Automotive Vehicle Mechanics and its Modelling

Project Title: Motorbike

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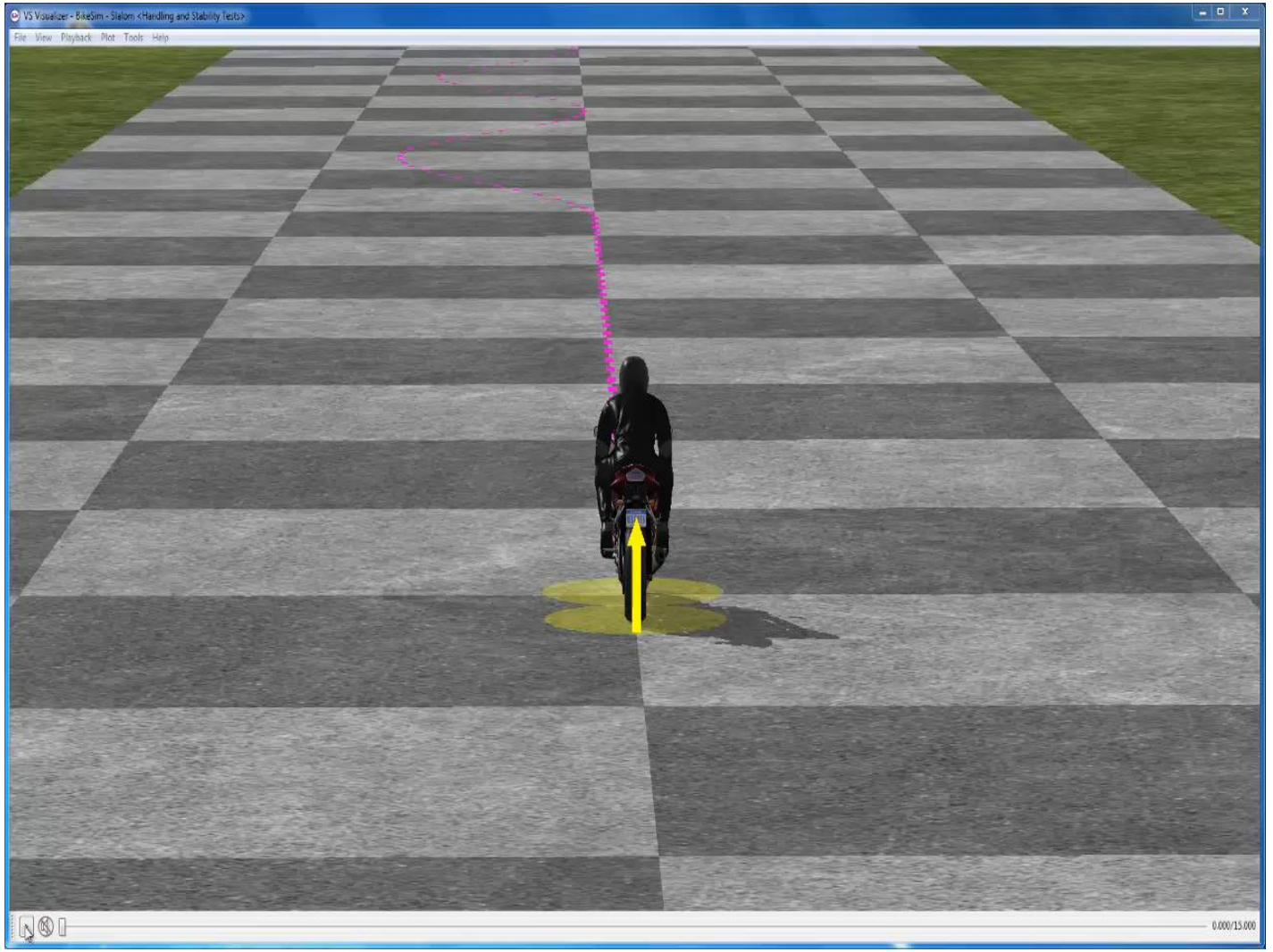
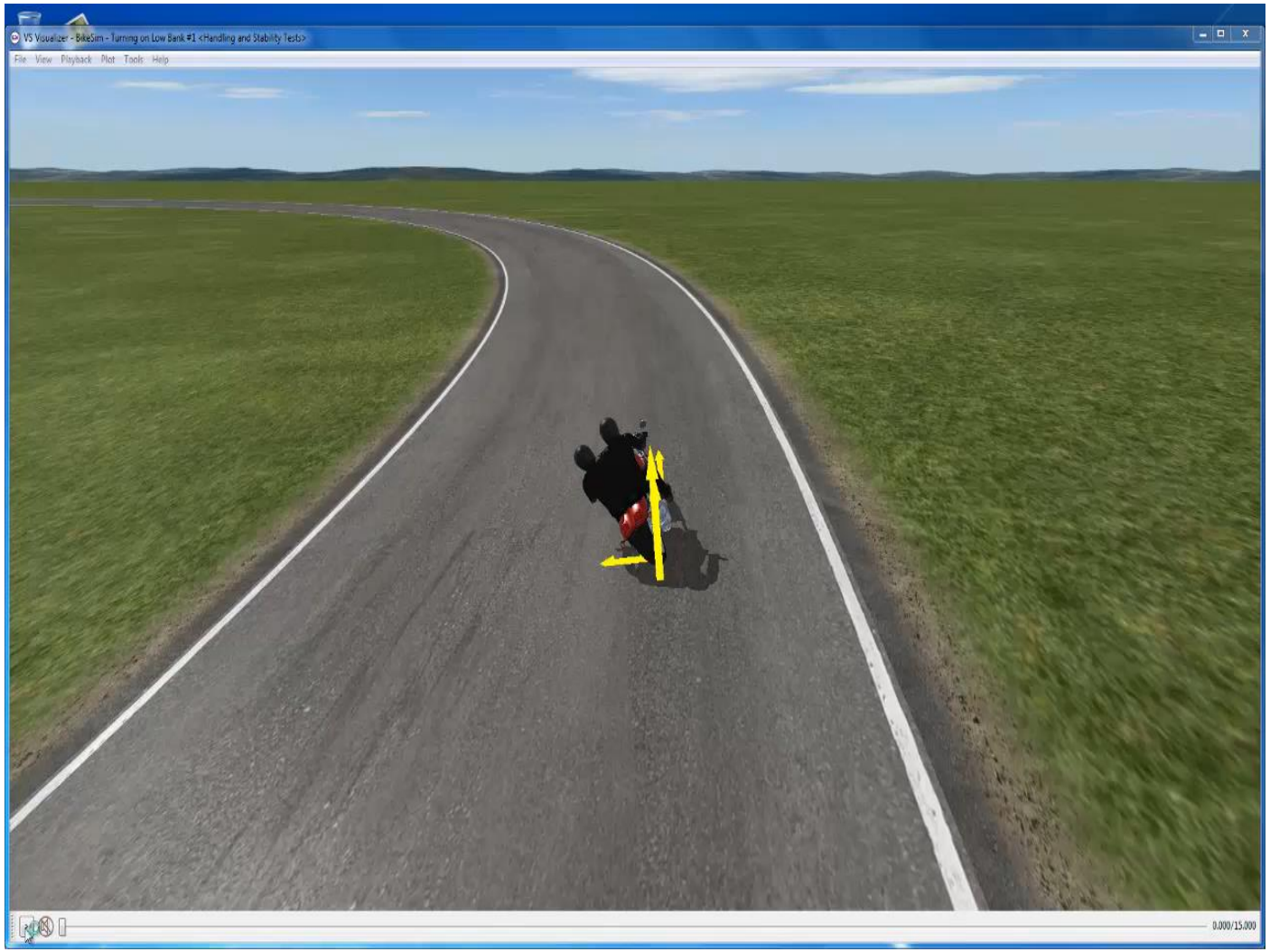
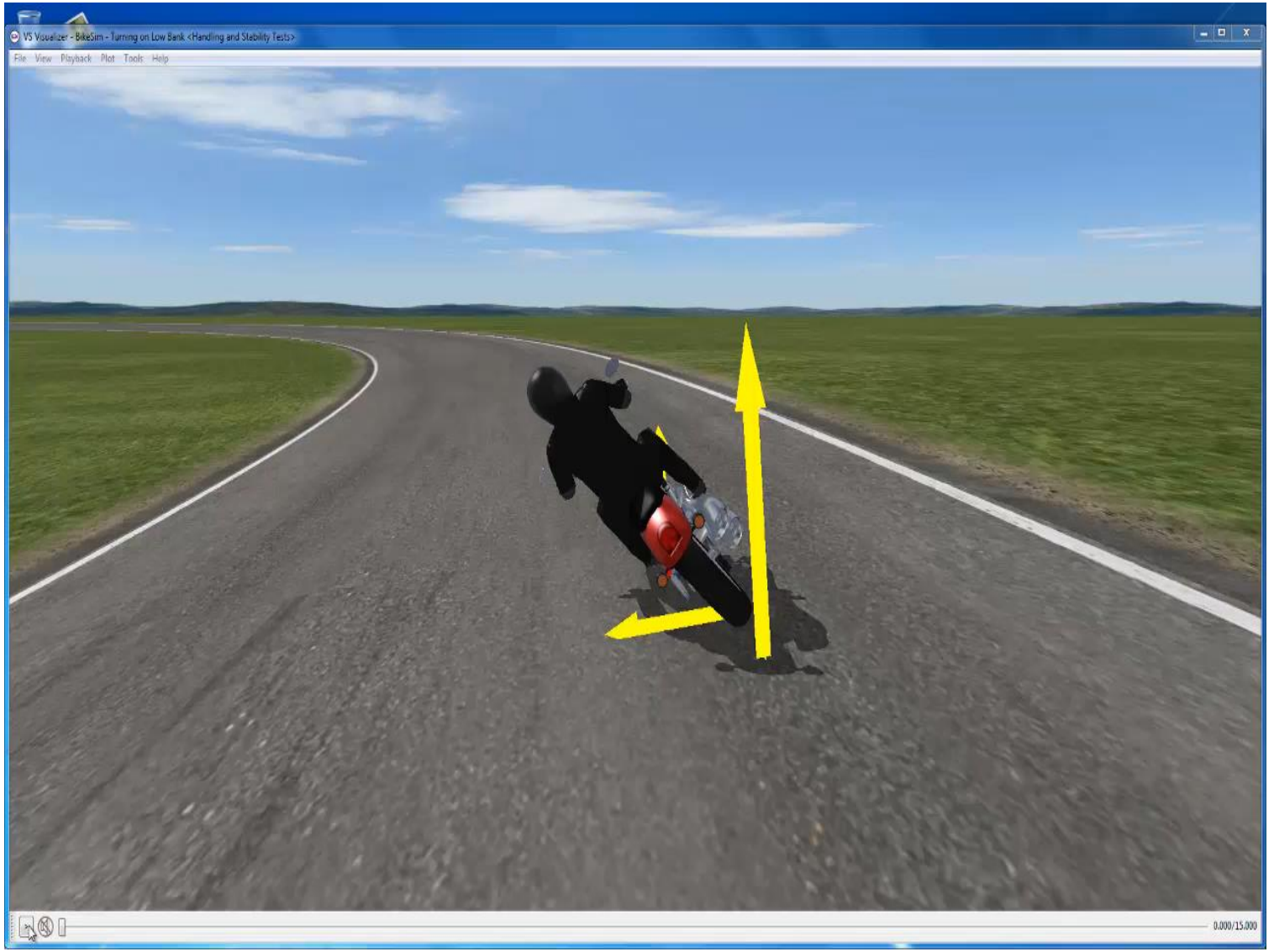
Animation of various forces acting on bike

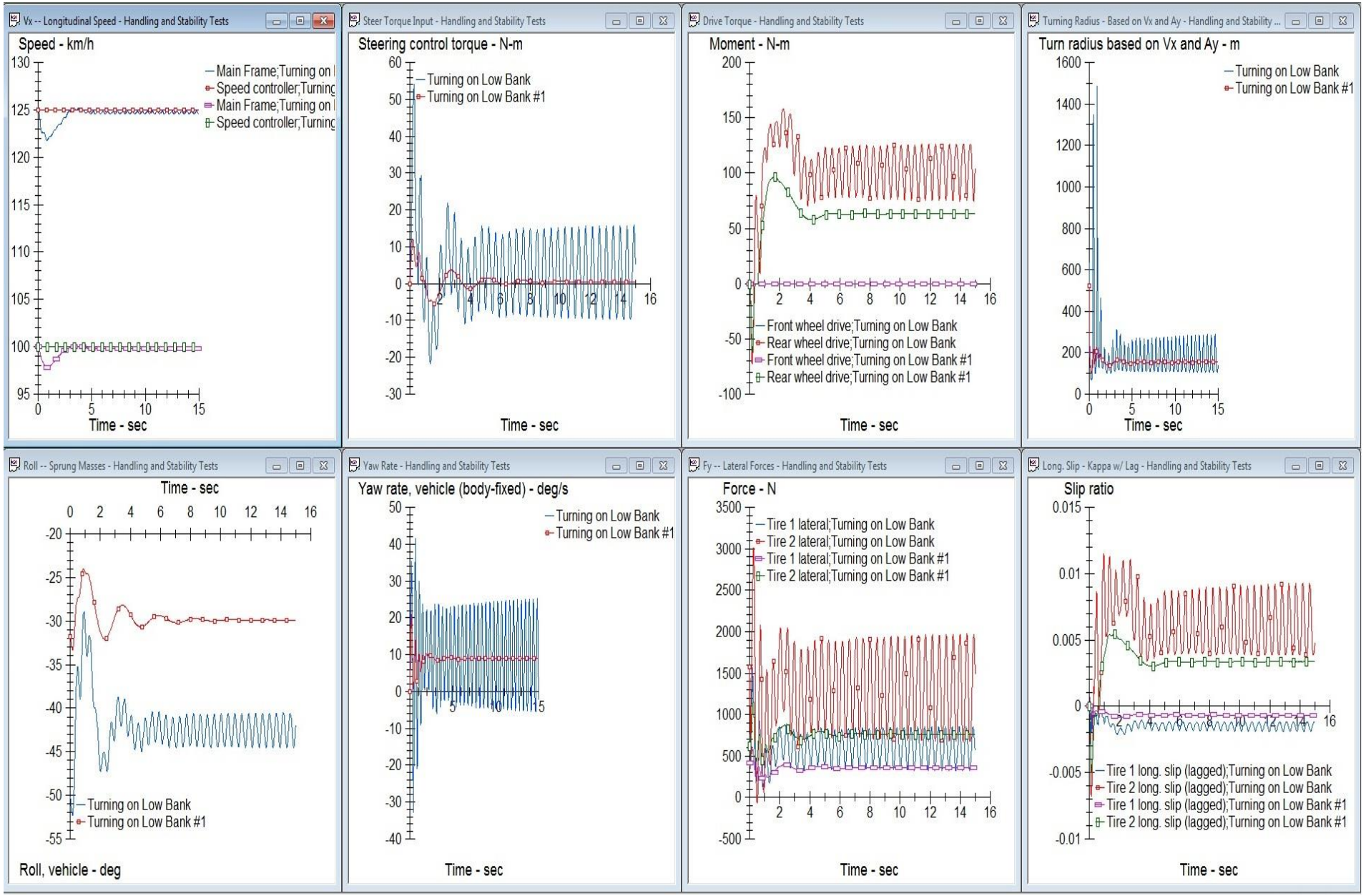


Locked Stability Control-Capsize:Unstable

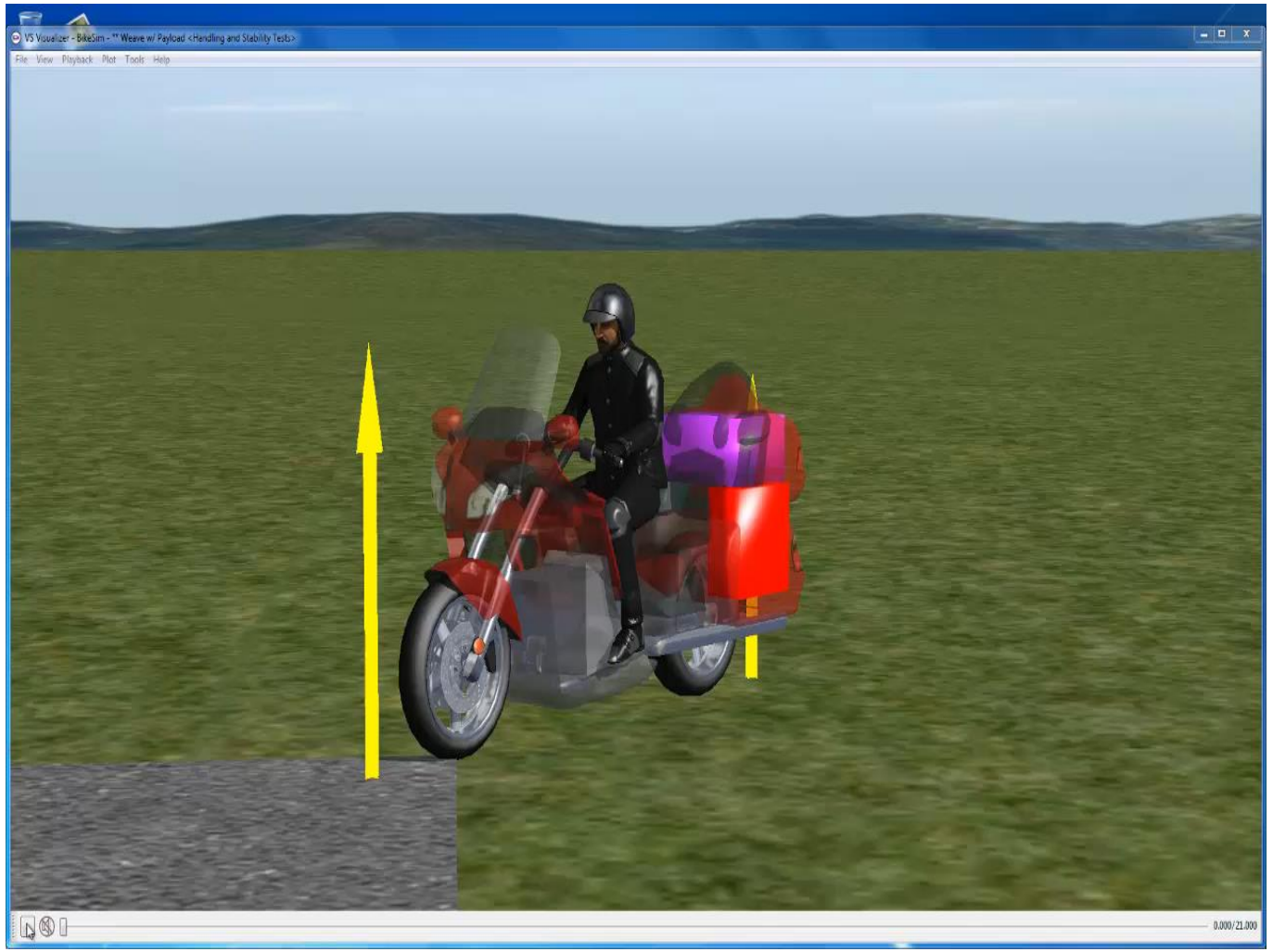


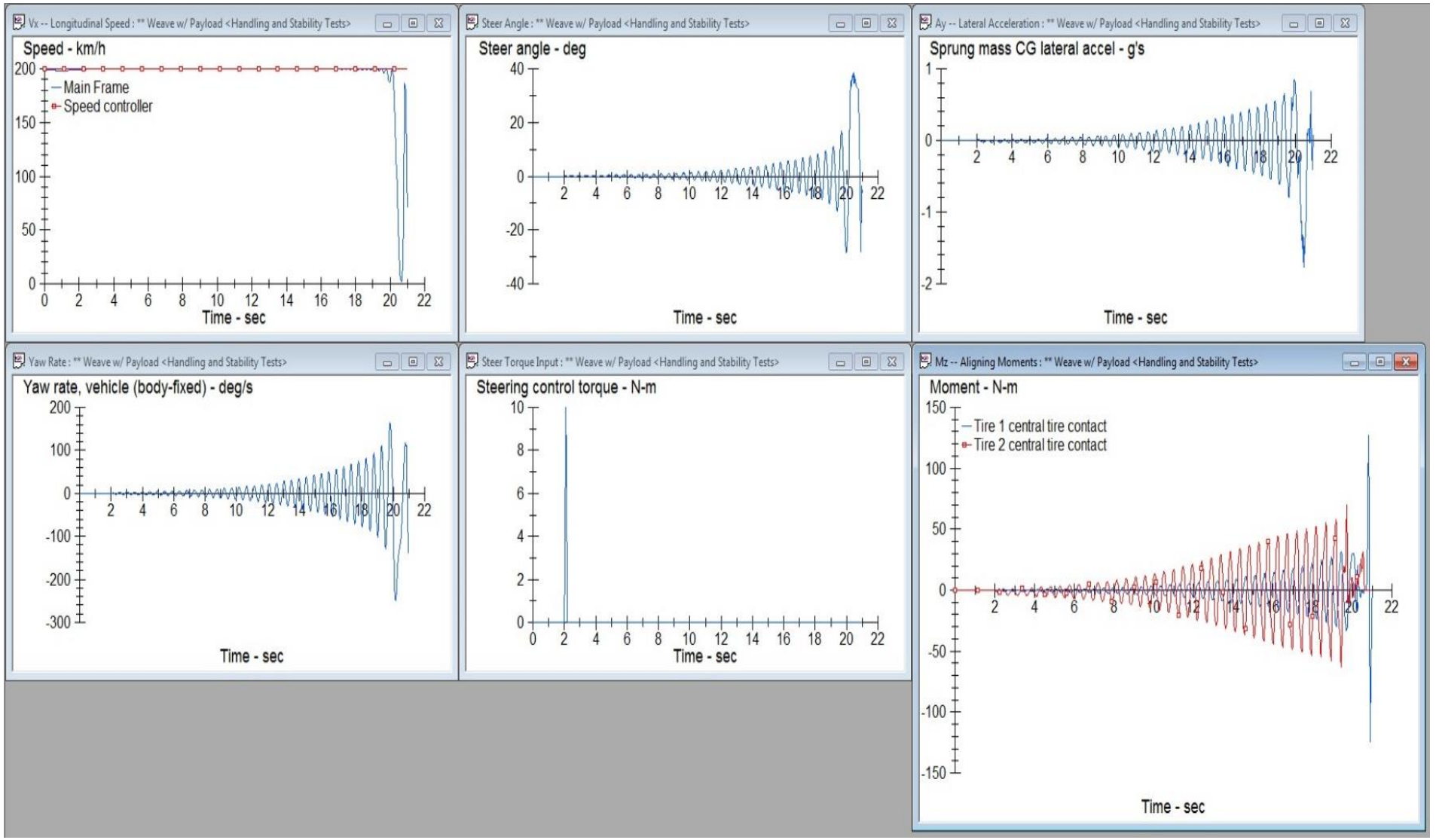
Stable @ 125 kmph



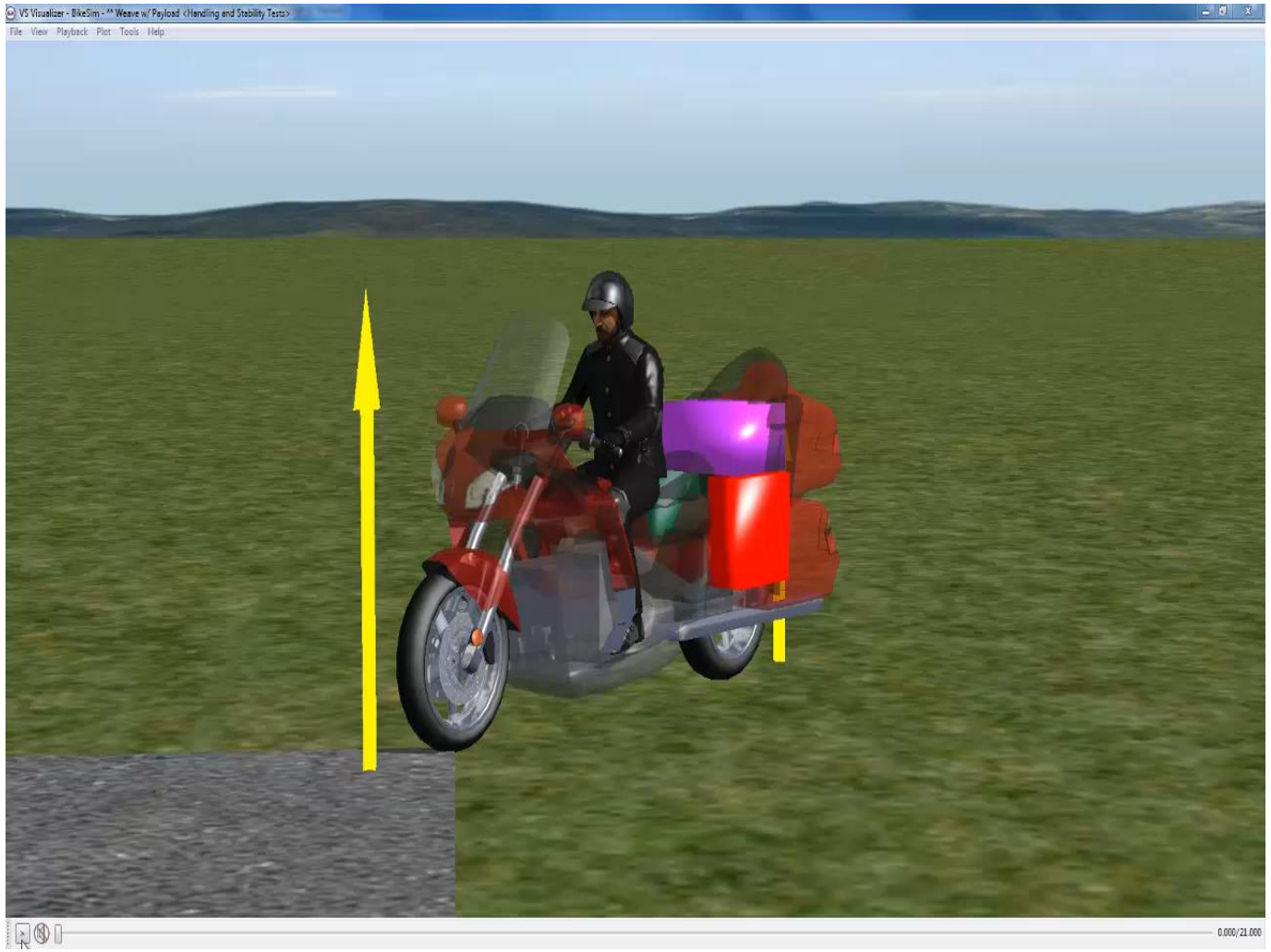

Vx -- Longitudinal Speed - Handling and Stability Tests
Speed - km/h
Main Frame;Turning on
Speed controller;Turning
Main Frame;Turning on
Speed controller;Turning
Time - sec
Steer Torque Input - Handling and Stability Tests
Steering control torque - N-m
Turning on Low Bank
Turning on Low Bank #1
Time - sec
Drive Torque - Handling and Stability Tests
Moment - N-m
Front wheel drive;Turning on Low Bank
Rear wheel drive;Turning on Low Bank
Front wheel drive;Turning on Low Bank #1
Rear wheel drive;Turning on Low Bank #1
Time - sec
Turning Radius - Based on Vx and Ay - Handling and Stability ...
Turn radius based on Vx and Ay - m
Turning on Low Bank
Turning on Low Bank #1
Time - sec
Roll -- Sprung Masses - Handling and Stability Tests
Time - sec
Turning on Low Bank
Turning on Low Bank #1
Roll, vehicle - deg
Yaw Rate - Handling and Stability Tests
Yaw rate, vehicle (body-fixed) - deg/s
Turning on Low Bank
Turning on Low Bank #1
Time - sec
Fy -- Lateral Forces - Handling and Stability Tests
Force - N
Tire 1 lateral;Turning on Low Bank
Tire 2 lateral;Turning on Low Bank
Tire 1 lateral;Turning on Low Bank #1
Tire 2 lateral;Turning on Low Bank #1
Time - sec
Long. Slip - Kappa w/ Lag - Handling and Stability Tests
Slip ratio
Tire 1 long. slip (lagged);Turning on Low Bank
Tire 2 long. slip (lagged);Turning on Low Bank
Tire 1 long. slip (lagged);Turning on Low Bank #1
Tire 2 long. slip (lagged);Turning on Low Bank #1
Time - sec

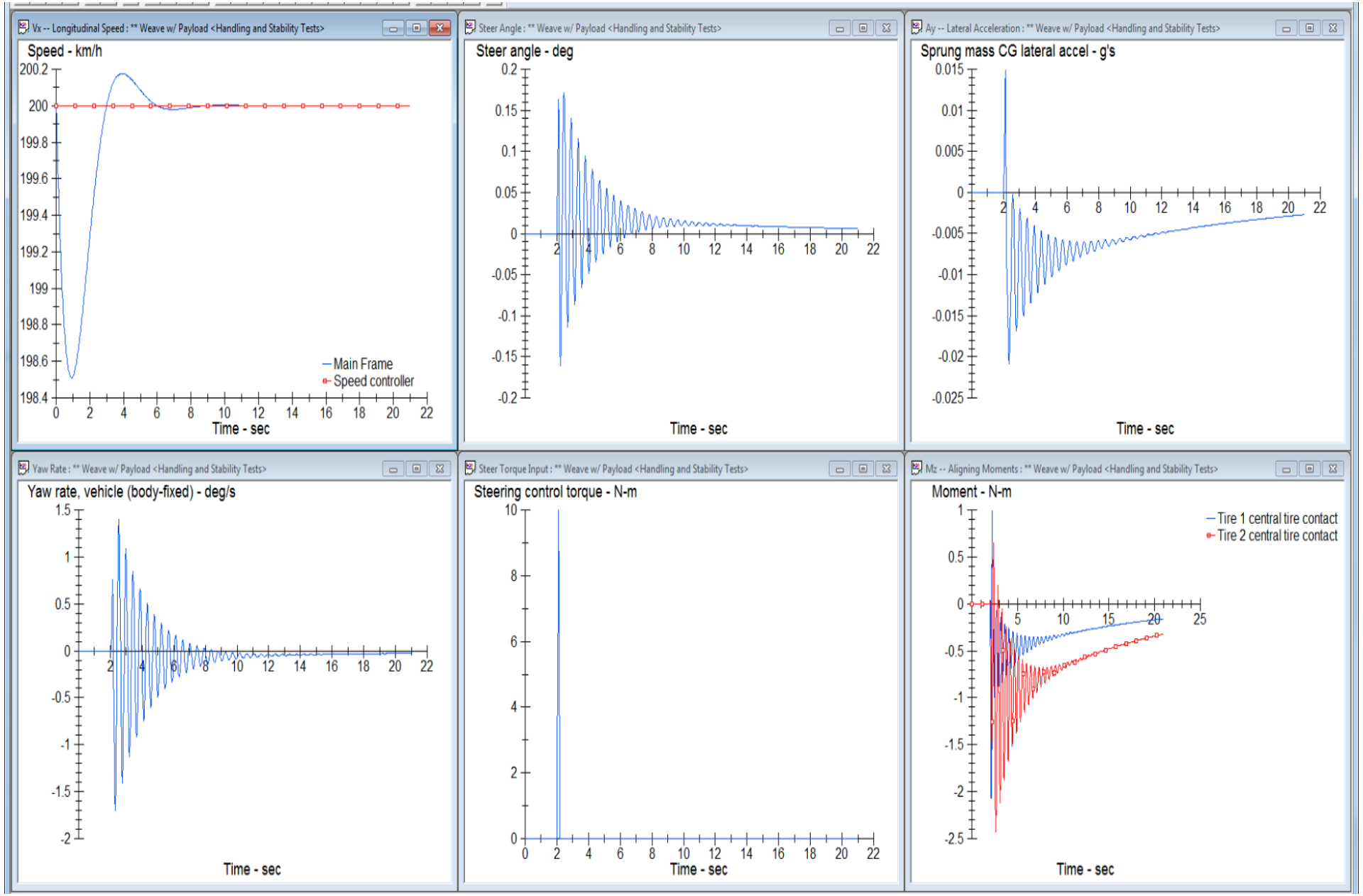
Weave Motion: Unstable



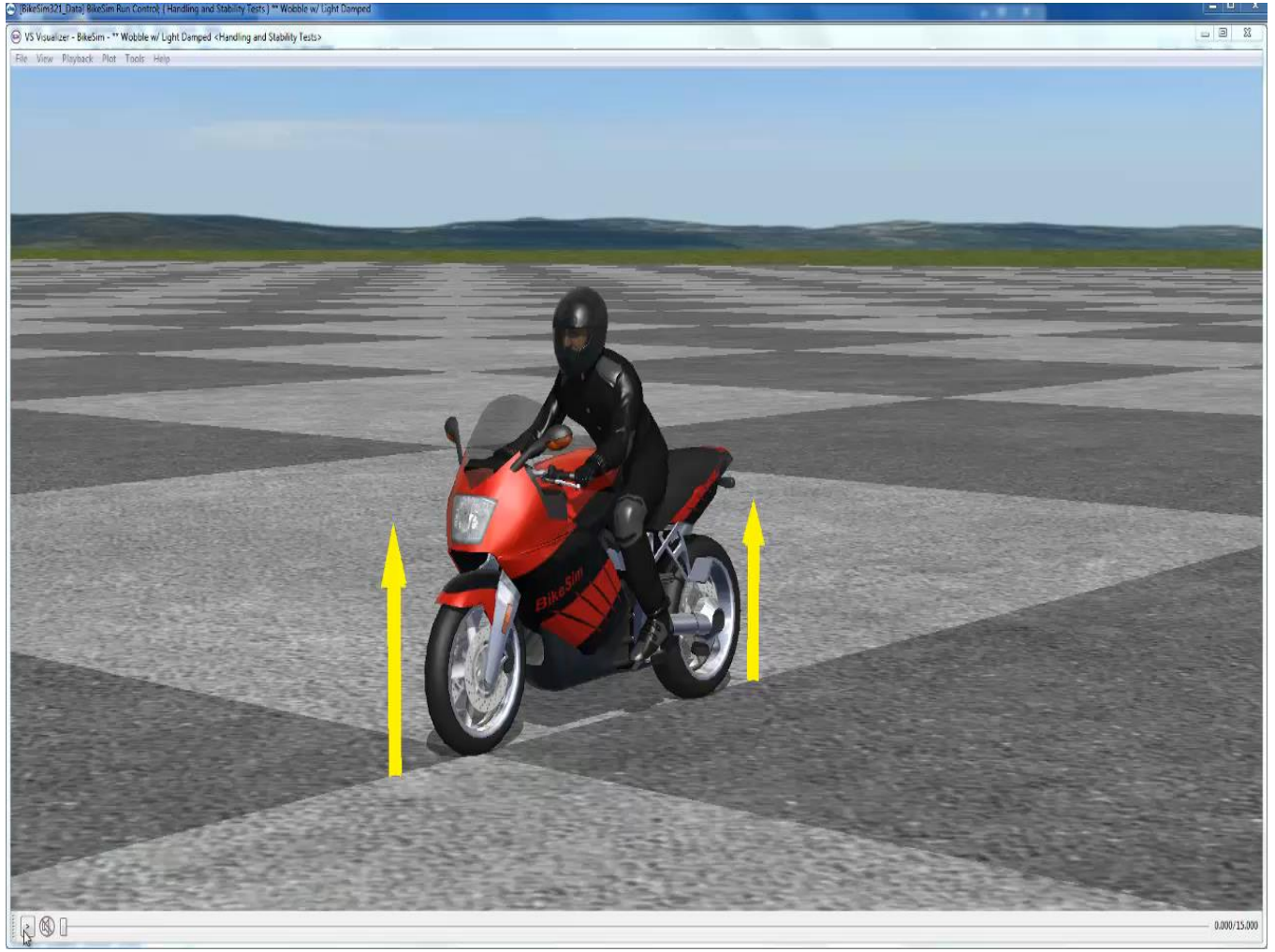

Vx -- Longitudinal Speed : ** Weave w/ Payload <Handling and Stability Tests>
Speed - km/h
Main Frame
Speed controller
Time - sec
Steer Angle : ** Weave w/ Payload <Handling and Stability Tests>
Steer angle - deg
Time - sec
Ay -- Lateral Acceleration : ** Weave w/ Payload <Handling and Stability Tests>
Sprung mass CG lateral accel - g's
Time - sec
Yaw Rate : ** Weave w/ Payload <Handling and Stability Tests>
Yaw rate, vehicle (body-fixed) - deg/s
Time - sec
Steer Torque Input : ** Weave w/ Payload <Handling and Stability Tests>
Steering control torque - N-m
Time - sec
Mz -- Aligning Moments : ** Weave w/ Payload <Handling and Stability Tests>
Moment - N-m
Tire 1 central tire contact
Tire 2 central tire contact
Time - sec

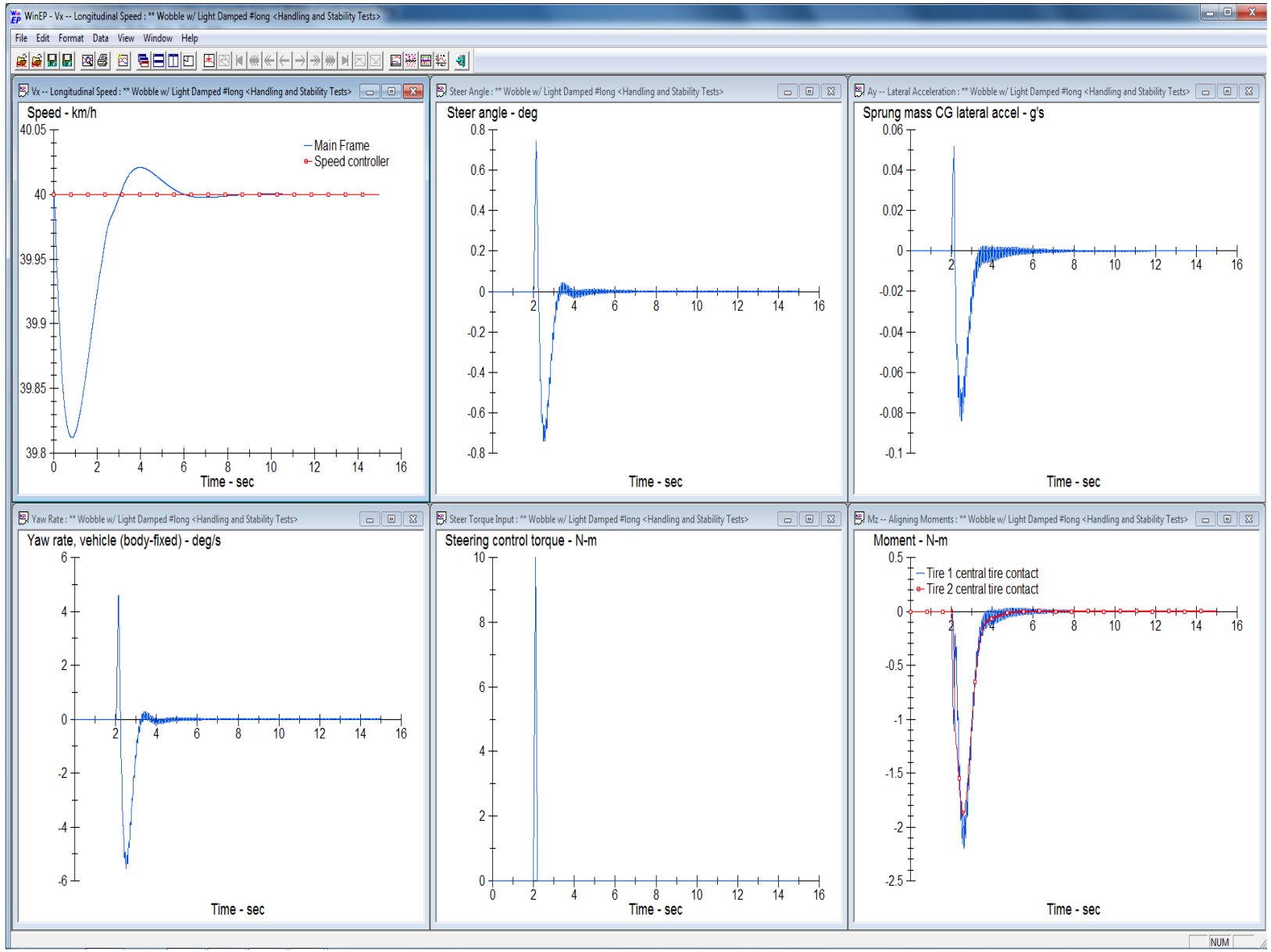
Stable after increase in wheelbase $V = \frac{l_2}{2}\sqrt{\frac{C_2 l_2}{J\cos(\eta)}}$




Vx -- Longitudinal Speed : ** Weave w/ Payload <Handling and Stability Tests>
Speed - km/h
200.2
200
199.8
199.6
199.4
199.2
199
198.8
198.6
198.4
0 2 4 6 8 10 12 14 16 18 20 22
Time - sec
Main Frame
Speed controller
Steer Angle : ** Weave w/ Payload <Handling and Stability Tests>
Steer angle - deg
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
2 4 6 8 10 12 14 16 18 20 22
Time - sec
Ay -- Lateral Acceleration : ** Weave w/ Payload <Handling and Stability Tests>
Sprung mass CG lateral accel - g's
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
2 4 6 8 10 12 14 16 18 20 22
Time - sec
Yaw Rate : ** Weave w/ Payload <Handling and Stability Tests>
Yaw rate, vehicle (body-fixed) - deg/s
1.5
1
0.5
0
-0.5
-1
-1.5
-2
2 4 6 8 10 12 14 16 18 20 22
Time - sec
Steer Torque Input : ** Weave w/ Payload <Handling and Stability Tests>
Steering control torque - N-m
10
8
6
4
2
0
0 2 4 6 8 10 12 14 16 18 20 22
Time - sec
Mz -- Aligning Moments : ** Weave w/ Payload <Handling and Stability Tests>
Moment - N-m
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
5 10 15 20 25
Time - sec
Tire 1 central tire contact
Tire 2 central tire contact

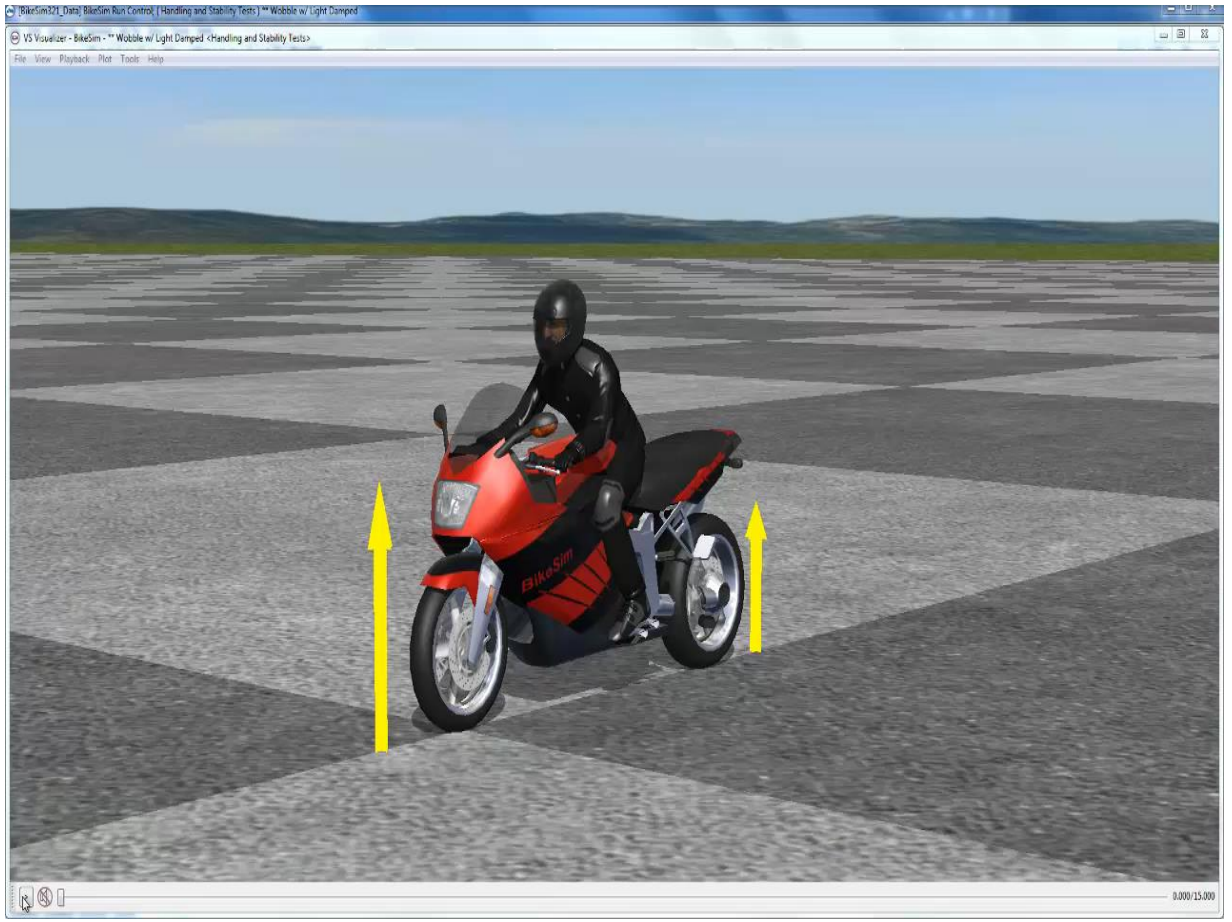
Free Control Stability - Wobble

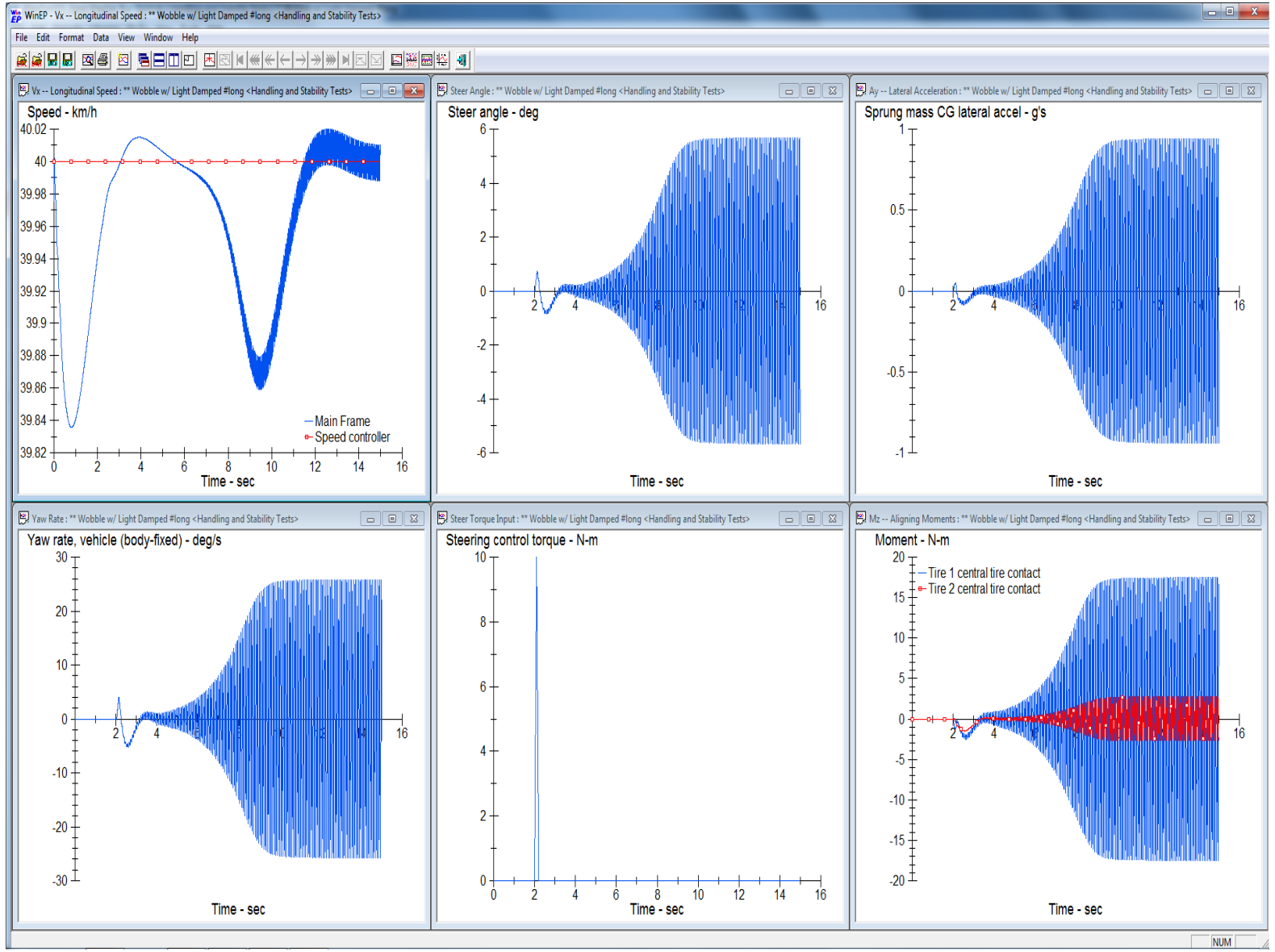



WinEP - Vx -- Longitudinal Speed : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
File Edit Format Data View Window Help
Vx -- Longitudinal Speed : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Speed - km/h
Main Frame
Speed controller
Time - sec
Steer Angle : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Steer angle - deg
Time - sec
Ay -- Lateral Acceleration : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Sprung mass CG lateral accel - g's
Time - sec
Yaw Rate : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Yaw rate, vehicle (body-fixed) - deg/s
Time - sec
Steer Torque Input : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Steering control torque - N-m
Time - sec
Mz -- Aligning Moments : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Moment - N-m
Tire 1 central tire contact
Tire 2 central tire contact
Time - sec
NUM

Bike becomes unstable due to increase in wheel base

$$V = \frac{e\cos(\eta)}{2}\sqrt{\frac{C_1 e}{J}}$$




WinEP - Vx -- Longitudinal Speed : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
File Edit Format Data View Window Help
Vx -- Longitudinal Speed : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Speed - km/h
Main Frame
Speed controller
Time - sec
Steer Angle : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Steer angle - deg
Time - sec
Ay -- Lateral Acceleration : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Sprung mass CG lateral accel - g's
Time - sec
Yaw Rate : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Yaw rate, vehicle (body-fixed) - deg/s
Time - sec
Steer Torque Input : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Steering control torque - N-m
Time - sec
Mz -- Aligning Moments : ** Wobble w/ Light Damped #long <Handling and Stability Tests>
Moment - N-m
Tire 1 central tire contact
Tire 2 central tire contact
Time - sec
NUM

Conclusion

- By modifying the motorbike based on stability criteria the bike can be made stable for various motions like capsize, weave and wobbling.
- **BikeSim** is a very useful tool in doing such stability analysis. Changes in various parameters can be easily done in BikeSim and their effect can be visualised in real time and similar to actual conditions.