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## **Annex Q – CSIR – SOUTH AFRICAN MOBILITY PREDICTION SOFTWARE MOBSIM**

**Note:** This Annex appears in its original format.



# South African Mobility Prediction Software MOBSIM

NATO CSO CDT-308  
Keweenaw Research Centre MI USA  
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JD Reinecke, D. Modungwa and P. Nkosi



**ARMSCOR**  
Armaments Corporation of South Africa SOC Ltd

**CSIR**  
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# 1 Introduction to Armscor and CSIR

Defence Evaluation and Research Institute (DERI)

## ➤ Armscor

- Armscor Acquisition
- Armscor R&D

## ➤ Council for Scientific and Industrial Research (CSIR)

- Built environment (soils / hydrology, paving etc.), Natural Environment, Energy, Health, Industry (Mining, Advanced Manufacturing) and ***Defence Peace, Safety and Security***

## ➤ Industry (limited technology specific areas)

- Denel (DLS (including Mechem, DVS, LMT), Aviation etc.)
- Rheinmetall Denel Munition (RDM)



# 2 MOBSIM History

- Operational Guerrilla Warfare from 1960's
- Large number of landmine incidents (ca 1 000= pa)
- Developed local range of successful vehicles (Sanctions)
- Large mobility research effort from late 1970's to early 1990's
- Outputs Combined (MOBSIM) late 1990's and last update 2006



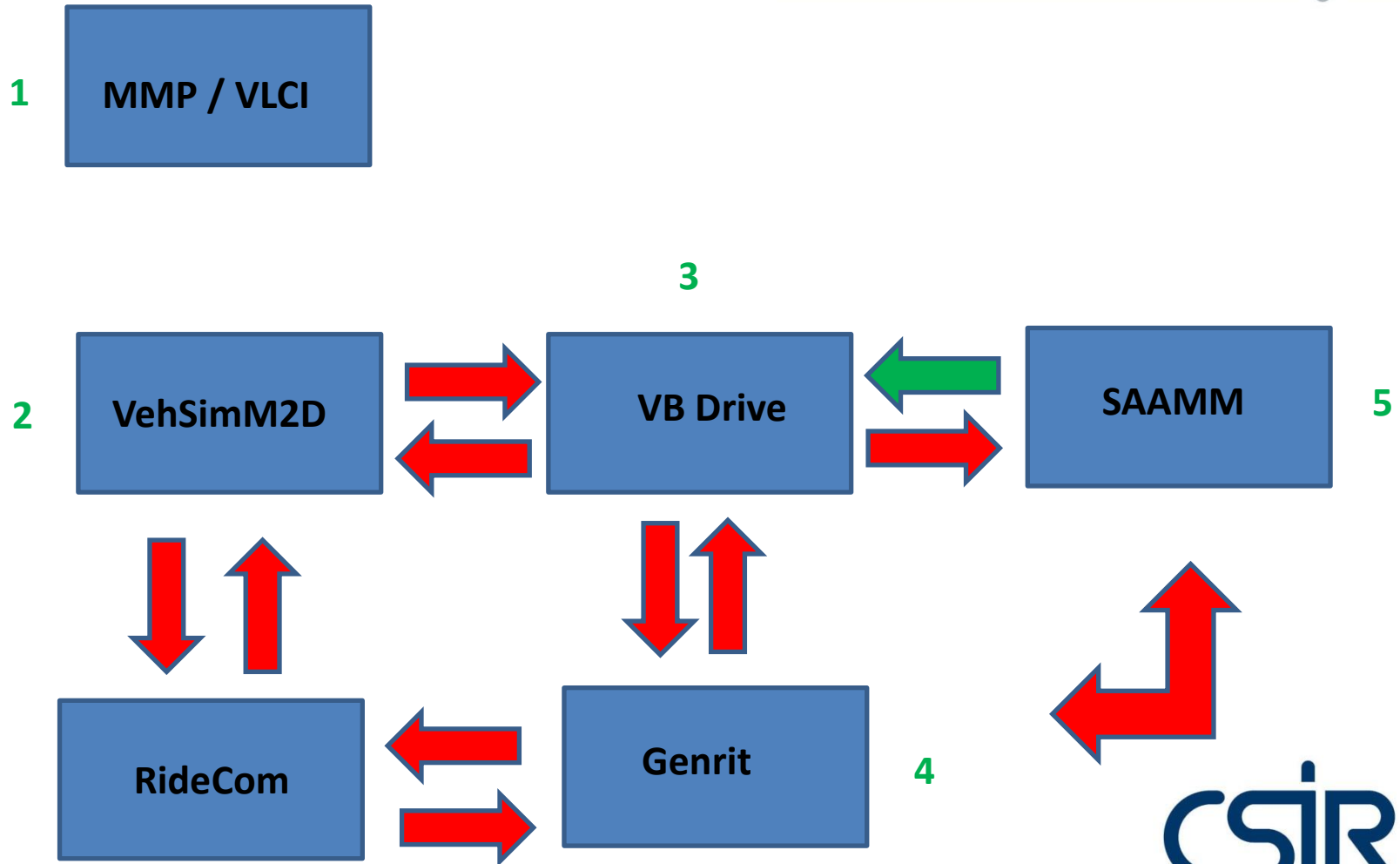
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# 3 MOBSIM Structure



# 3 MOBSIM Structure





# 4. MMPSIM

Mean Maximum pressure calculator : C:\...\CDT\_FED\_CPG.mmp

File Help

**Wheeled vehicles** | Tracked vehicles

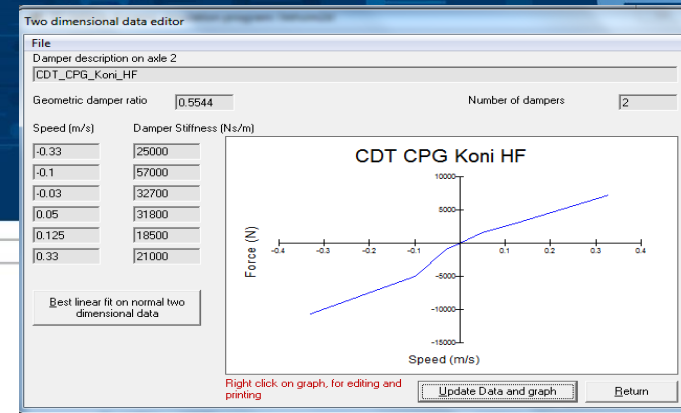
Vehicle description: CDT\_FED\_CPG  
Tyre description: Goodyear 335/65R22.5 G275 MSA

General characteristics		MMP according to Larminie's equations	
Vehicle weight (kN)	66	Tyre deflection on hard surface (m)	0.05588
Number of axles	2	Factor K'	1.83
Unladen tyre diameter (m)	1.01092	Differential lock factor	0.97
Unladen tyre width (m)	0.334	MMP (kPa)	312.5

MMP according to Rowland's equations		Vehicle Limiting Cone Index (VLCI)	
Unladen tyre section height (m)	0.21711	Tyre deflection on hard surface (m)	0.05588
Tyre deflection on hard surface (m)	0.05588	Factor K'	1.85
Factor K'	3.65	VLCI (kPa)	230.7
MMP (kPa)	297.8		

Enter the characteristics as indicated. Click on the buttons to perform the required tasks

# 5. VehSim2D



**2D Vehicle dynamic simulation program: Vehsim2d**

File Help

Number of axles for vehicle: 2

**Vehicle data**  
 Vehicle description: CDT\_CPG\_Calib

MP - Measuring point  
 CG - Center of gravity

MP2: 0.422 m, MP1: 0.362 m, CG: -0.214 m

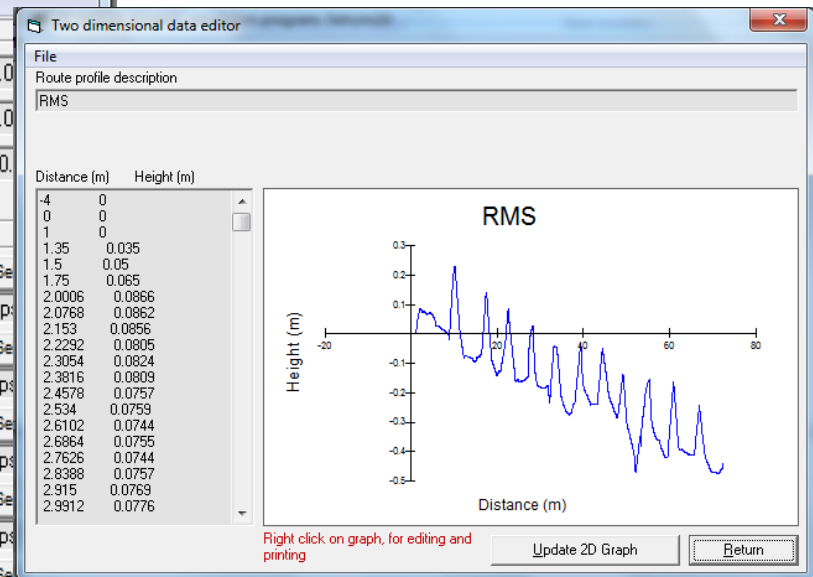
Spring mass: 2772.8 kg<sup>2</sup>  
 Vehicle mass: 4616.7 kg  
 Vehicle speed: 25.75 km/h

Spring: 1.592 m, Damper: 1.001 m, Bumpstop: 3.3 m, Tyre stiffness: 434.87 kg, Tyre damping: 430.1 kg, Geometry: 1.001 m

**Simulation data**  
 Time step for simulation (s): 0.0  
 Time step for output to file (s): 0.0  
 End time (s): 10.0  
 Use sector tyre model

**File names**  
 Vehicle data: C:\...\CDT\CDT\_FED\_Calib\_40ps  
 Simulation output: C:\...\CDT\CDT\_FED\_CPG\_40ps  
 Post processor input data: C:\...\CDT\CDT\_FED\_CPG\_40ps  
 Post processor output data: C:\...\CDT\CDT\_FED\_CPG\_40ps  
 Animation geometry: C:\MobSim\vehsim2d\data\CDT\CDT.ge

Run simulation, Postprocessor, Animate, LFOPC: Optimisation of vehicle/suspension parameters, Exit

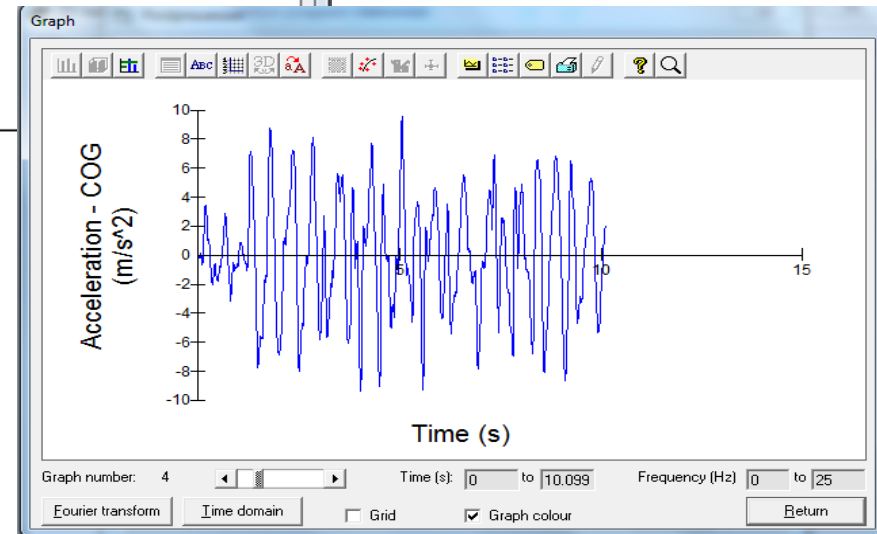
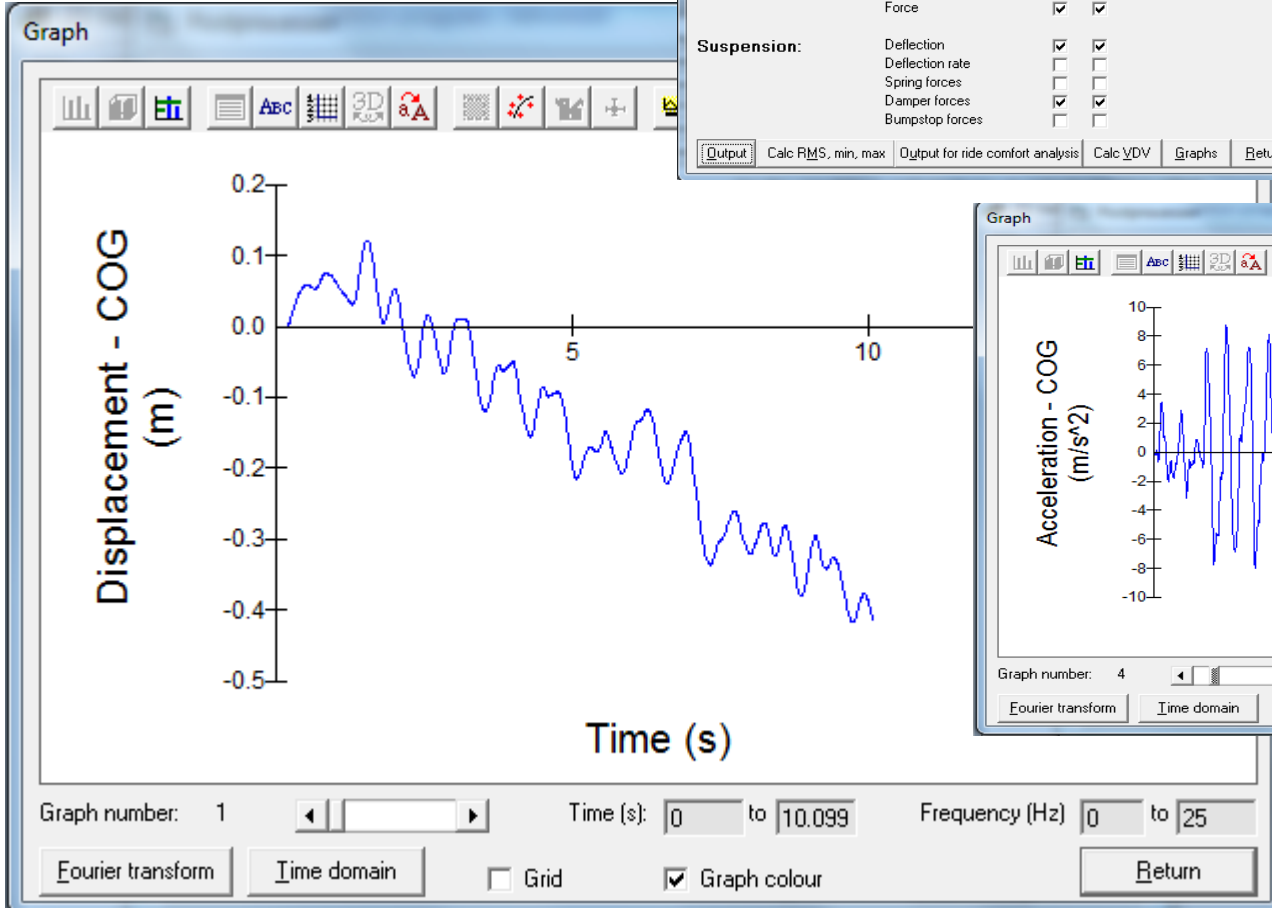


# 5. VehSim2D

Postprocessor

<b>Centre of gravity:</b>	Displacement	<input checked="" type="checkbox"/>			
	Velocity	<input type="checkbox"/>			
	Acceleration	<input type="checkbox"/>			
	Angular displacement	<input type="checkbox"/>			
	Angular velocity	<input type="checkbox"/>			
	Angular acceleration	<input type="checkbox"/>			
<b>Measuring points:</b>	<b>Measuring point</b>	1	2		
	Displacement	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
	Velocity	<input type="checkbox"/>	<input type="checkbox"/>		
	Acceleration	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
<b>Wheels:</b>	<b>Axle number:</b>	1	2	3	4
	Displacement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Velocity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Acceleration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Deflection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Deflection rate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Force	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Suspension:</b>	Deflection	<input type="checkbox"/>	<input checked="" type="checkbox"/>		
	Deflection rate	<input type="checkbox"/>	<input type="checkbox"/>		
	Spring forces	<input type="checkbox"/>	<input type="checkbox"/>		
	Damper forces	<input type="checkbox"/>	<input type="checkbox"/>		
	Bumpstop forces	<input type="checkbox"/>	<input type="checkbox"/>		

Output Calc RMS, min, max Output for ride comfort analysis Calc DVV Graphs Return



# 6. RideCom


Ride Comfort Calculator (Version 2.0)

Measured Data - 12 Channels | Measured Data - 2 Channels (z-direction only) | VehSim2d Data | Help

Inputs

Input Filename: C:\MobSim\vehsim2d\data\VCDT\VCDT\_FED\_CPG\_40psi.rod

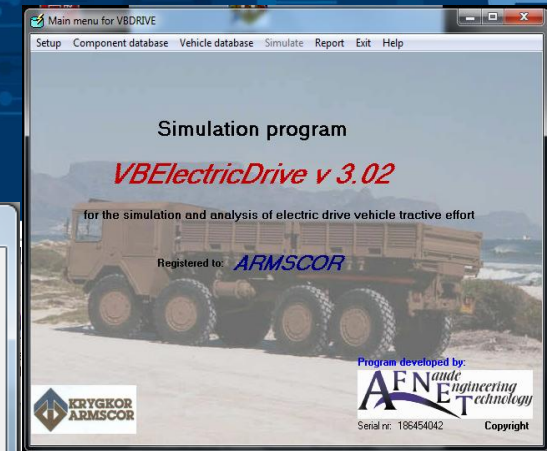
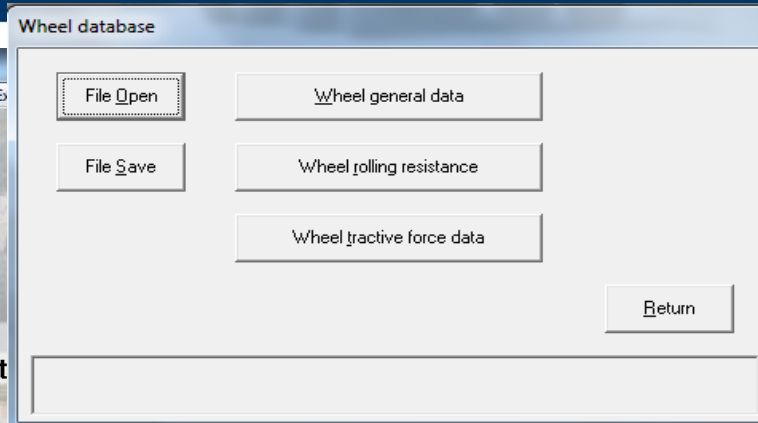
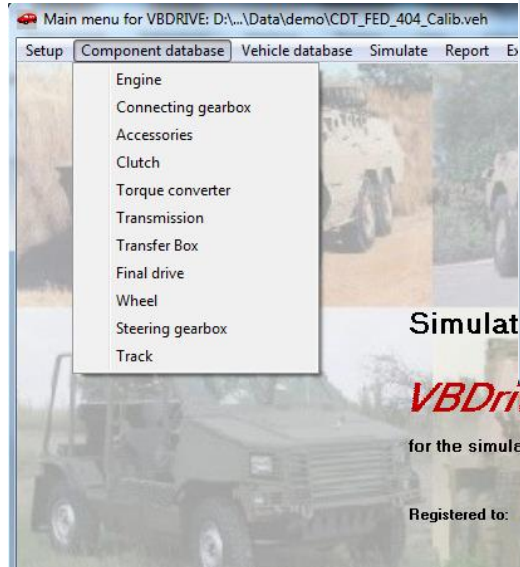
Seat Filename:



Results

	ISO		BS		AAP		VDI
	RMS	4h. VDV	RMS	4h. VDV			
Centre of Gravity :	5.256 m/s <sup>2</sup>	82.436 m/s <sup>1.75</sup>	4.879 m/s <sup>2</sup>	77.54 m/s <sup>1.75</sup>	7.61	W	107.99
Measuring point 1 :	3.636 m/s <sup>2</sup>	56.07 m/s <sup>1.75</sup>	3.31 m/s <sup>2</sup>	51.657 m/s <sup>1.75</sup>	7.61	W	77.564
Measuring point 2 :	3.071 m/s <sup>2</sup>	44.545 m/s <sup>1.75</sup>	2.639 m/s <sup>2</sup>	38.968 m/s <sup>1.75</sup>	7.61	W	70.128

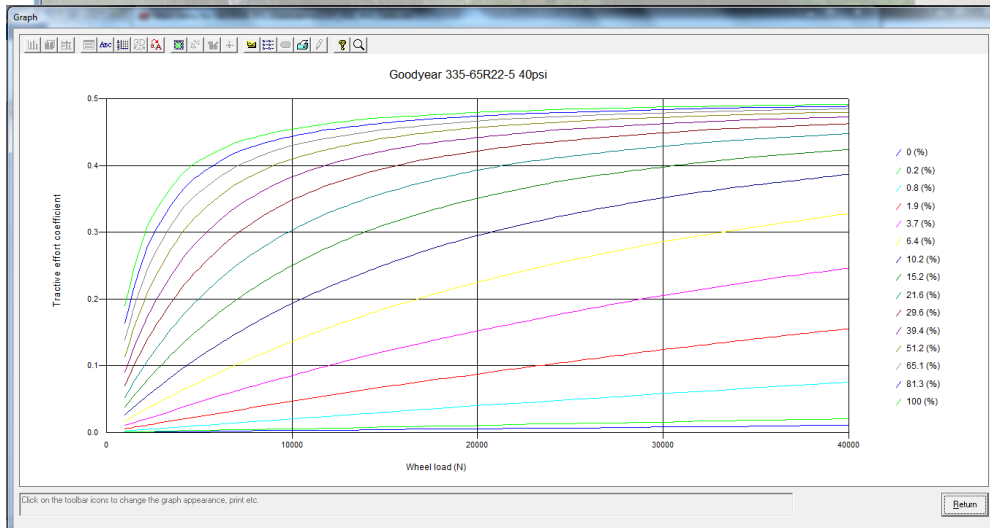
# 7. VBDrive / VBDrive Electric



for wheeled vehicles

PARAMETER	VALUE
Unladen wheel diameter (m)	1.01092
Wheel tread width (m)	0.35818
Tyre inflation pressure (Pa)	275790.3
Tyre carcass stiffness equivalent pressure (Pa)	113260
Exponent of sinkage	0.51
Pressure sinkage parameter - Kc (Pa)	56150
Pressure sinkage parameter - Kphi (Pa)	410800
Saturated weight density (N/m <sup>3</sup> )	16719
Cohesion parameter (Pa)	20
Shear angle (degrees)	26.75
Shear shift deformation modulus (m)	0.00881

Return

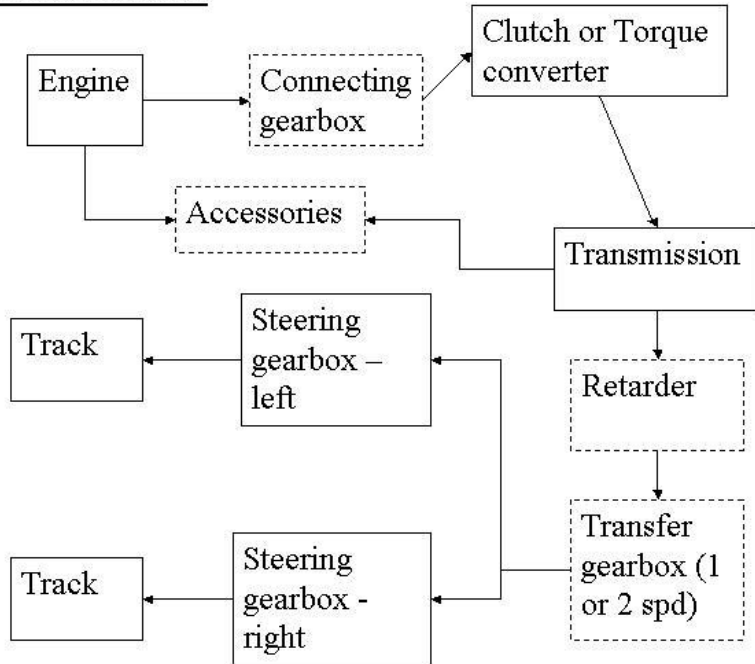


Program developed by:  
**AFNET**  
Serial nr: 708580604 Copyright

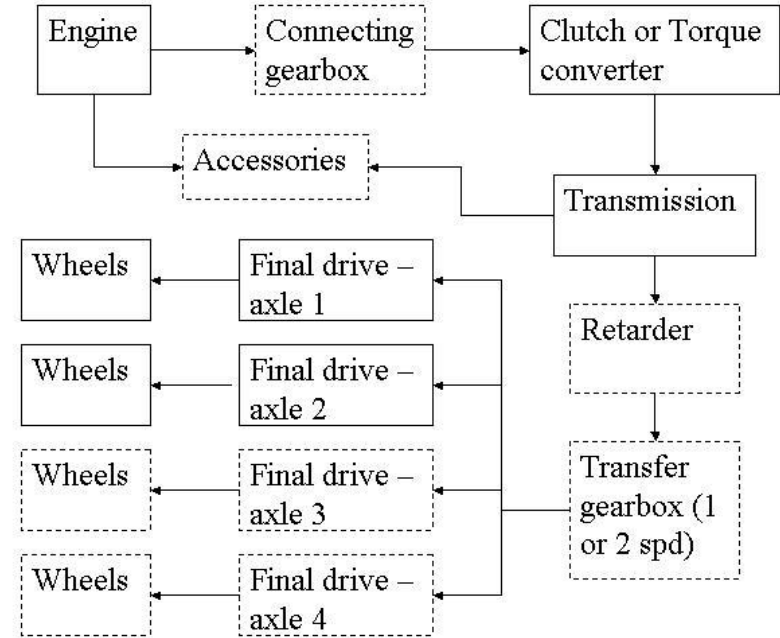


# 7. VBDrive / VBDrive Electric

## Tracked vehicles



## Wheeled vehicles



# 7. VBDrive / VBDrive Electric

### Tractive effort simulation

#### Simulation Input data

Vehicle file name  
D:\MOBSIM\SA\_MOBSIM\_FED\_Model\Data\demo\

Vehicle description  
CDT\_FED

Output file name  
D:\MOBSIM\SA\_MOBSIM\_FED\_Model\Data\demo\  
Output file

Engine rpm increment  ▶◀

Number of gradients  ▶◀

Gradient percentages:

-5	0	5	10	20
25	30	40	50	60

Direction  
 Forward  Reverse

#### Simulation

Start simulation

#### Simulation output

Engine speed (rpm)

Gear number

Vehicle speed (km/h)

Tractive effort required (N) on 60 % gradient

#### Type of vehicle

Vehicle description  
CDT\_FED

**Vehicle type**

Wheeled vehicle  
 Tracked vehicle

**Connecting gearbox options**

No connecting gearbox  
 Connecting gearbox fitted

**Accessories options**

No accessories  
 Accessories fitted

**Transmission type**

Manual shift with clutch  
 Automatic shift with torque converter

**Transferbox options**

No transferbox fitted  
 Transferbox fitted

#### Vehicle characteristics

CdA (m<sup>2</sup>)  Number of axles  ◀ ▶

Height of cg (m)  ◀ ▶

Axle nr from front	Wheelbase (m)	Axle load (kg)	% Drive torque	% Brake efficiency
1	0	2839.49	47	85
2	3.302	2642.18	53	85

Total vehicle mass (kg)

**Ambient conditions**

Temperature (deg C)  Calculate ambient

Dry pressure (kPa)  Corrected engine graph

Wind speed (m/s)

Return

#### Analyse results

Tractive effort

Speed

Gradients

Acceleration

Overtaking acceleration

Fuel consumption

Route simulation

Gear shift

Brake

Hill climb

Export to SAAMM

Return

# 7. VBDrive / VBDrive Electric

**Hill climb simulation**

**Simulation Input data**

Output file name

Final gradient percentage at distance (m)

Time interval for calculations (s)  Time interval for save to file (s)

Distance options (m)  
 0 to  0 to  0 to   
 0 to  0 to

Time options (s)  
 0 to  0 to

Rolling start speed (km/h) in gear number  
   Gear shift allowed

**Transferbox position**  
 Low range  High range

**Simulation**

**Analyse results**

The hill climb simulation was previously, if data in the configuration were changed, repeat the changes to take effect

**Hill climb: Results**

VEHICLE: CDT\_FED - Forward  
 File = D:\Data\demo\CDT\_FED\_404\_Calib.veh  
 GVM: 5482kg - (52.48%), CdA: 2.28m<sup>2</sup>, Wheelbase - 0.00,3.30m  
 Drive torque split: (47,53%), Brake capacity: (85,85%), Height cg: 1.04m  
 ENGINE: Cummins\_ISB4.5E5  
 File = D:\Data\demo\CDT\_FED\_Engine.eng  
 Performance: 705.1Nm @ 1223rpm, 136.8kW @ 2462rpm at 99kPa, 25degC  
 Drop down gearbox: Ratio = 1.000, Efficiency = 100.0%  
 TORQUE CONVERTER: Aisin 6 Speed AT Transmission  
 File = D:\Data\demo\CDT\_FED\_Trans.tcv  
 TRANSMISSION: Aisin 6 Speed AT  
 File = D:\Data\demo\CDT\_FED\_GB\_1800-2200.tfm  
 Forward (Ratio, Eff): 3.740,91%; 2.003,92%; 1.343,93%; 1.000,93%; 0.773,93%; 0.634,92%  
 Reverse (Ratio, Eff): 3.740,91%  
 TRANSFERBOX: CDT\_TGB  
 File = D:\Data\demo\CDT\_TGB.tfb  
 Ratio, efficiency: Low range - 2.720,94%; High range - 1.000,93%

Vehicle start speed (km/h)  in gear  **Low range**

Gradient %  at  m Gear shift allowed

Distance interval (m)	Time (s)	Gear	Gradient (%)	Vehicle speed (km/h)
0 to 10 m	3.28	3	4.89	16.33
0 to 20 m	5.45	4	9.88	17.15
0 to 30 m	7.46	4	14.87	18.26
0 to 40 m	9.49	4	19.88	16.77
0 to 45 m	0.00	0	0.00	0.00

Time interval (s)	Distance (m)	Gear	Gradient (%)	Vehicle speed (km/h)
0 to 3 s	8.75	3	4.27	15.37
0 to 7 s	27.66	4	13.70	18.24





# 7. VBDrive / VBDrive Electric

### Acceleration simulation

**Simulation Input data**

Output file name  
D:\MOBSIM\SA\_MOBSIM\_FED\_Model\Data\demo\

**Forward** Output file

Gradient percentage  
0

Time interval for calculations (s) Time interval for save to file (s)  
0.050 0.100

Final vehicle speed options (km/h)  
0 to 40    0 to 60    0 to 80  
0 to 100    0 to 113

Final distance options (m)  
0 to 400    0 to 1000

Engine start rpm    Start acceleration run in gear  
2192    1

**Transferbox position**  
 Low range     High range

Click to start simulation

### Simulation

Start simulation

### Simulation output

Time (seconds) 42.600

Engine speed (rpm) 2049

Gear number 6 - High

Vehicle speed (km/h) 121.909

Distance travelled (m) 1001.04

Acceleration (m/s<sup>2</sup>) 0.243

Lambda factor 1.054

Number of points saved 427

### Analyse results

Graph    Numerical    Animate

Return

### Acceleration simulation results

VEHICLE: CDT\_FED - Forward  
File = D:\...\Data\demo\CDT\_FED\_404\_Calib.veh  
GVM: 5482kg - (52.48%), CdA: 2.28m<sup>2</sup>, Wheelbase - 0.00,3.30m  
Drive torque split: (47.53%), Brake capacity: (85.85%), Height cg: 1.04m  
ENGINE: Cummins JSB4.5E5  
File = D:\...\Data\demo\CDT\_FED\_Engine.eng  
Performance: 705.1Nm @ 1223rpm; 136.8kW @ 2462rpm at 99kPa, 25degC  
Drop down gearbox: Ratio = 1.000, Efficiency = 100.0%  
TORQUE CONVERTER: Aisin 6 Speed AT Transmission  
File = D:\...\Data\demo\CDT\_FED\_Trans.tcv  
TRANSMISSION: Aisin 6 Speed AT  
File = D:\...\Data\demo\CDT\_FED\_GB\_1800-2200.trm  
Forward (Ratio, Eff): 3.740,91%; 2.003,92%; 1.343,93%; 1.000,93%; 0.773,93%; 0.634,92%  
Reverse (Ratio, Eff): 3.740,91%  
TRANSFERBOX: CDT\_TGB  
File = D:\...\Data\demo\CDT\_TGB.ttb  
Ratio, efficiency: Low range - 2.720,94%; High range - 1.000,99%  
FINAL DRIVE: CDT Final Drive; CDT Final Drive  
Files = D:\...\demo\CDT\_Final\_Drive.fdr; D:\...\demo\CDT\_Final\_Drive.fdr  
Ratio, efficiency: 4.880,94%; 4.880,94%  
WHEELS: Goodyear\_335-65R22-5\_60psi; Goodyear\_335-65R22-5\_60psi  
Files = D:\...\CDT\_60psi\_404\_Front.whl; D:\...\CDT\_60psi\_404\_Rear.whl  
Tyre radius: 0.491m, 0.491m  
Rolling resistance coefficient @ 50km/h: 0.011, 0.011  
Tractive effort (Max coef @ slip%): 0.82,21%; 0.82,21%  
SIMULATION at: 101kPa, 4degC, 0m/s on: 12-09-2018

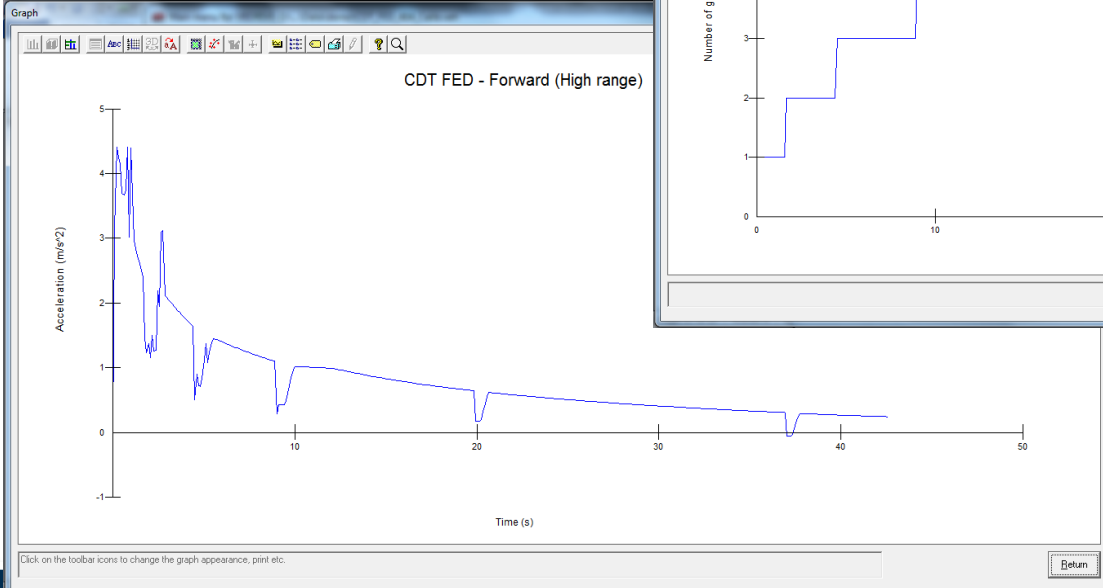
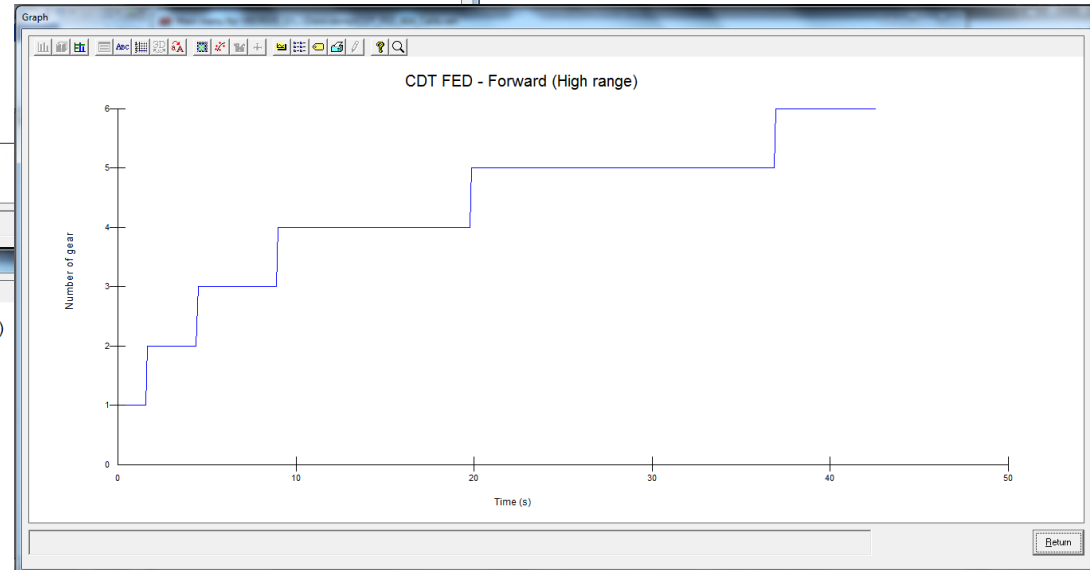
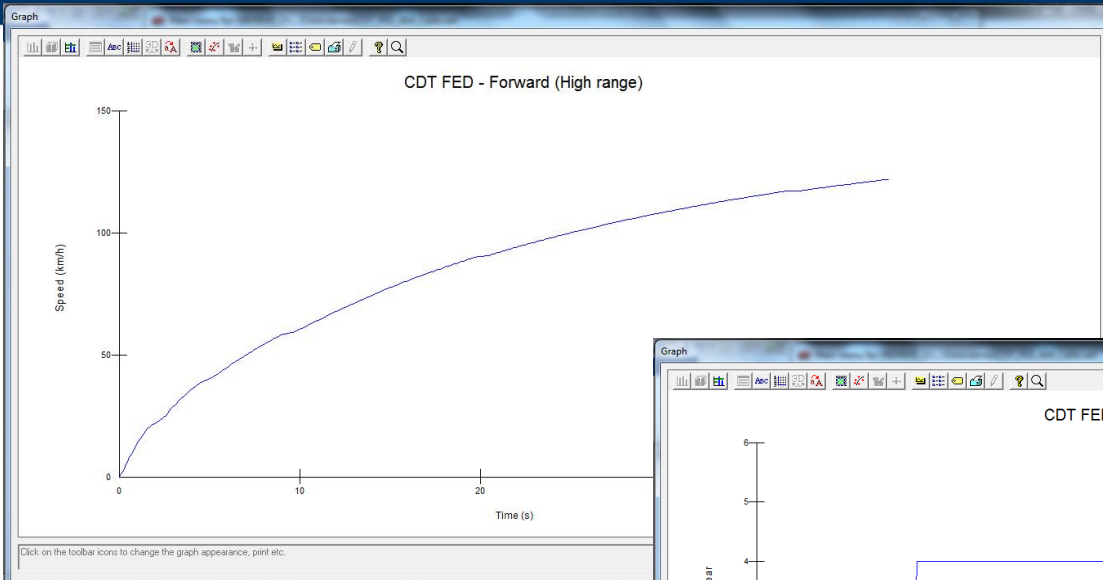
Speed interval (km/h)	Time (s)	Gear	Engine speed (rpm)	Gradient percentage
0 to 40 km/h	4.93	3	2189	High range
0 to 60 km/h	9.85	4	1596	
0 to 80 km/h	15.83	4	2122	
0 to 100 km/h	25.00	5	2052	
0 to 113 km/h	33.50	5	2317	

Distance interval (m)	Time (s)	Gear	Engine speed (rpm)	Final speed (km/h)
0 to 400 m	23.12	5	1979	96.43
0 to 1000 m	42.57	6	2048	121.88

Compare  
Add to report  
Print  
Return

# 7. VBDrive / VBDrive Electric

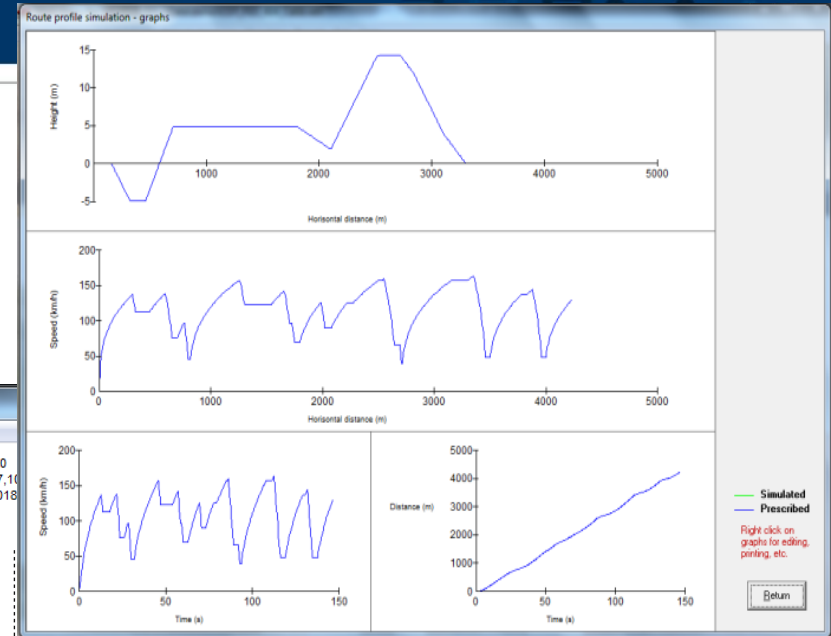
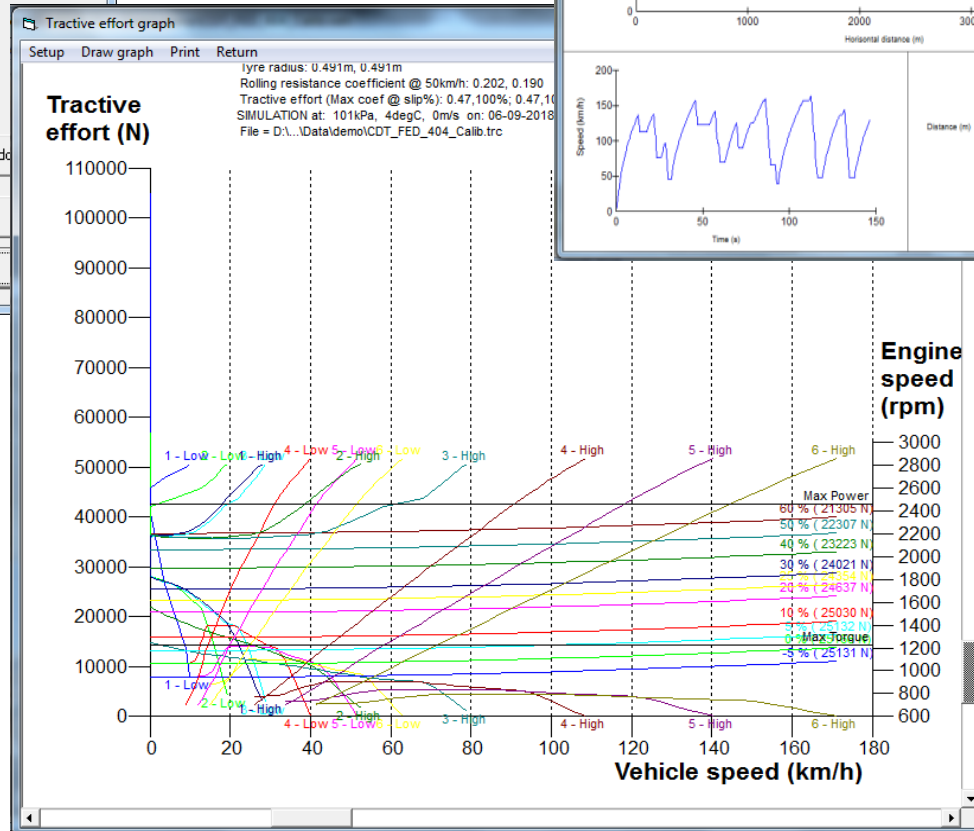


# 7. VBDrive / VBDrive Electric

Optimum gear shift points

VEHICLE: CDT\_FED - Forward  
 File = D:\...\Data\demo\CDT\_FED\_404\_Calib.veh  
 GVM: 5482kg - (52,48%), CdA: 2.28m<sup>2</sup>, Wheelbase - 0.00,3.30m

Gear no	Up shift Engine rpm	Down shift Engine rpm
1 - Low	2704	
2 - Low	2461	2440
3 - Low	2522	2130
4 - Low	2523	1846
5 - Low	2523	1911
6 - Low		2027
1 - High	2600	
2 - High	2545	2135
3 - High	2512	2159
4 - High	2512	1834
5 - High	2503	1902
6 - High		2013



# 8. GENRIT

Vehicle Model

Force Elements    Wheel and External Forces    Points of Interest    Tyre, Wheel, Steering

Vehicle Type and Constants    General Data    Component Data    Constraints

### Vehicle Type and Constants

Vehicle Type

Wheeled Vehicle

Tracked Vehicle

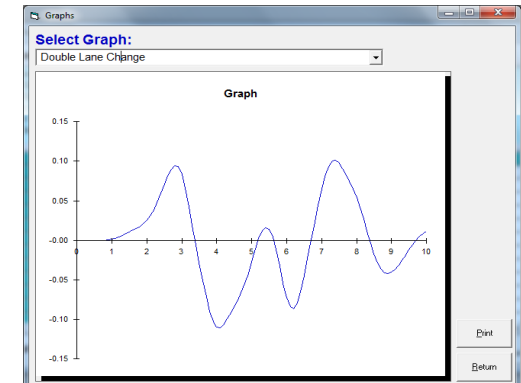
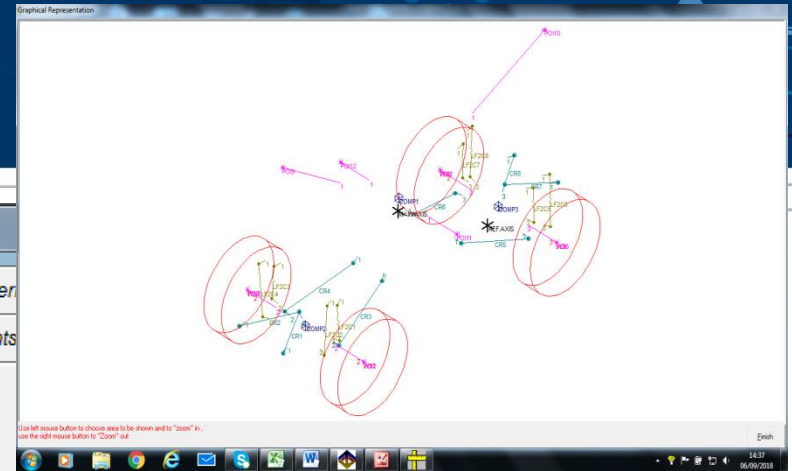
Equilibrium Convergence Limit	0.001
Equilibrium Iteration Variance constant	0.001
Equilibrium Iteration Damping value	0.8
Maximum number of Equilibrium Iteration Steps	150

Help

Error List

Save

Return



# 8. GENRIT

Vehicle Model

Vehicle Type and Constants    General Data    Component Data    Constraints

Force Elements    Wheel and External Forces    Points of Interest    **Tyre, Wheel, Steering, Driving**

**Terrain, Steering and Driving Model**

**Terrain Profile**

Function number for terrain profile under LEFT Wheels	11
Function number for terrain profile under RIGHT Wheels	11

**Choice of Tyre Model**    1 - Basic Sector Model

**Choice of Steering Model**    2 - Follow prescribed route

Function number for Specified Model    17

Reaction Time for Driver    0.6

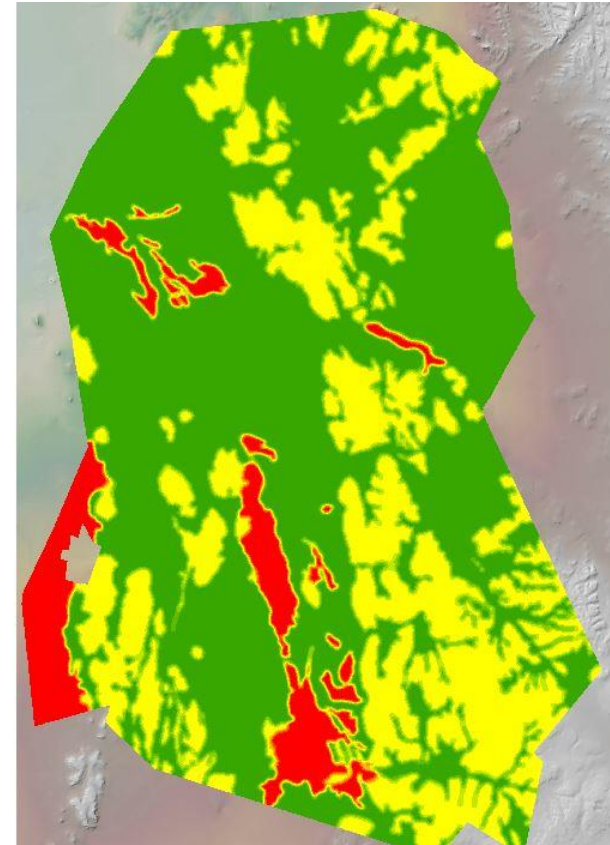
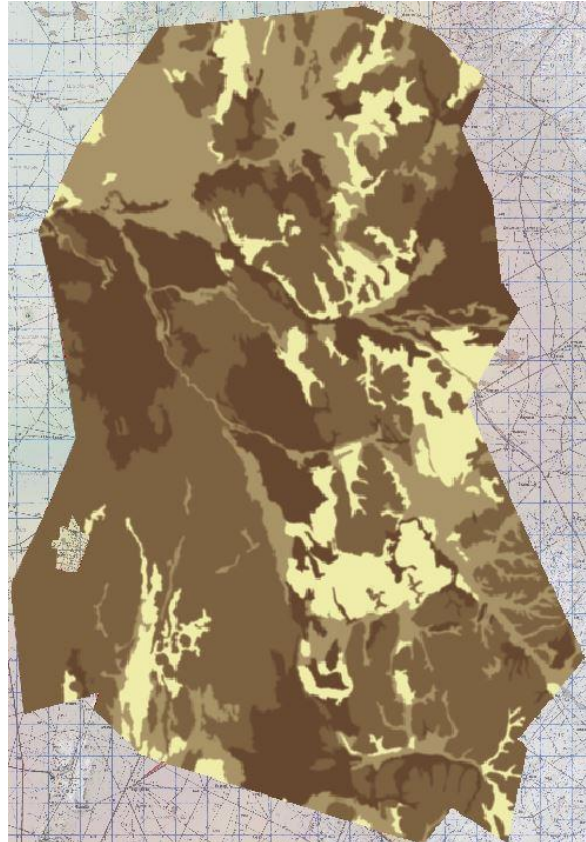
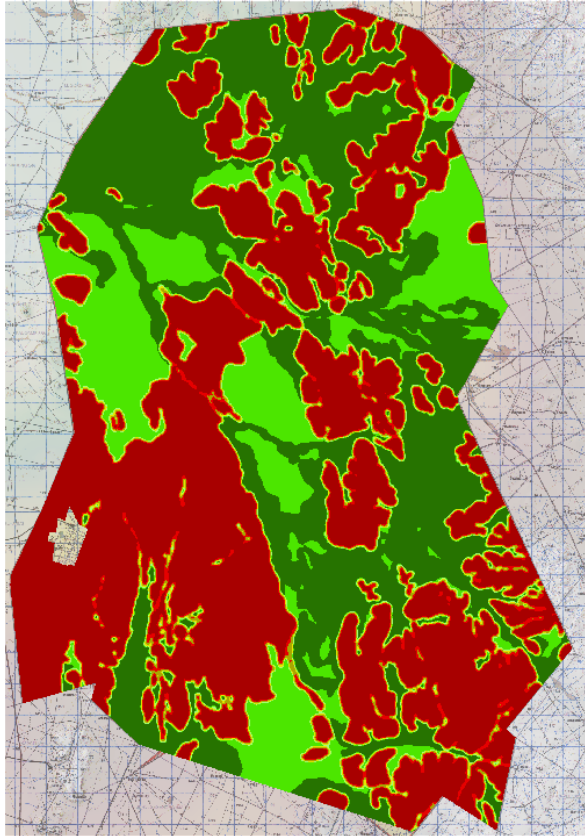
**Choice of Driving Model**    2 - Constant vehicle speed (= reference axis speed)

Constant Drive Torque (Nm)    0

Function Number for driving model    0

Help    Error List    Save    Return

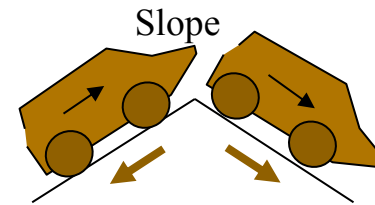
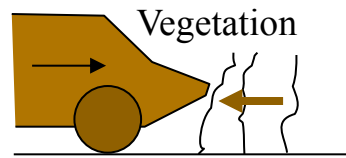
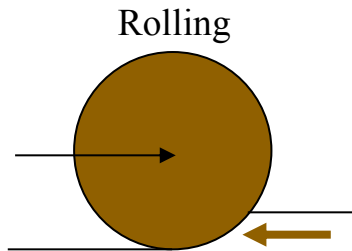
# 9. SAAMM



# 9. SAAMM

- SAAMM Speed Made Good / Maximum Possible Speed

➤ Supply vs. Demand



➤ Speed constraints

Max Speed

Ride Comfort



Visibility: Vegetation



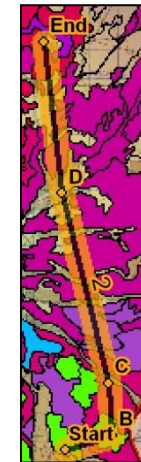
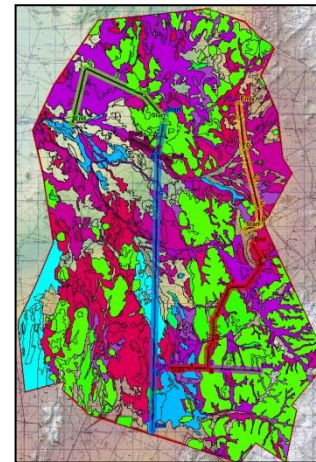
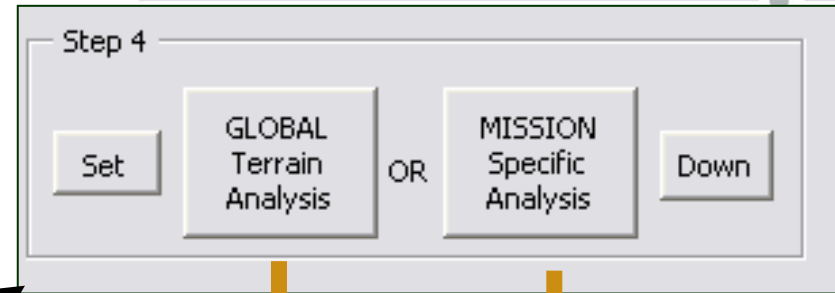
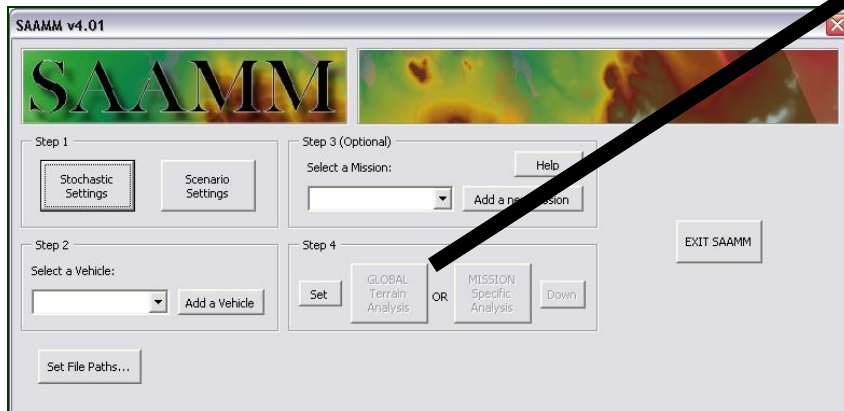
Visibility: Elevation



# 9. SAAMM

## SAAMM

### ➤ Analysis options

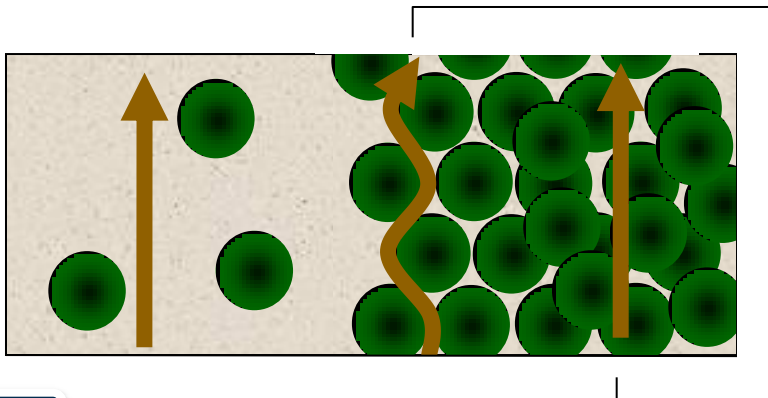
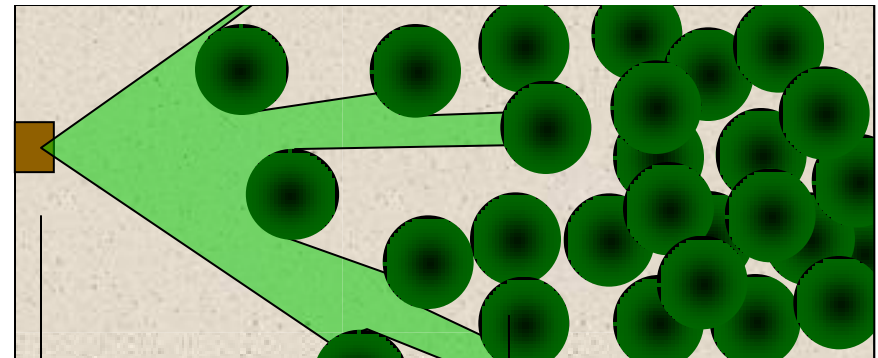
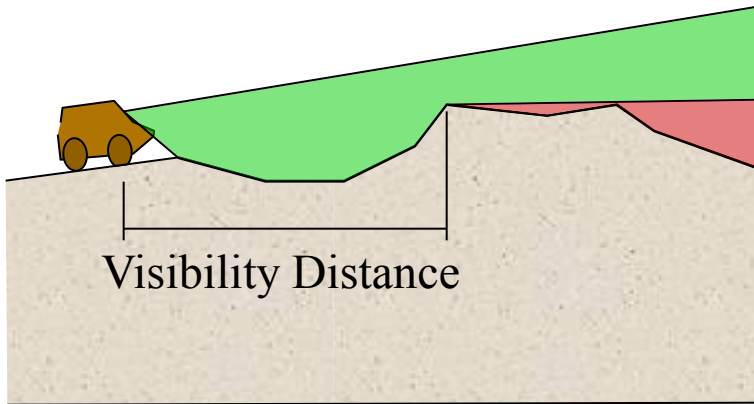




# 9. SAAMM

- SAAMM

  - Visibility modelling



Increased Distance

Increased Resistance

# 10. MOBSIM Gaps

## Gaps

- Based on old software platforms (VBA / FORTRAN /ArcGIS9.0)
- Fixed outputs (Difficult to get other data e.g. rut depth nett tractive coefficient, Output data fixed format (jpeg plots v.s. CSV or similar data))
- Data input strings limited e.g. terrain roughness (smaller data strings)
- Excludes latest mobility modelling capabilities e.g. DEM
- Tedious to do multiple runs (manual inputs / model links)

## Advantages

- Low Cost (no software licences other than Windows)
- Fast (minutes to run on laptop)
- Well Structured GUI

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**Thank you**

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Name (email@csir.co.za)

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