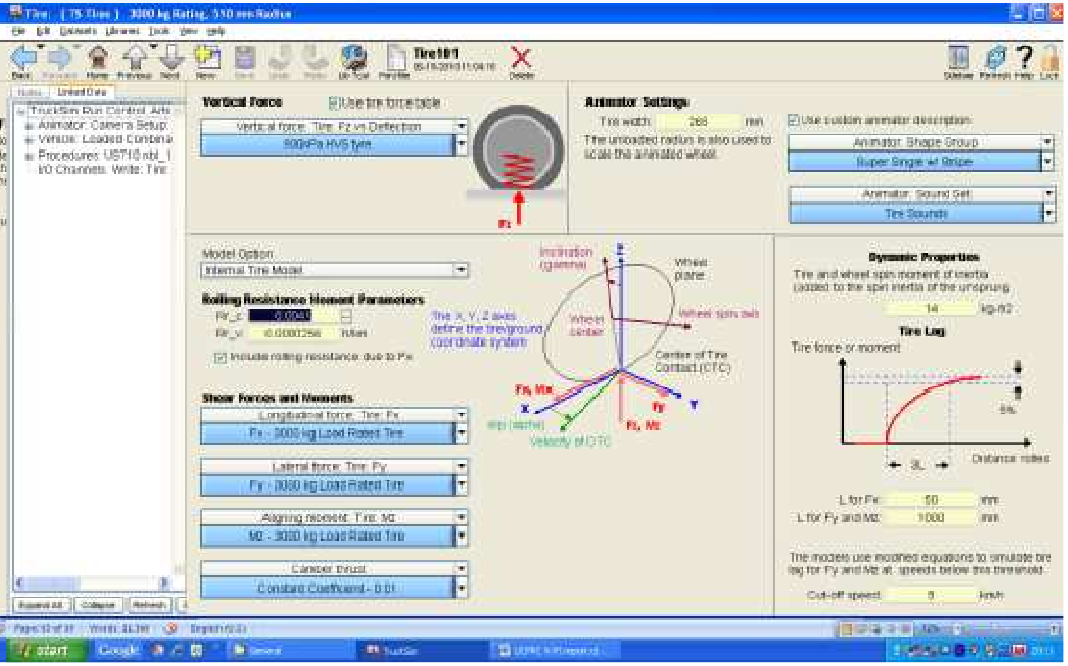
Simulation process

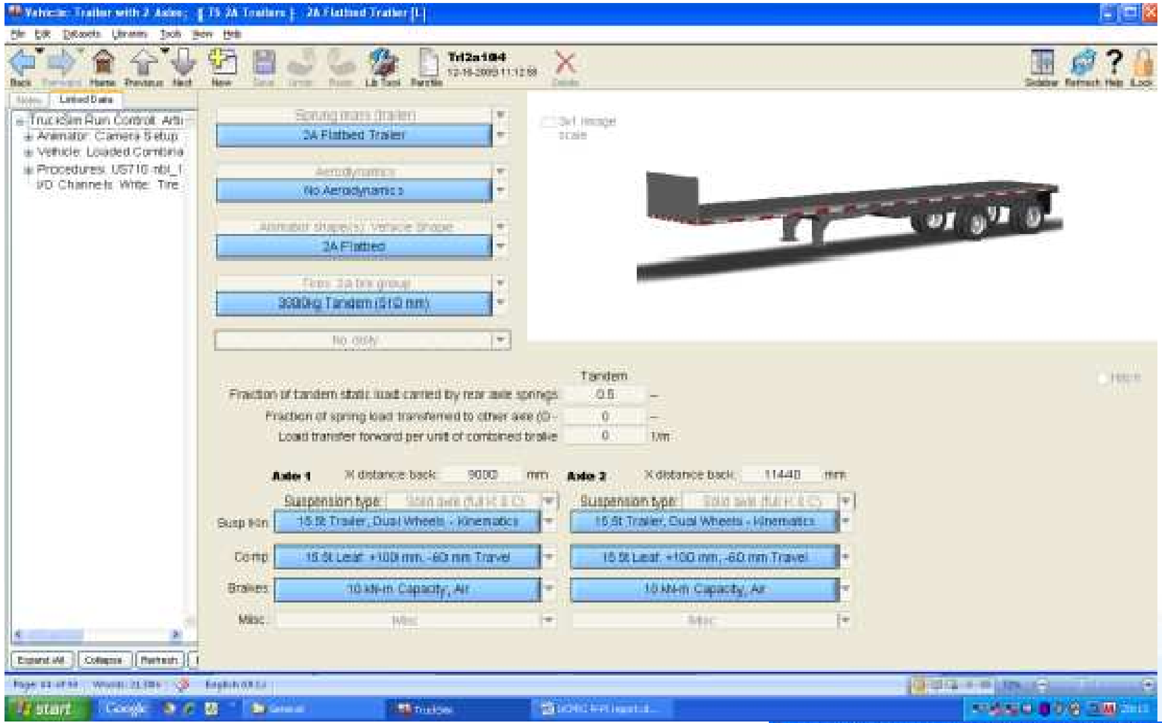
- Use TruckSIM
- Simulates vehicle travelling on pavement profile
- Well developed and calibrated

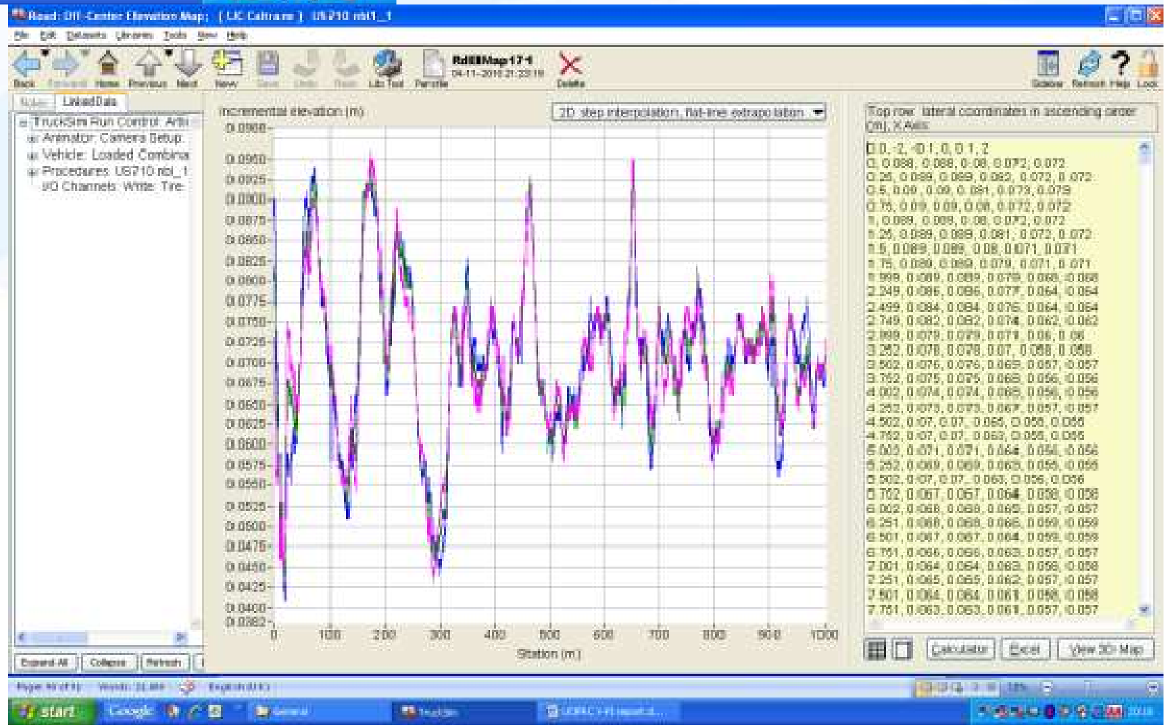

TruckSim Run Control; { UC Caltrans } Artic 710 nbl3_2 empty 100km/h
Run801
Test Specifications
Vehicle configuration: S_SS + SS
UC Caltrans artic basic empty
Procedure
US710 nbl3_2 100 km/h
Show more options on this screen
Run Control: Built-In Solvers
Run Math Model
Write all available outputs
Output variables: Write Channels
Tire outputs #1
Results (Post Processing)
Animate
Rear View, Road Ref. w/o Yaw (Frt. Fa
Plot
(No dataset selected)
Overlay animations and plots with othe
TruckSim
Mechanical Simulation
UC Caltrans artic basic empty
{ Tractor Trailers }
View
Simulation results (Exce


Vehicle: Lead Unit with 3 Axles; { TS 3A Trucks } 3A Tractor 5.5T/15.5T/15.5T (18 spd.)
Lead3a101
Sprung mass: Rigid Sprung Mass
3A Sleeper Cab Sprung Mass
Aerodynamics
Conv. Cab w/ Fairings, 5 m Ref.
Animator shape(s): Vehicle Shape
3A Sleeper
Tires: 3a tire group
3000kg Steer, 3000kg Drive/Tandem
Steering wheel torque
1/25 (Typical)
Dist. back
Height
Hitch
5635
0
1100
mm
5th Wheel (Typical)
Powertrain:
6x4, axles 2 & 3
330 kW, 18 spd. MT, 4WD
Tandem for axles 2 & 3
Static load for rear axle of
0.5
Dynamic load transfer coefficient
0.45
Load transfer due to brake torque:
0
1/m
Axle 1
X distance back
0
mm
Axle 2
5000
Axle 3
6270
Suspension type:
Solid axle (full K & C)
Susp Kin:
5.5t Steer, Single Wheel - Kinematics
15.5t Drive, Dual Wheels - Kinematics
Comp:
5.5t Leaf: +150 mm, -60 mm Travel
15.5t Leaf: +100 mm, -60 mm Travel
Brakes:
7.5 kN-m Capacity, Air
10 kN-m Capacity, Air
Steering:
Medium (5 m) Wheelbase
No Steering
Misc.:


Height (for animator)
3200
Width (for animator)
2438
Lateral coordinate of mass center
1000
0
Mass center of unladen sprung mass
1518
Origin of sprung mass coordinate system
All dimensions and coordinates are in millimeters
Frame Torsional F
The inertial properties are for the sprung mass in the design configuration, with no additional loading
Sprung mass:
6308
kg
Roll inertia (Ixx):
6879
kg-m2
Pitch inertia (Iyy):
21711
Yaw inertia (Izz):
19685
Rx:
1.044
Ry:
1.855
Rz:
1.766


Tire101
Vertical Force
Model Option
Internal Tire Model
Rolling Resistance Moment Parameters
Shear Forces and Moments
Longitudinal force: Tire Fx
Lateral force: Tire Fy
Aligning moment: Tire Mz
Camber thrust
Animator Settings
Tire width
268
mm
Dynamic Properties
14
Tire Lag
L for Fx
50
L for Fy and Mz
1000
Cut-off speed
5





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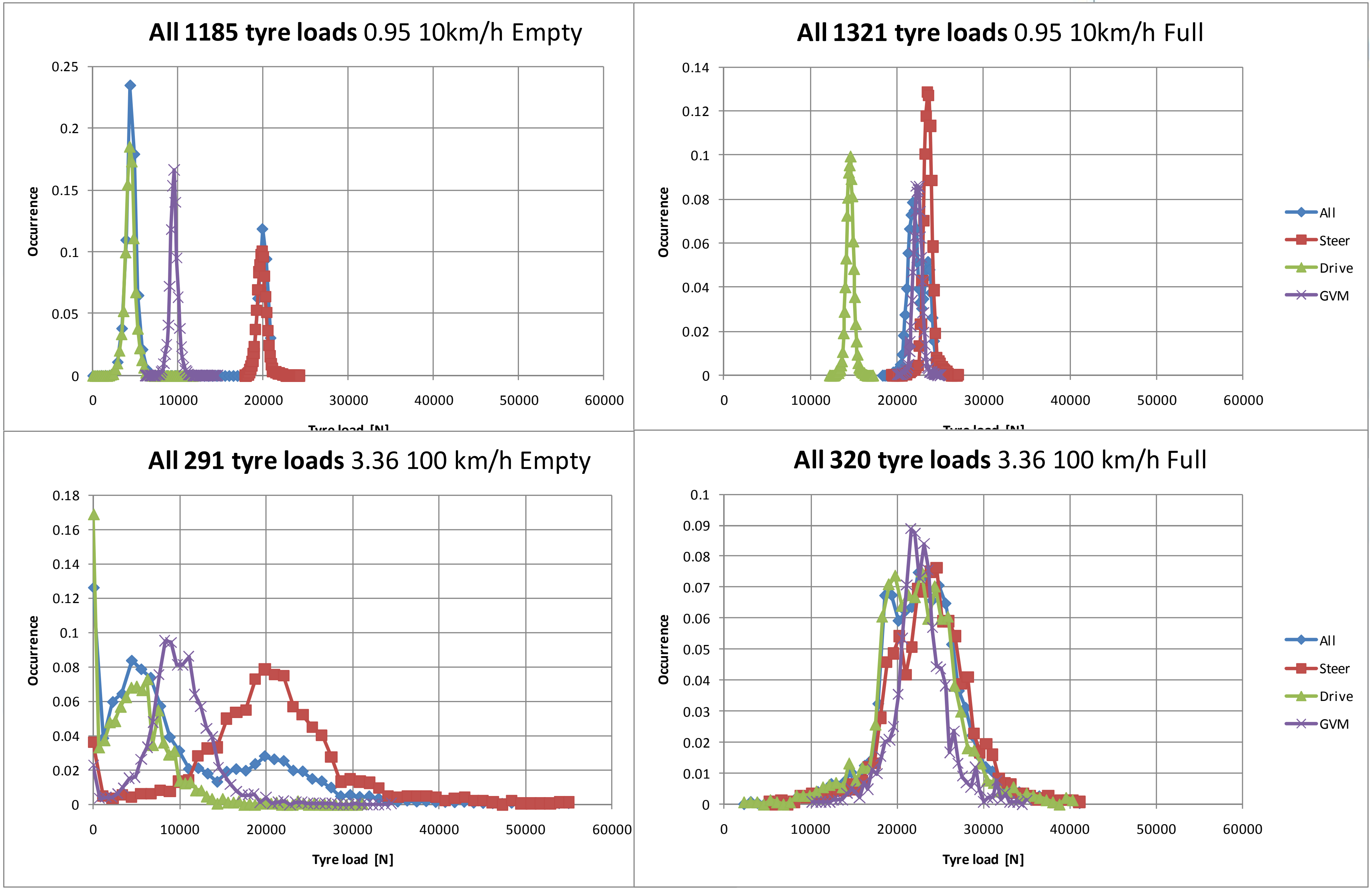
Matrix

- Rigid, Articulated, Interlink
- Empty, full, 10% overloaded
- 10, 40, 80, 100 km/h
- IRI range – (0) 1.07 to 3.71 m/km

Tyre load comparisons Rigid (axles converted to tyres)



Initial relationships for Rigid

- Relationships for tyres, axles, axle groups, vehicles

- **CoV** = -0.0643 + 0.0198***HRI** + 0.0058***Speed** - 1.2152E-07***GVM** - 5.2393E-07***Load**
  - R^2 = 98.6 per cent; SE = 0.03

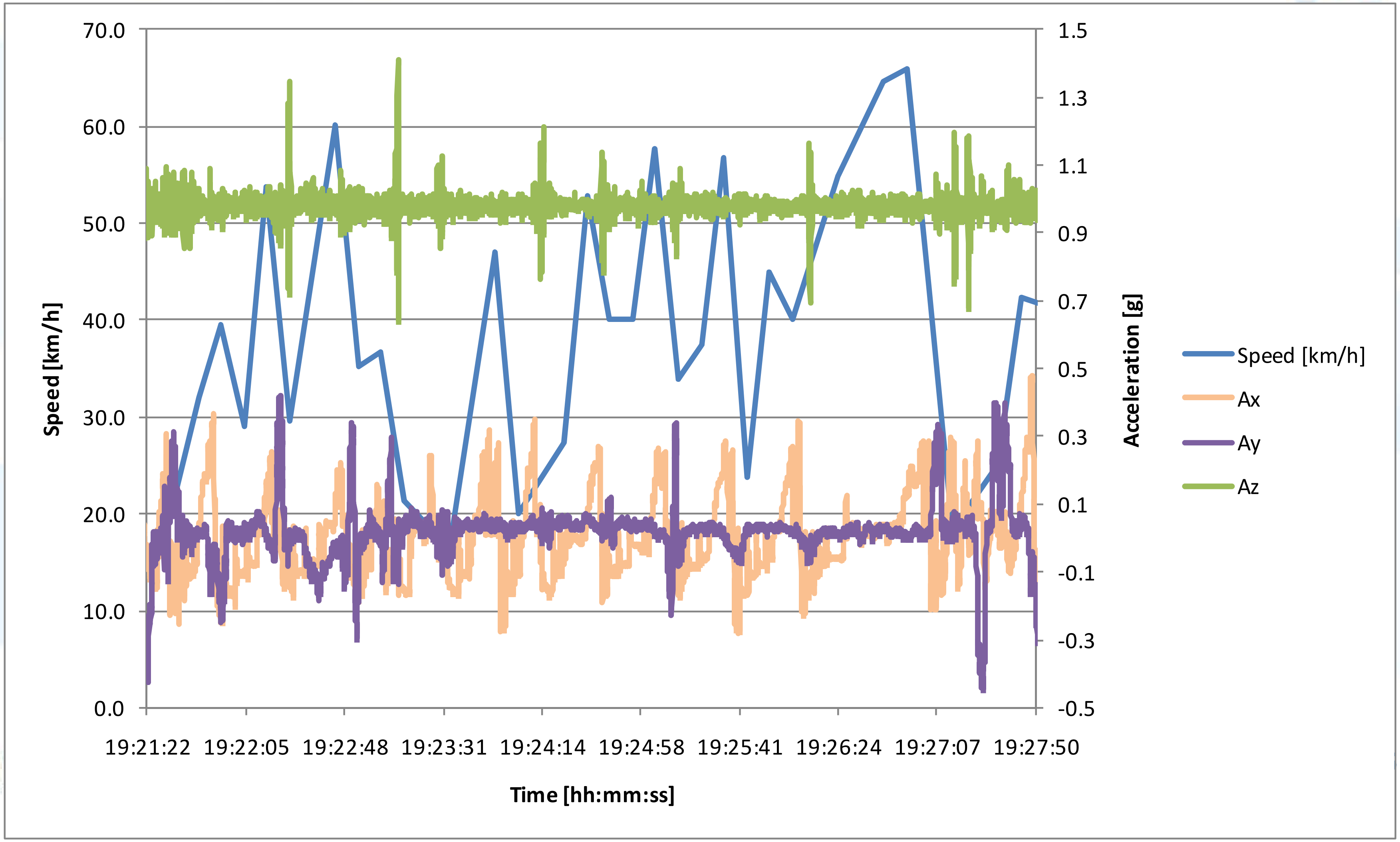
- **Ave** = 36086.112 + 0.533***HRI** - 101.623***Speed** + 0.5210***GVM/wheel** - 0.0221***Load**
  - R^2 = 99.7 per cent; SE = 336.420

Proposed process

- Measure actual traffic on a spot (WIM)
- Convert to static through WIM calibration
- Use as input together with speed, vehicle type, road roughness and relationships to predict expected MDL per axle type
- Select data from distribution for iterative Monte Carlo analysis in pavement design

Cargo accelerations due to road profile

- State of Logistics issues



Conclusions

- Riding quality of roads deteriorate with use leading to changes in road profile
- Increases in road roughness leads to increased dynamic loads and increased number of higher-than-average tyre loads
- Changing riding quality affects design and analysis loads over lifetime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