VI-MOTORCYCLE AND VI-BIKEREALTIME: VI-GRADE'S SOLUTION TO MODEL, SOLVE AND IMPROVE MOTORCYCLE PRODUCTS

VEHICLE DEVELOPMENT CHALLENGES TODAY

TIME TO MARKET

DEVELOP
IN LESS TIME

DEVELOPMENT COSTS

LESS PROTOTYPES AND
TESTING

COMPLEX SYSTEMS INTEGRATION

COLLABORATIVE
DEVELOPMENT PLATFORM
AMONG THE INDUSTRY

DEVELOPMENT CHALLENGES TODAY

SYSTEMS INTEGRATION

COMPLEX SYSTEMS INTEGRATION

VEHICLE MODEL

A detailed vehicle model with all its subsystems and components.

ROAD MODEL

A detailed and realistic road model, reproducing the exact test conditions.

RIDER MODEL

An advanced virtual driver model to reproduce any open-loop and closed-loop maneuver.

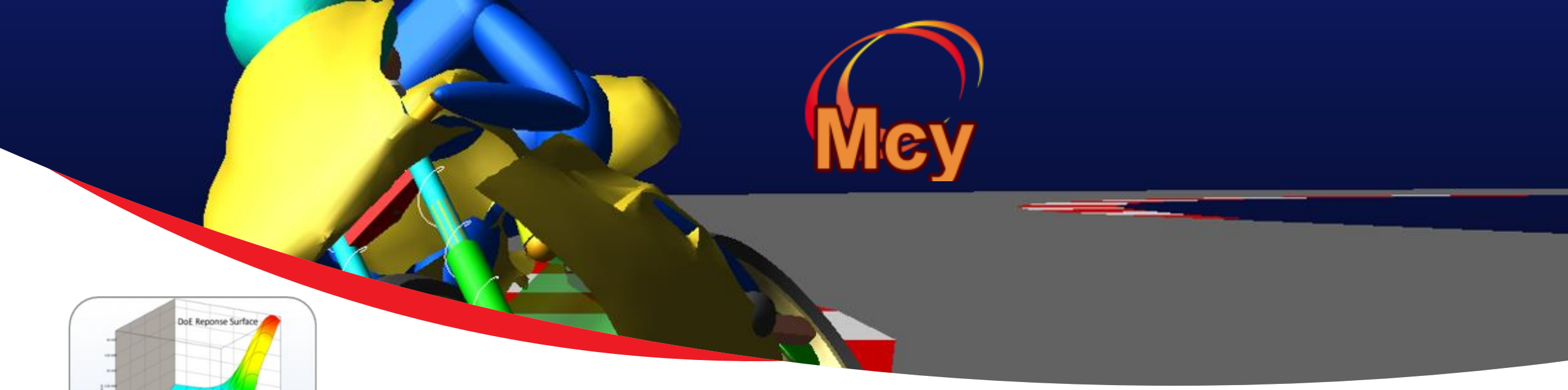
SOFTWARE SOLUTIONS

VI-Motorcycle

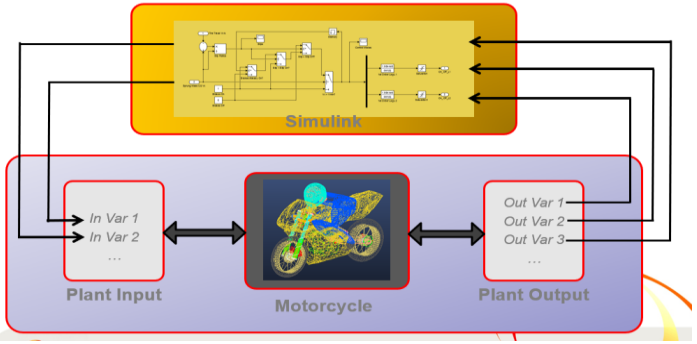
- Full multibody model
- Based on Adams
- Fully parametric
- Implicit Solver

VI-BikeRealTime

- Multibody model
- Predefined bike layout
- Explicit Solver
- Faster than real-time



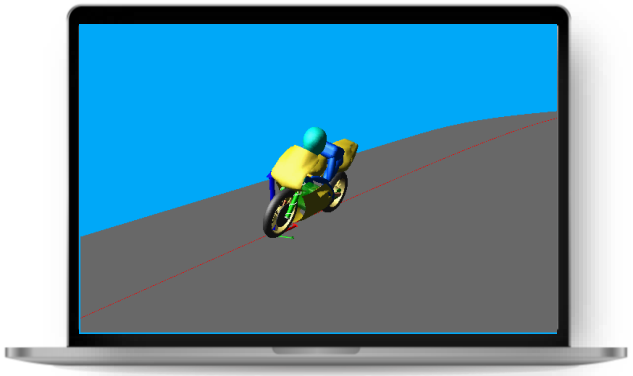
VI-GRADE



VI-MOTORCYCLE:

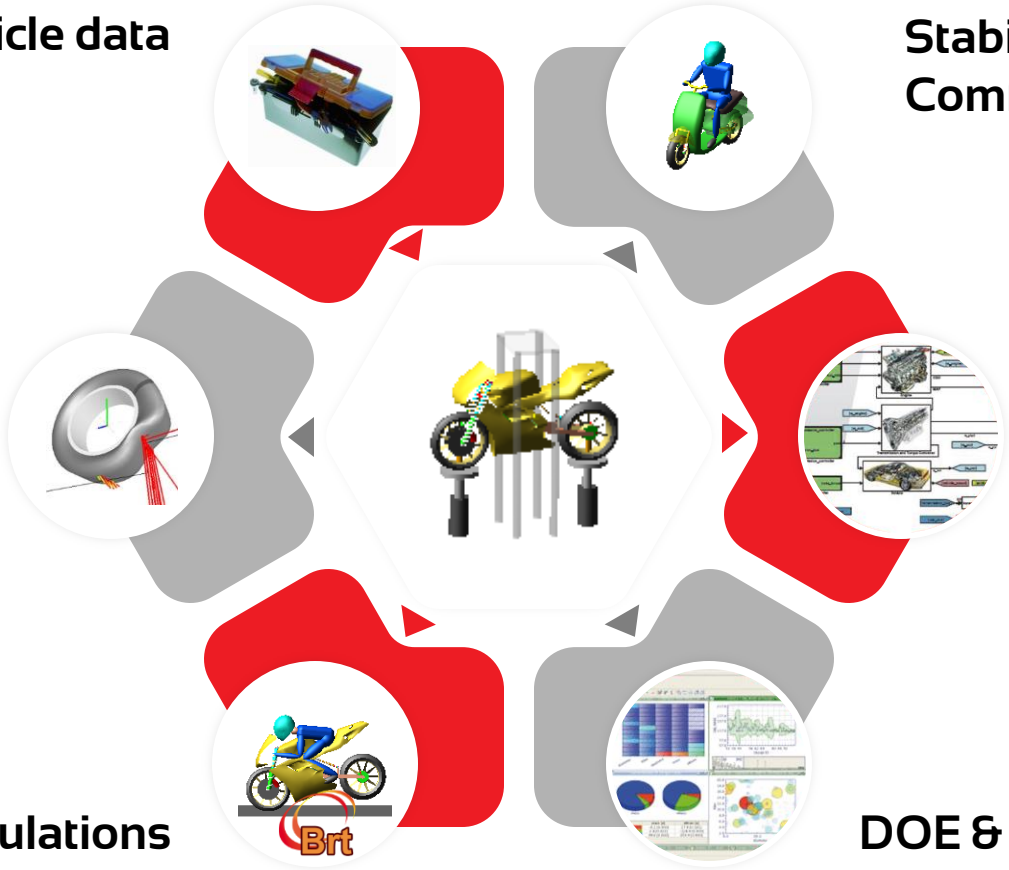
- FULL MULTIBODY DESIGN
- SYSTEM INTEGRATION AND SIMULATION FOR VIRTUAL SIGN OFF

VI-MOTORCYCLE



Vehicle data

Stability Traction/braking
Comfort Durability



Advanced Components

Control Systems

Real-time simulations

DOE & Optimization

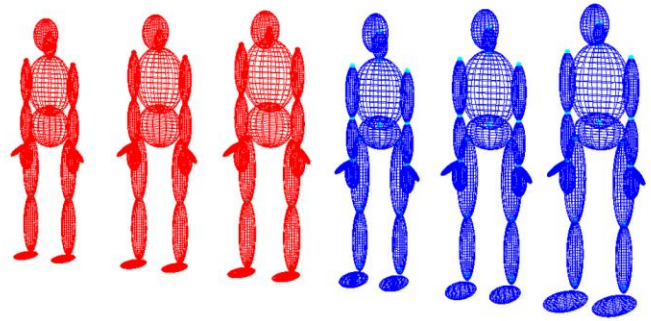
VI-MOTORCYCLE VEHICLE MODEL

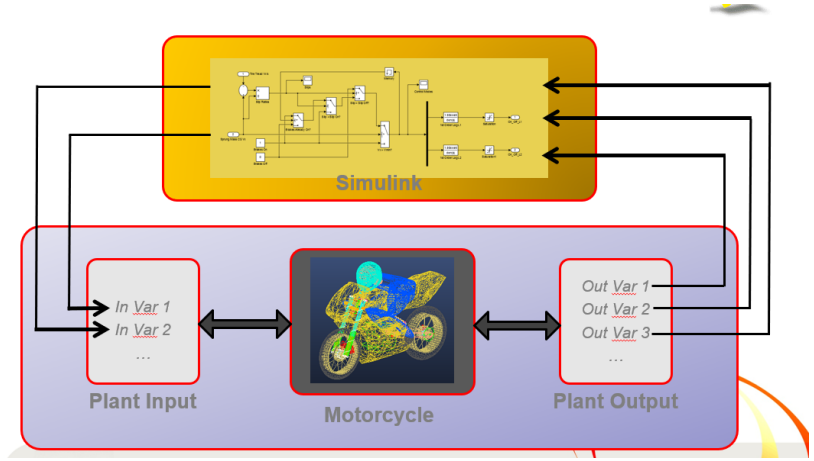
Vehicles types:

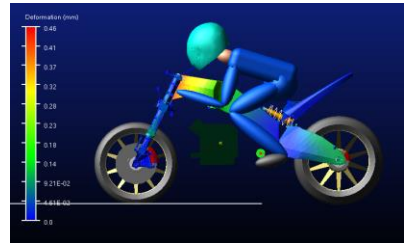
- 2, 3, 4-wheels tilting vehicles

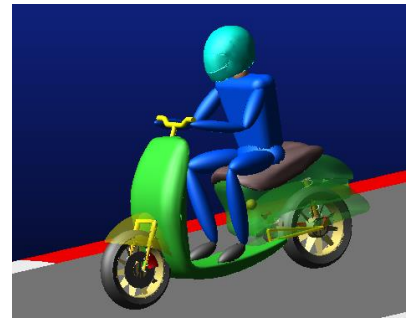
Models include:

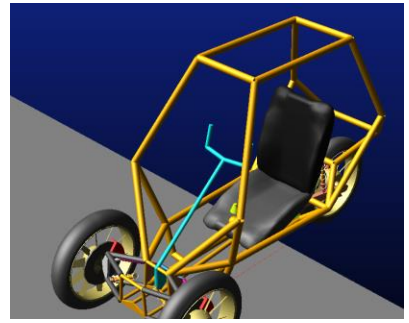
- Compliances, rigid & flexible bodies
- Control systems
- Human rider

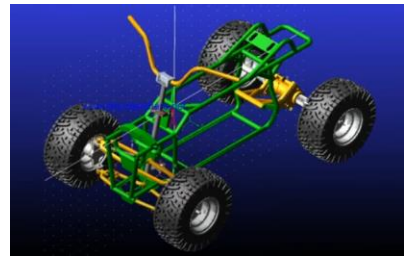








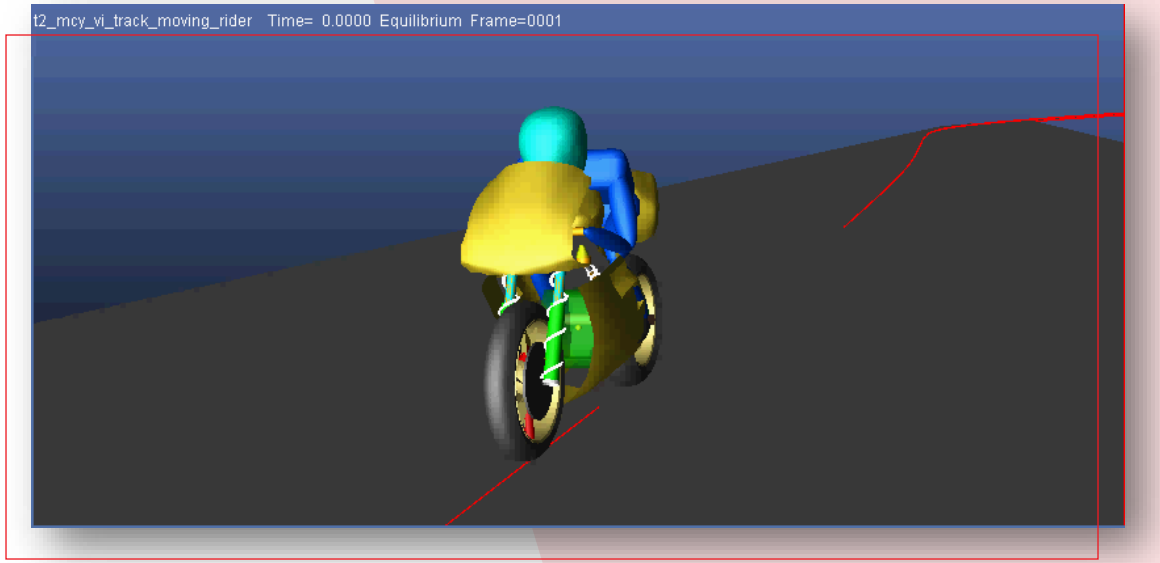


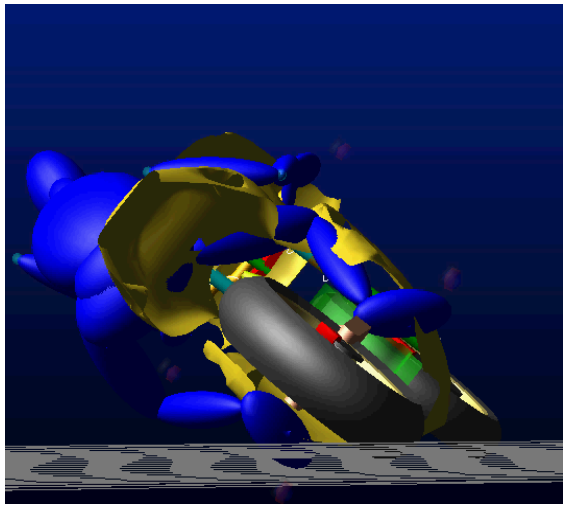


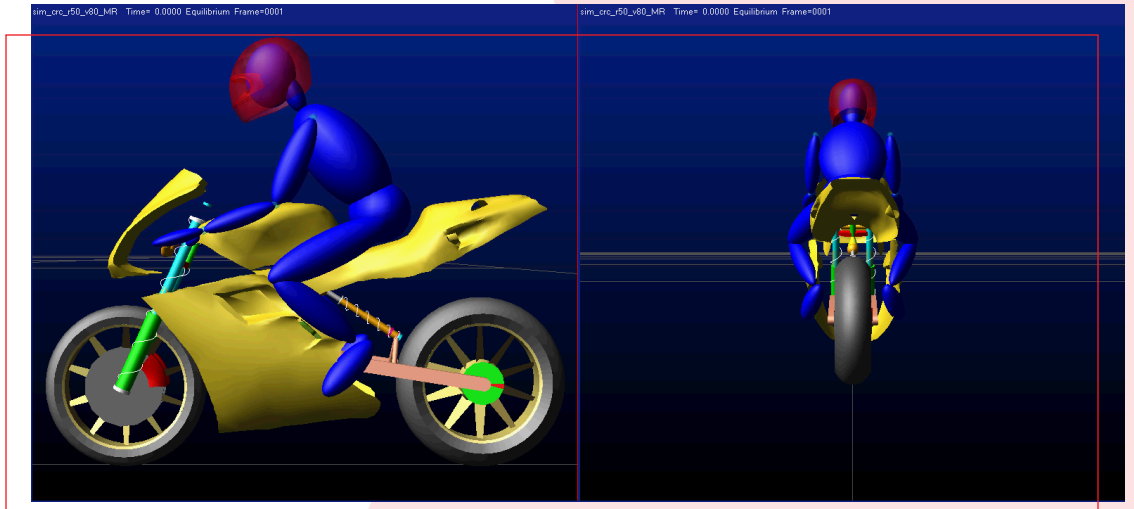
VI-MOTORCYCLE VEHICLE MODEL

Rider

- Fully parametrical
- Different postures available
- Estimation of mass and inertia properties
- Control mode on rider movement:
  - Open Loop (time, track position)
  - Closed Loop (vehicle states)
- Anthropomorphic Articulated rider
  - 16 segmented moving parts







ENVIRONMENT

Template Builder

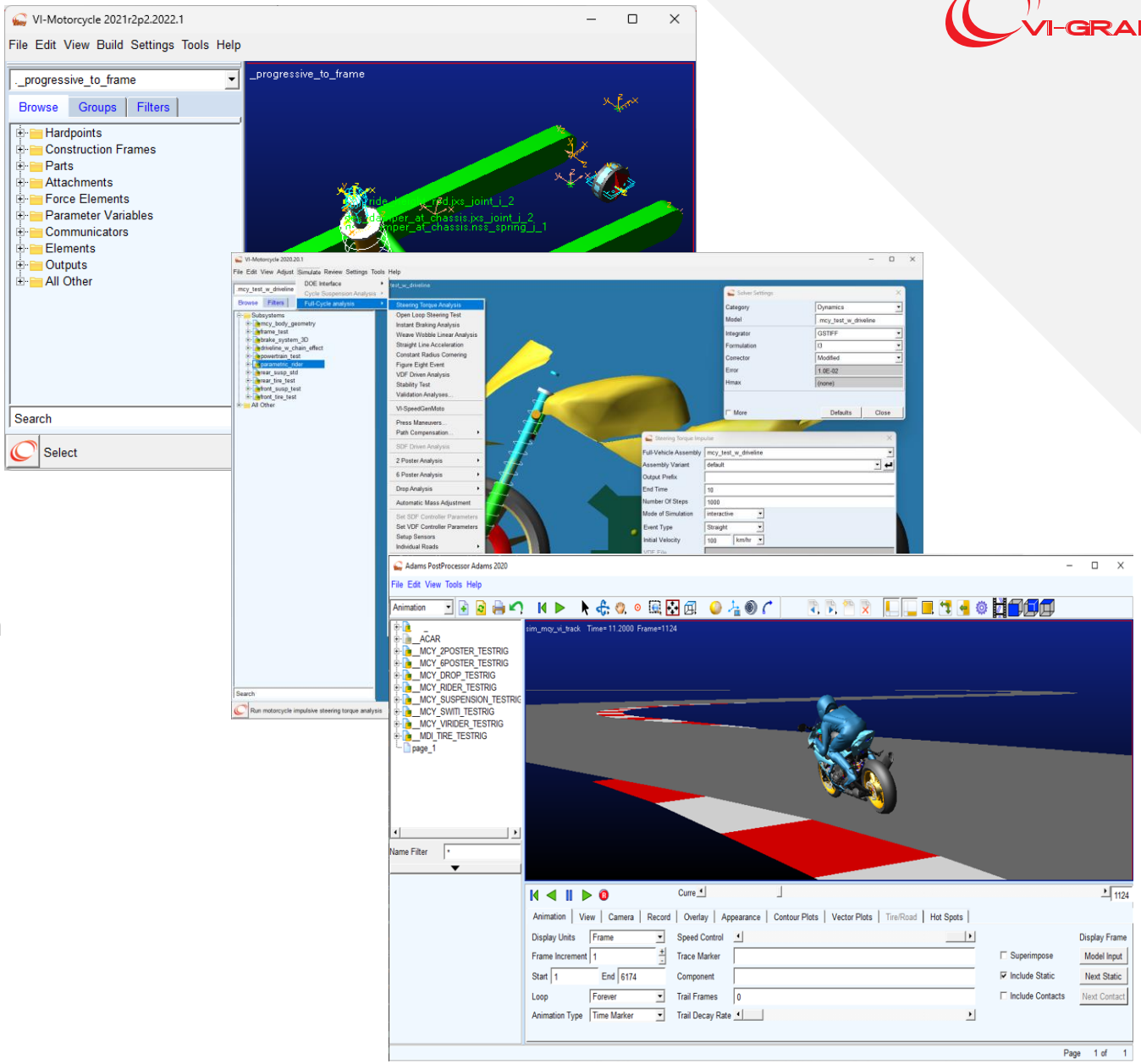
- Build and modify vehicle components
- Create topology and relation between parts
- Define the model parameters and parameterization

Standard Interface

- Create subsystems based on templates
- Assemble vehicle using components from the available databases
- Modify vehicle parameters
- Run Simulations

Post-Processor

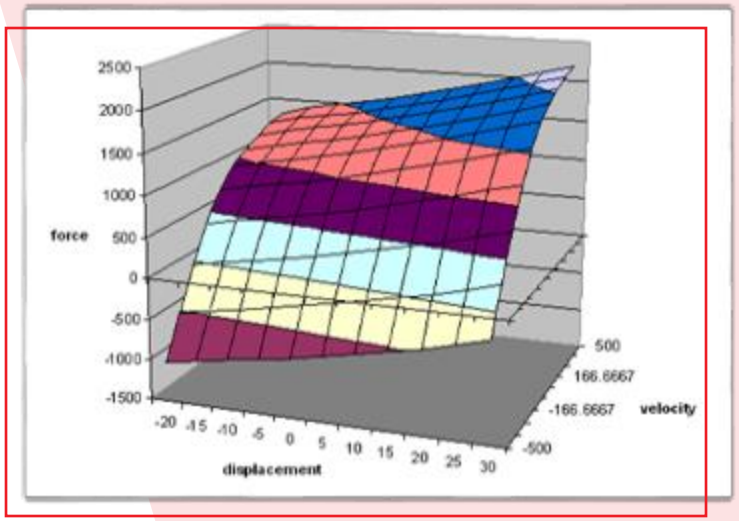
- Review results
- Review animation
- Analyze results

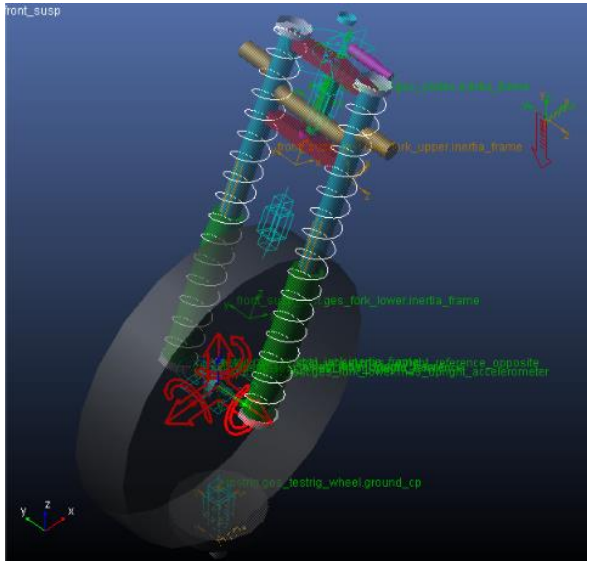


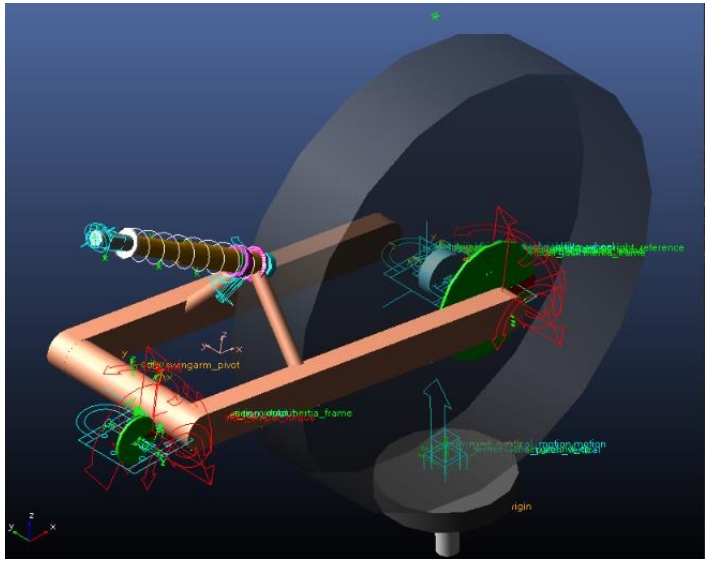
VI-MOTORCYCLE ANALYSIS

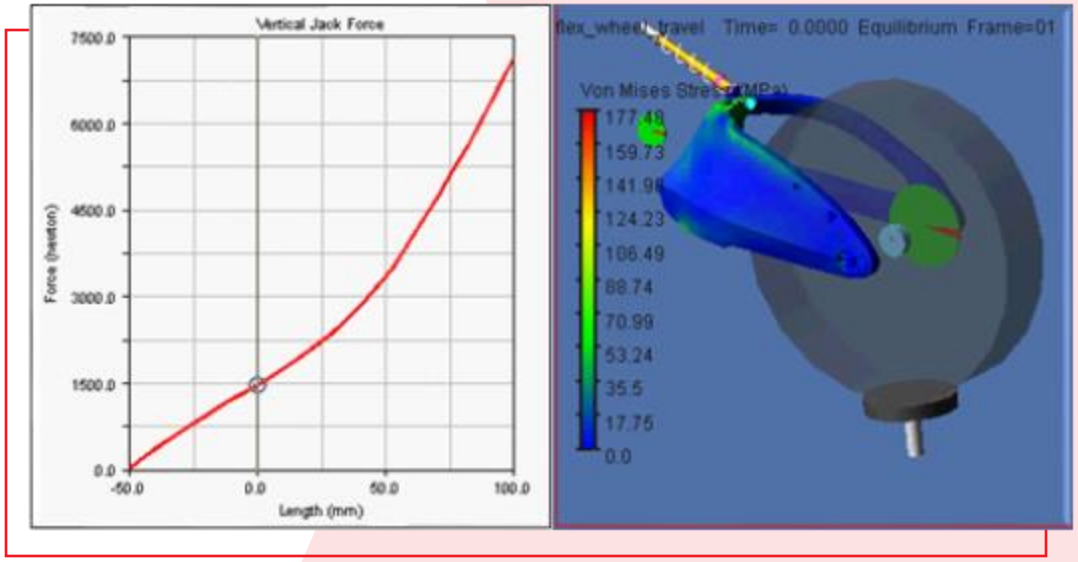
Suspension Analysis

- Investigate the elasto-kinematic behavior of the suspension sub-model by moving the tire contact patch along the vertical direction





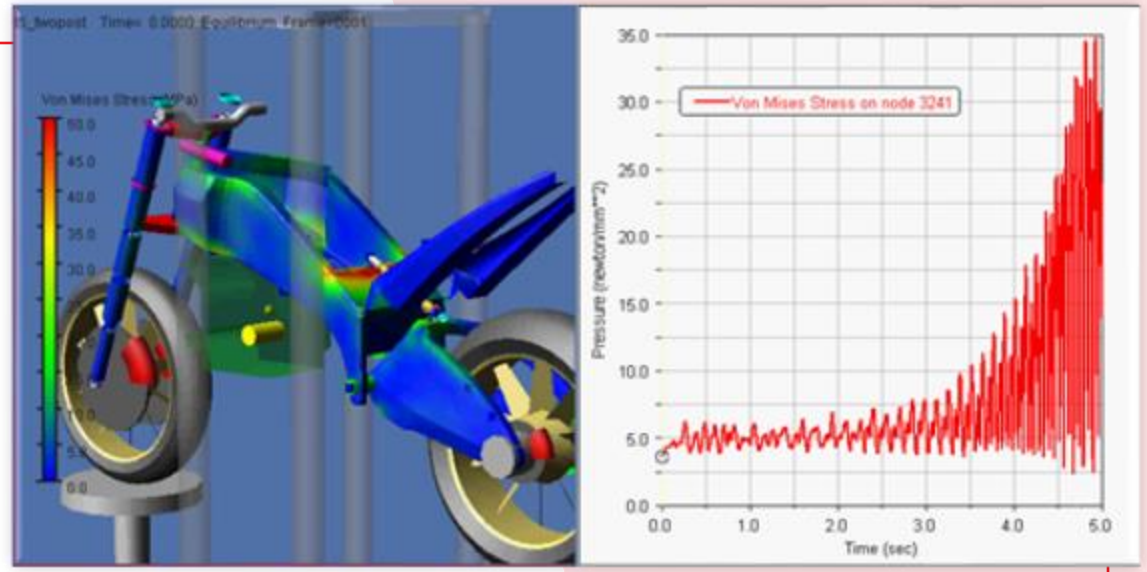


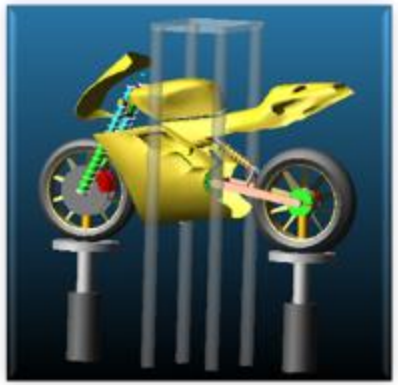


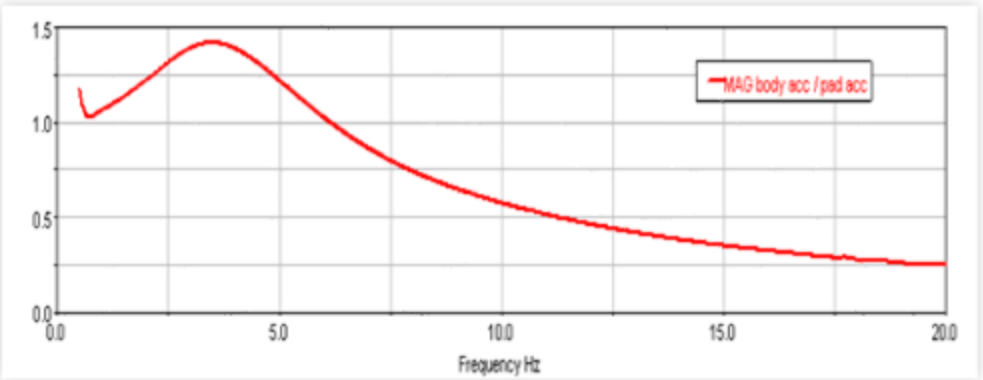
VI-MOTORCYCLE ANALYSIS

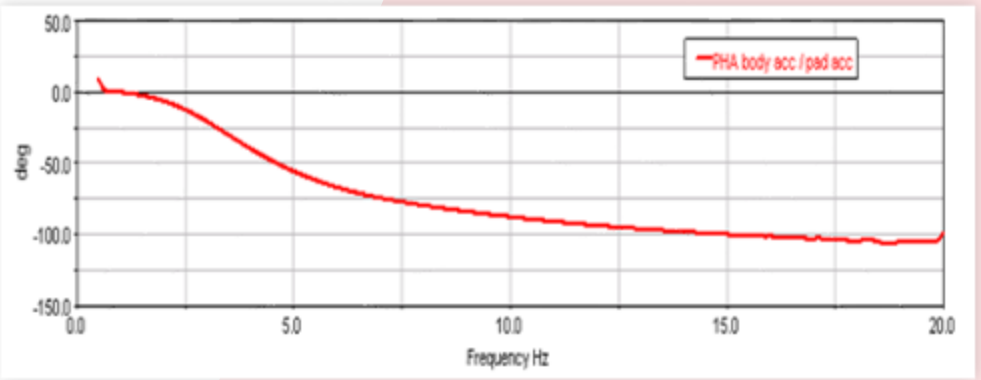
Two-Poster Testrig

- Investigate vertical dynamics by exciting its suspension subsystems
- Frequency Response Analysis
- Durability Analysis





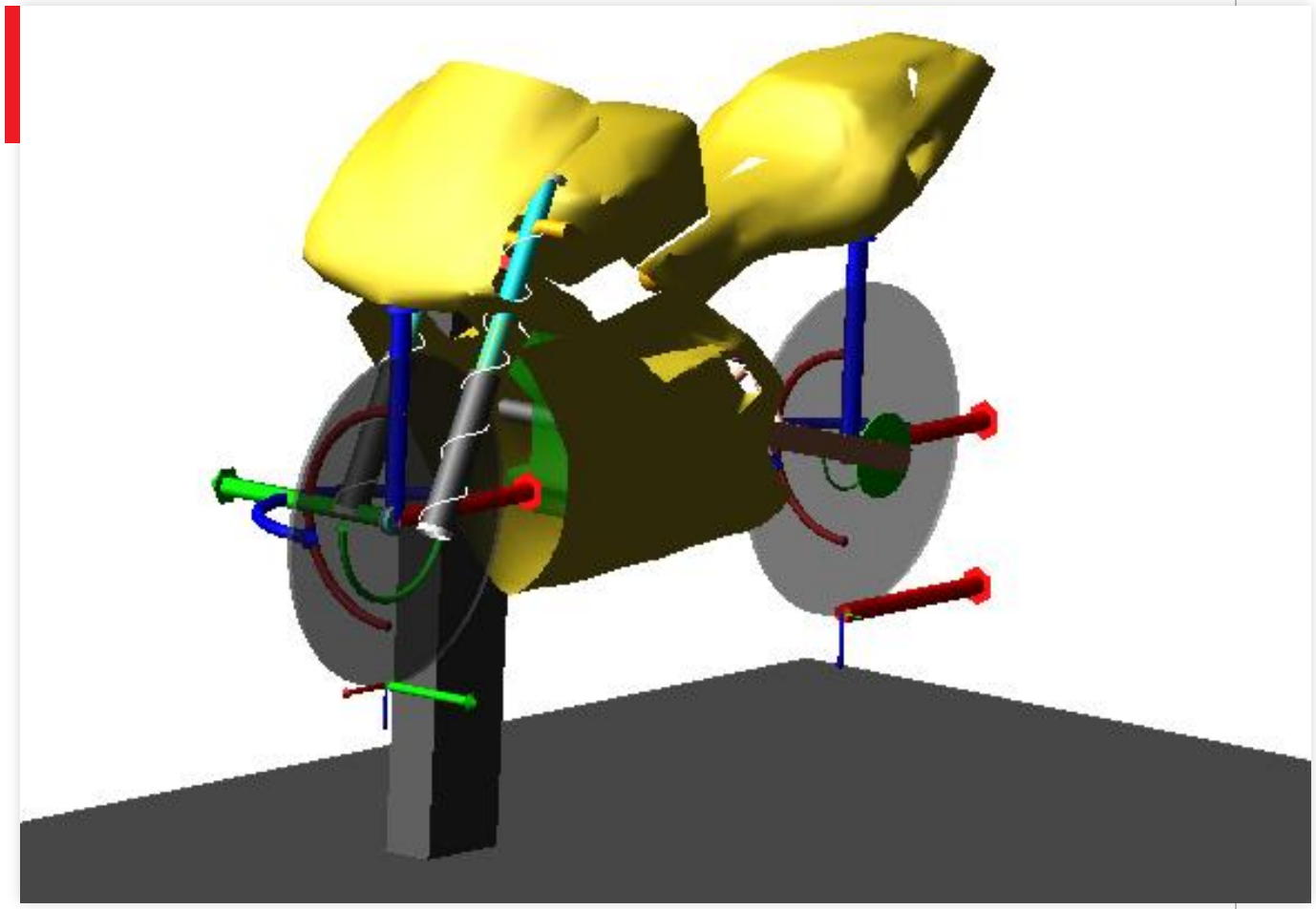




VI-MOTORCYCLE ANALYSIS

Six-Poster Testrig

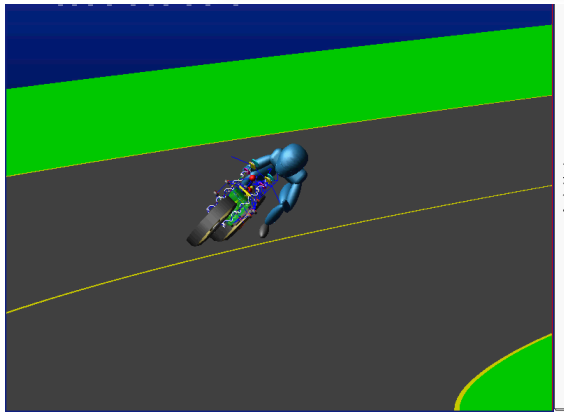
- Excites motorcycle dynamics
- Stiffness/Compliance analysis
- Frequency Response analysis
- 9 actuators per wheel
  - 6 actuators in wheel center (3 tra + 3 rot)
  - 3 actuators in theoretical Contact Patch (3 tra)
- 6 actuators on an additional part (3 tra + 3 rot)
- Analytic / time history input data
- Multiple testrig connections
  - Fixed joint on engine part
  - Revolute in swingarm pivot + hub constraint

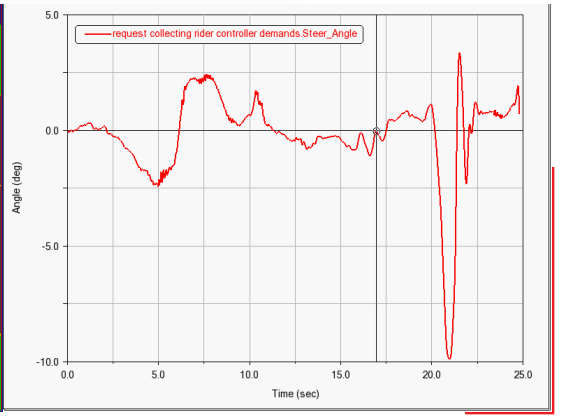


VI-MOTORCYCLE ANALYSIS

Full Vehicle R & H Analysis

1. Straight running
2. Steady state cornering
3. Figure eight
4. Straight Braking/Acceleration
5. Cornering Braking/Acceleration
6. Instant braking
7. Straight weave and wobble
8. Cornering weave and wobble
9. Vibration Mode Analysis
10. U-turn
11. Lane-change
12. Slalom
13. FRF Analysis
14. Kick-back
15. Handling course
16. Racetrack simulations

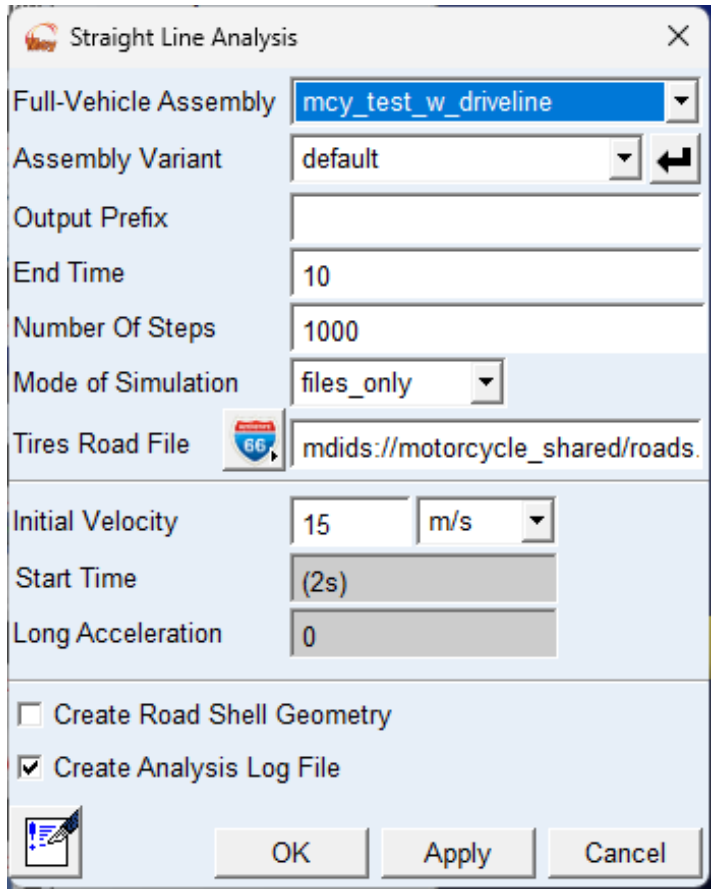




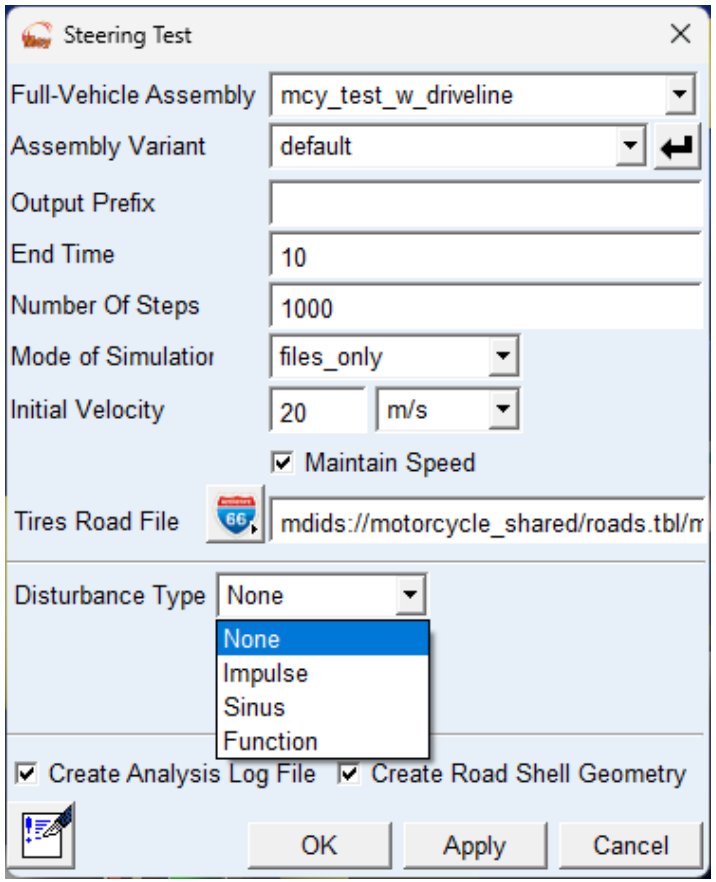
VI-MOTORCYCLE SIMULATIONS

Examples of predefined Full Vehicle analysis GUI:

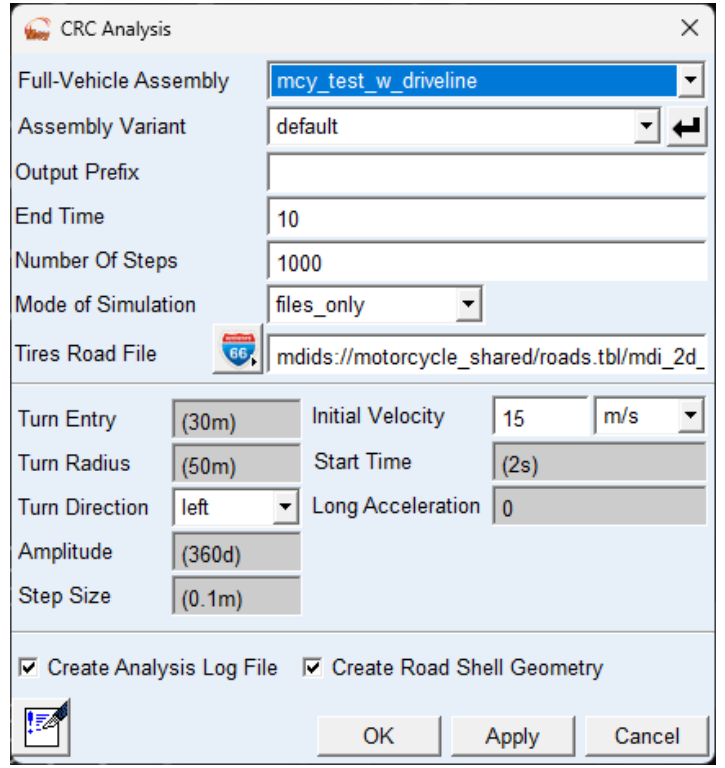
Straight Line Analysis



Steering Test



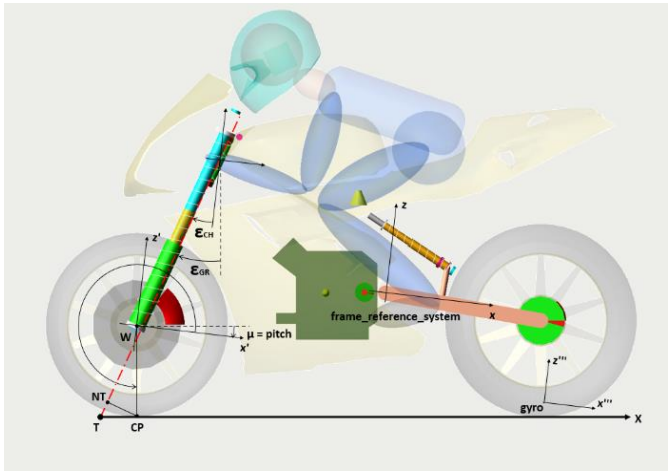
Steady State Cornering

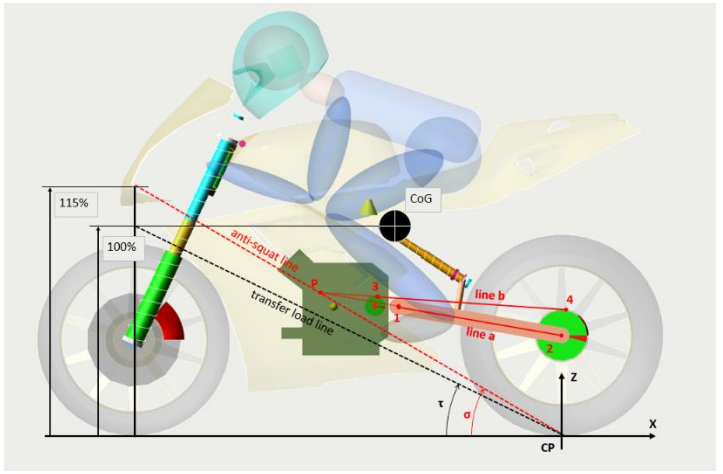


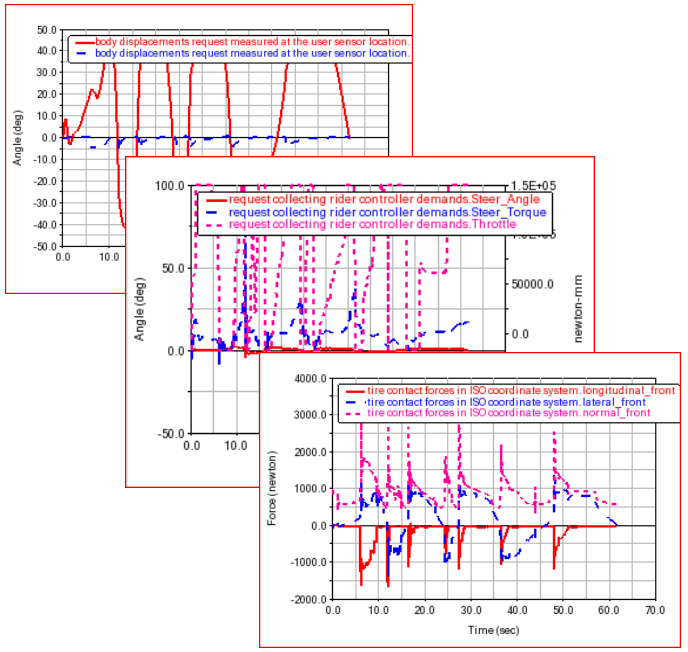
VI-MOTORCYCLE SIMULATIONS

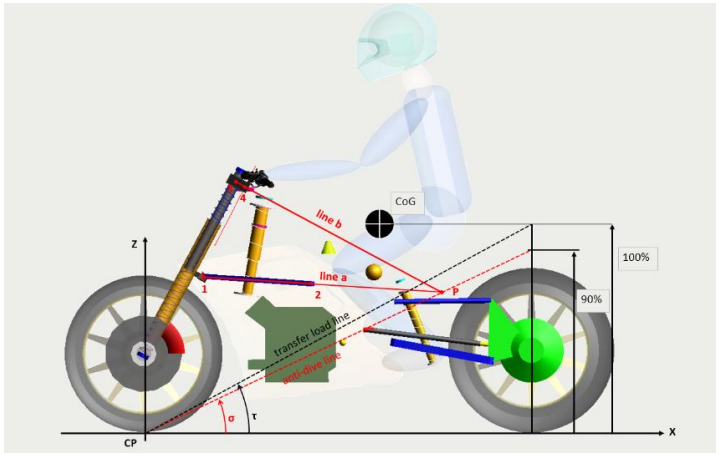
Example of Outputs:

- Chassis parameters
  - Rake angle
  - Trail/Normal trail
  - Wheelbase
  - Center of gravity
  - Anti-dive ratio
  - Anti-squat ratio
  - Anti-rise ratio
- Vehicle states
- Driver demands
- Powertrain outputs
- Components outputs
  - Springs
  - Dampers
  - Bushings
  - .....
- Tires
  - Force and Moments
  - Rolling states
  - Kinematics
- .....









VI-MOTORCYCLE SIMULATIONS

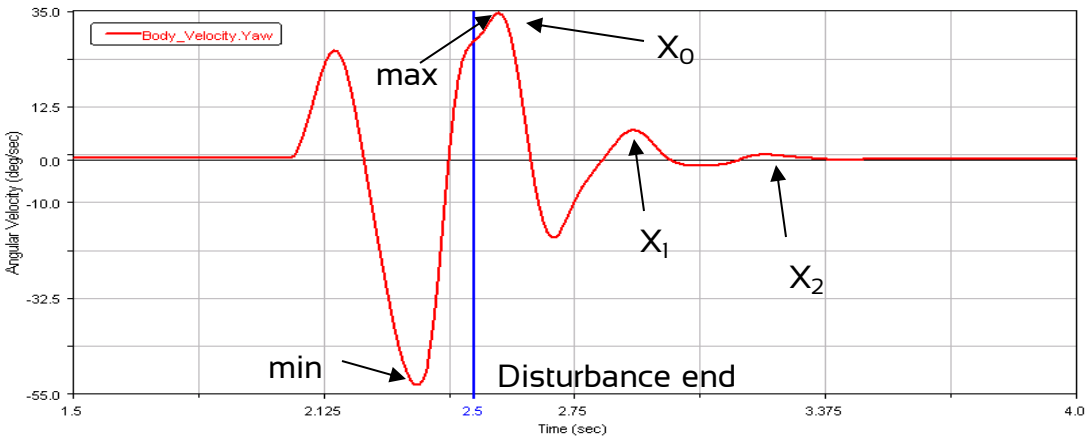
Stability Test

The stability test is a user configurable procedure for submitting multiple straight line time domain analyses

Calculations of stability metrics

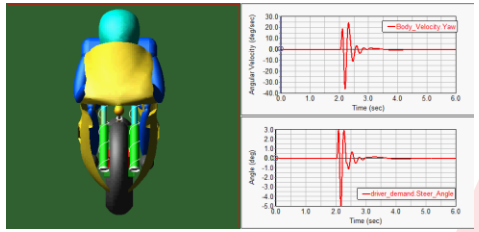
Disturbance applied to the handlebar

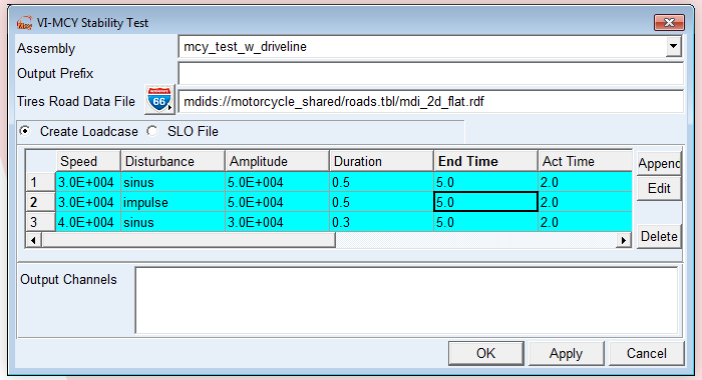
Automatic post processing of results

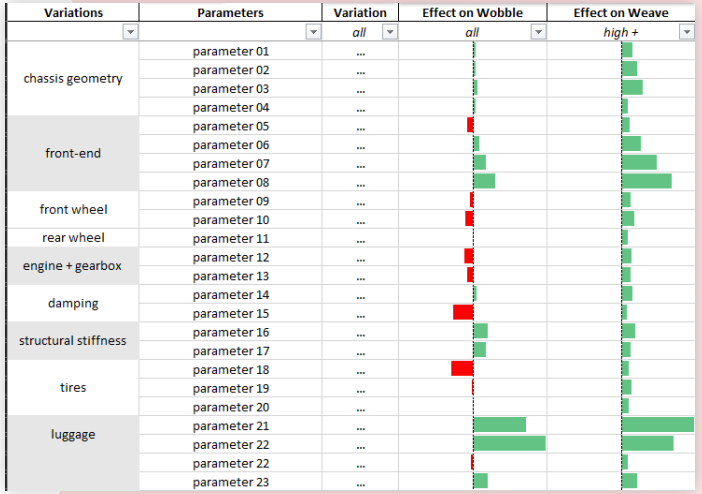


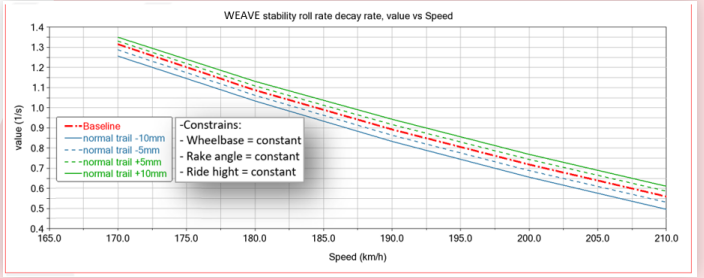
$$dmp = \frac{1}{(n-1)} \ln(abs(\frac{X_1}{X_n}))$$

$$freq = \frac{(n-1)}{(t_3 - t_1)}$$





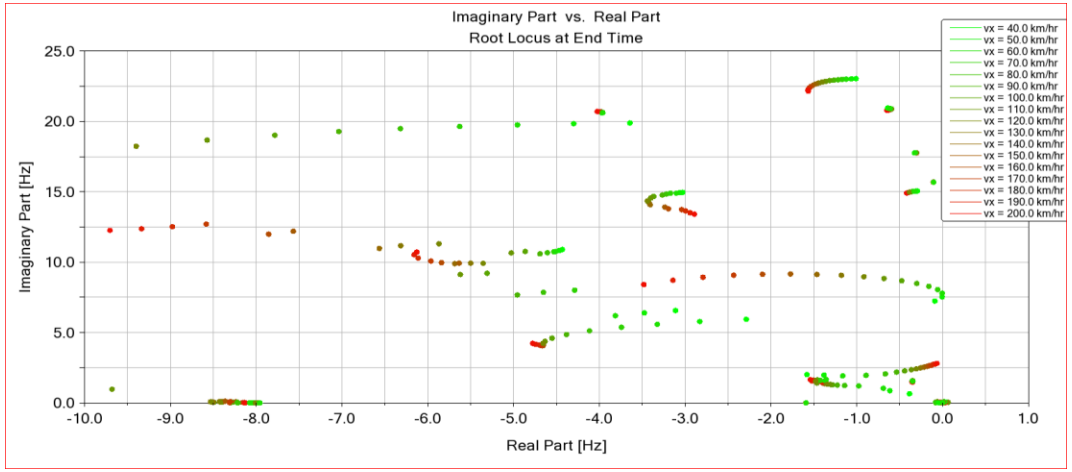




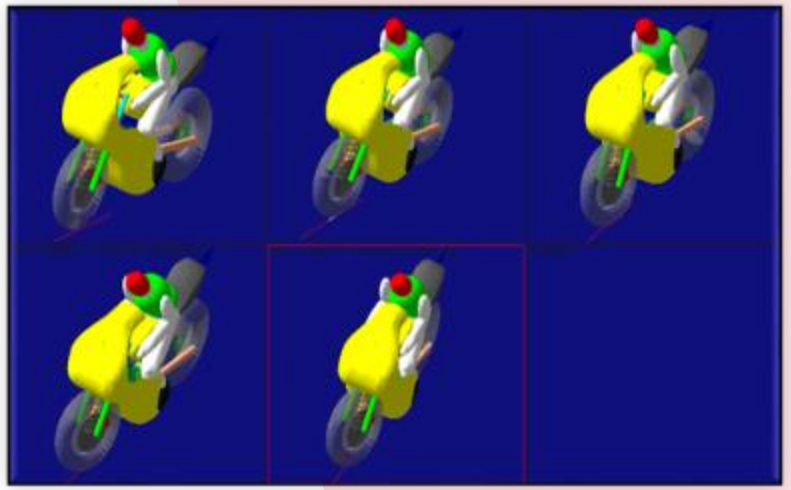
VI-MOTORCYCLE SIMULATIONS

Vibration Modes Analysis

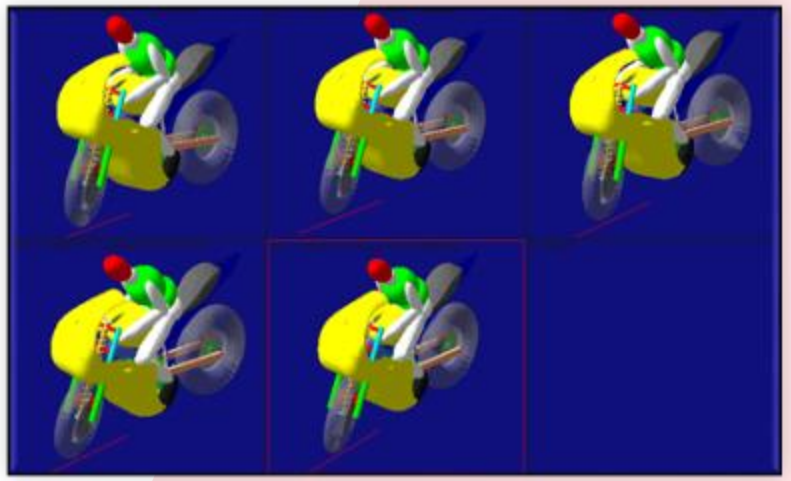
- Vibration modes can be animated in Post-Processor
- Running multiple analysis at different speeds
- Root-locus plot



WEAVE



WOBBLE



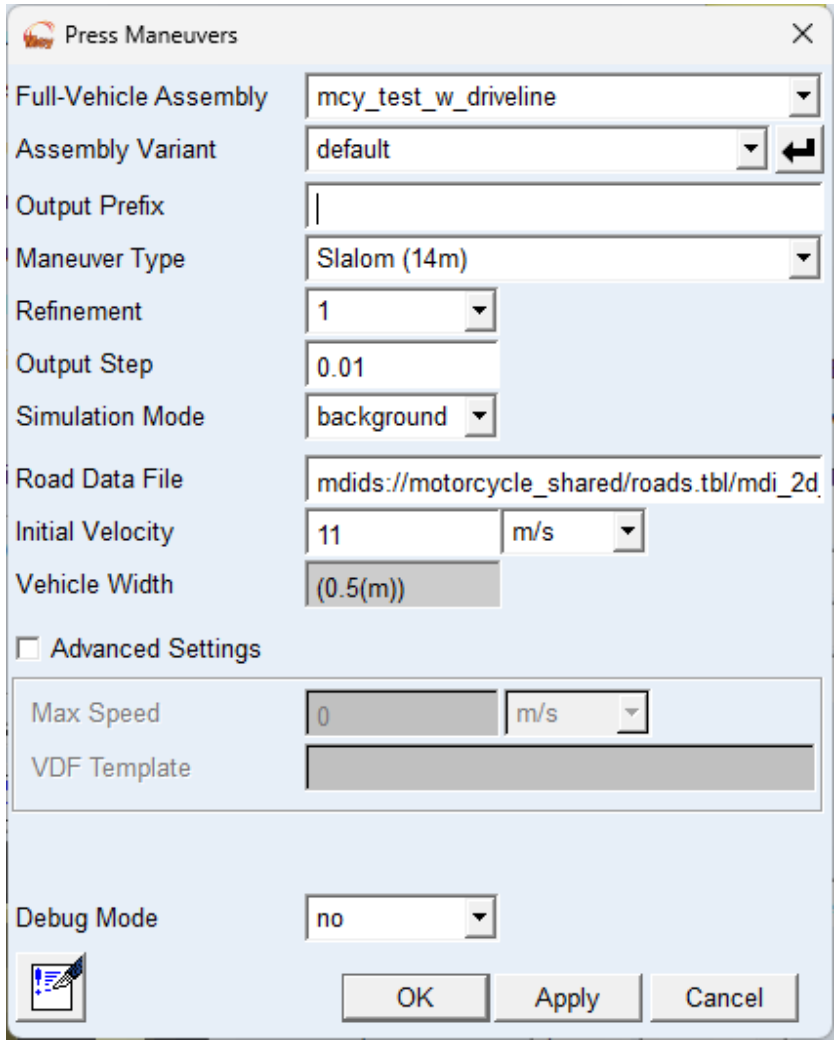
VI-MOTORCYCLE SIMULATIONS

PressManeuverMoto (slalom)

Genetic algorithm identifies best combination of trajectory and velocity (maximum) featuring a no cone hit situation

Learning: collect data from vehicle dynamics

Adapting: using information coming from previous trials, updating the trajectory and pushing the speed.



VI-MCY SIMULATIONS

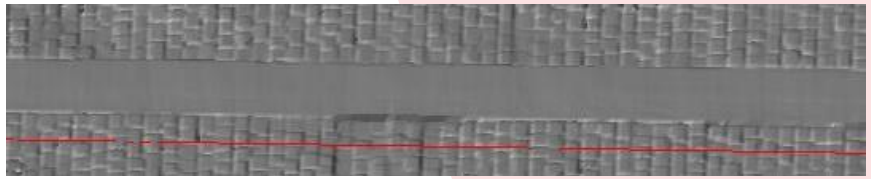
Durability Simulations

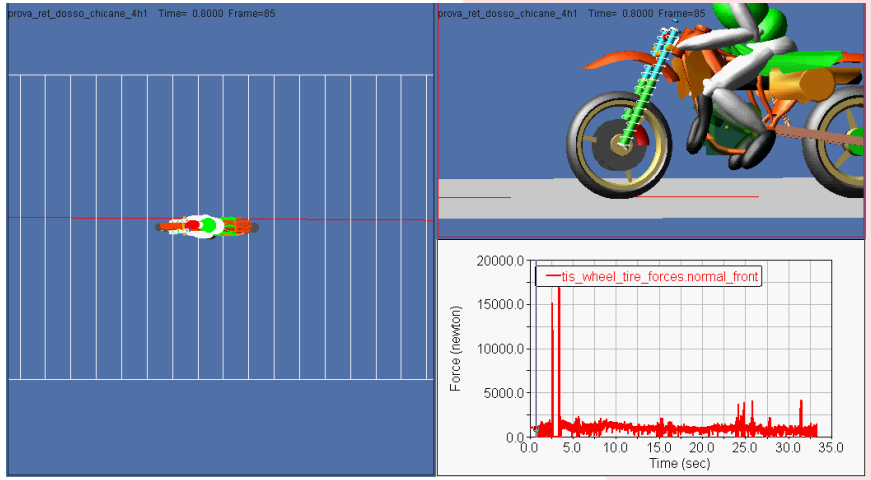
Components load prediction for durability analysis

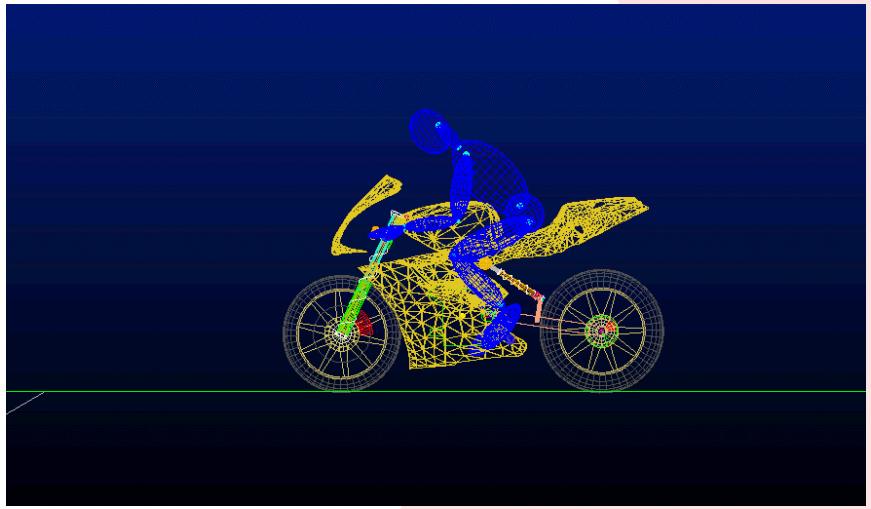
Simulation of special events:

- Running over a curb
- Sequence of potholes
- Jump
- Wheelie
- Stoppie

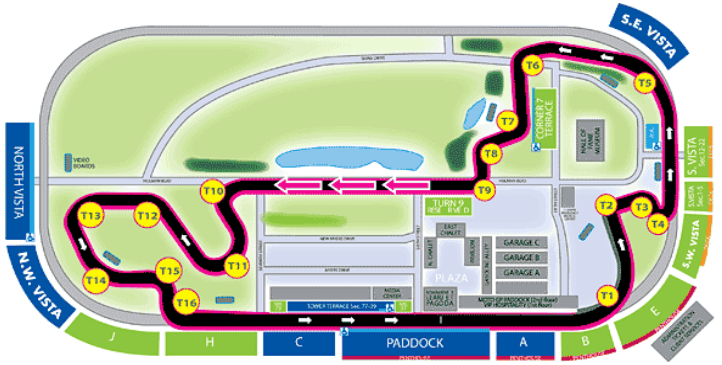
PSD road data or deterministic disturbances can be added to smooth 3D road profile





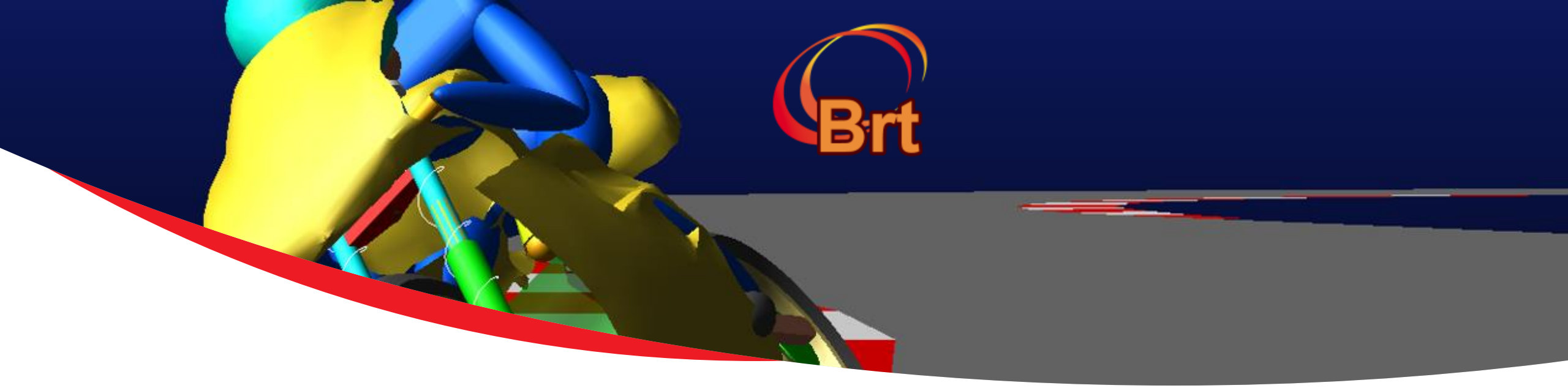


VI-MOTORCYCLE SIMULATIONS

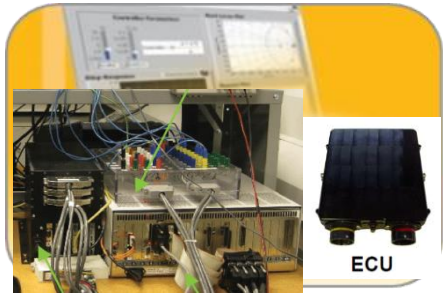


Racetrack Simulations:

- 3D track reconstruction
- Trajectory and speed from GPS and telemetry data
- Tire residual forces computation: VI-Tire Limits Module



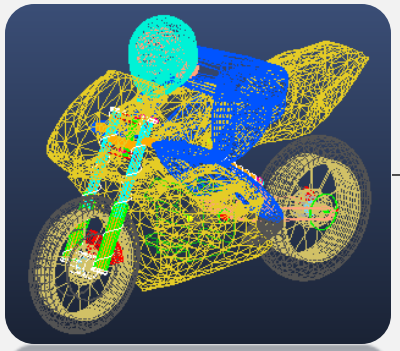
VI-GRADE



VI-BIKEREALTIME:

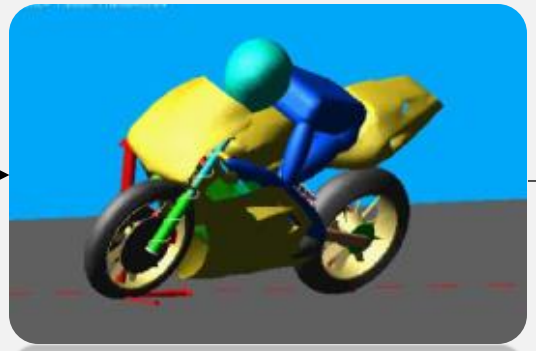
- MULTIBODY DESIGN
- SYSTEM INTEGRATION AND SIMULATION FOR VIRTUAL SIGN OFF

VI-BIKEREALTIME



VI-Motorcycle DB

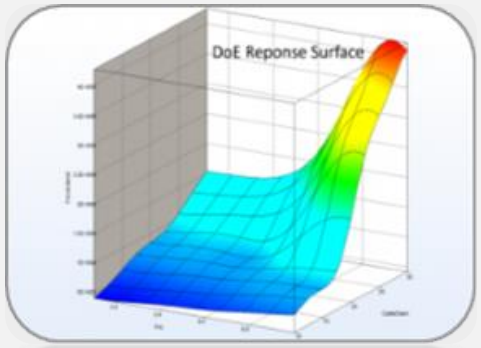
Modelling



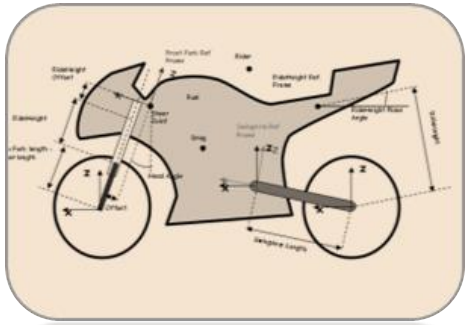
VI-BikeRealTime

Analysis

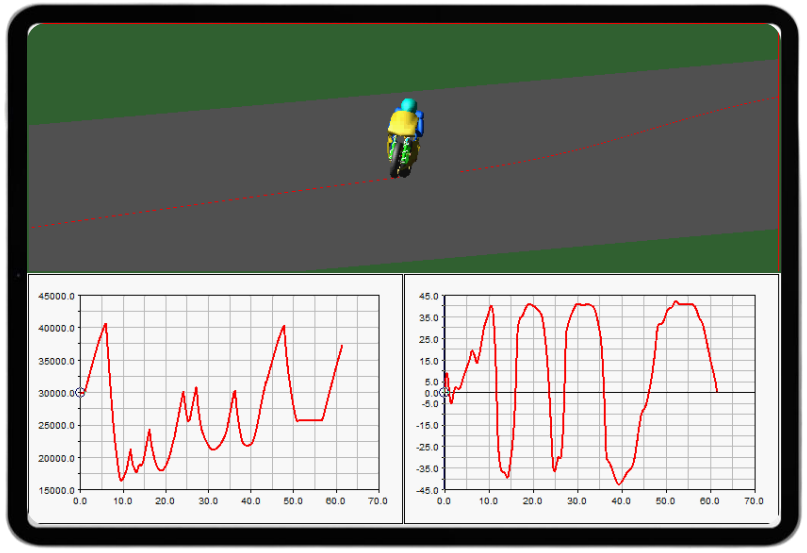
Ride & Handling

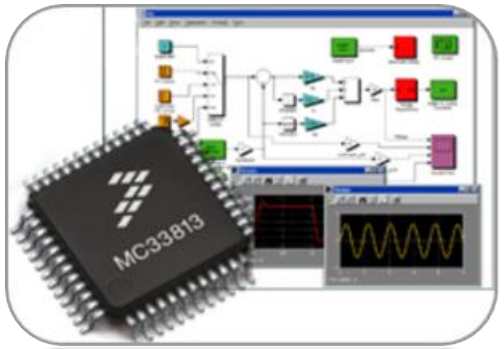


DOE / Optimizations

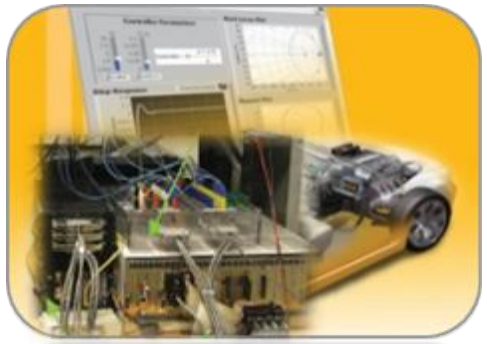


VI-BikeRealTime DB





SIL

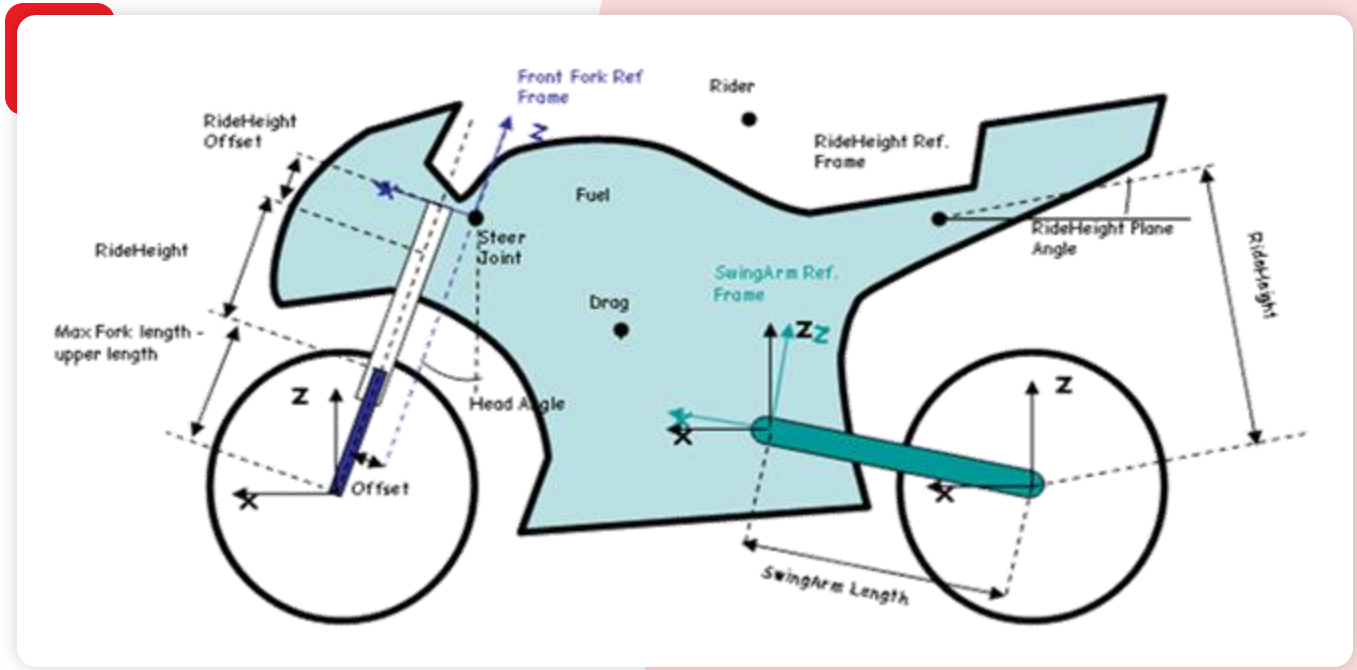


HIL

VI-BIKEREALTIME VEHICLE MODEL

Vehicle Model: the motorcycle is modeled using 11 dofs defined as follows:

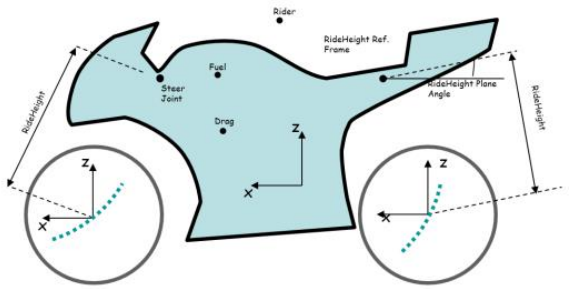
- 6 for chassis part
- 1 for relative translation between upper and lower front fork
- 1 for relative rotation between chassis and swingarm part
- 1 for relative rotation between front wheel and lower fork part
- 1 for relative rotation between rear wheel and swingarm part
- 1 for relative rotation between pinion and chassis
- The steering dof is controlled via motion



VI-BIKEREALTIME VEHICLE MODEL

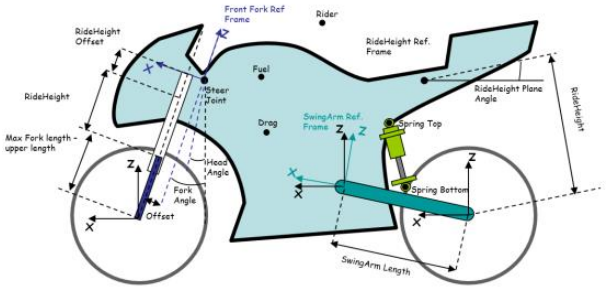
There are three **variants** to the Standard Model:

01 Conceptual

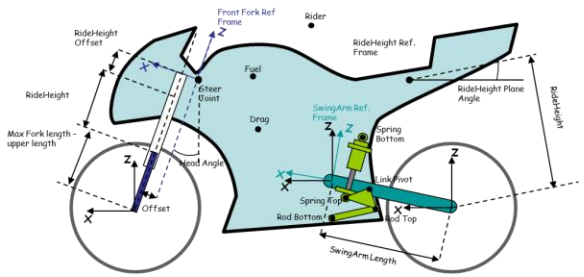


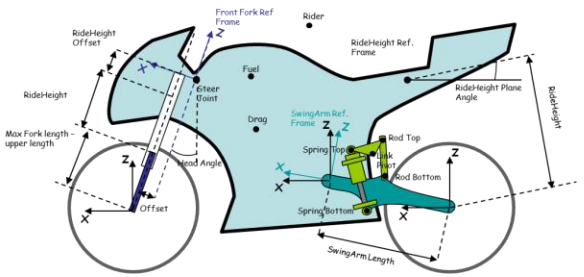
- uses wheel displacement curve and progression curve as a function of vertical wheel displacement for both front and rear suspension, no linkages are present
- any type of suspension can be modeled

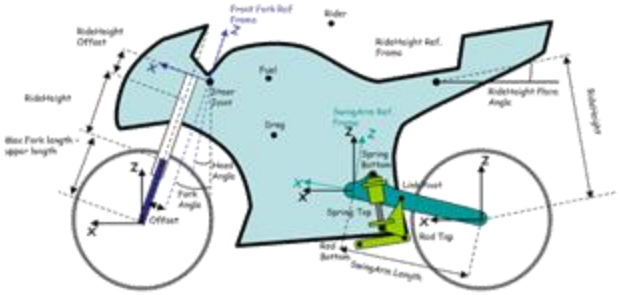
02 Direct Shock



03 Progressive Linkages



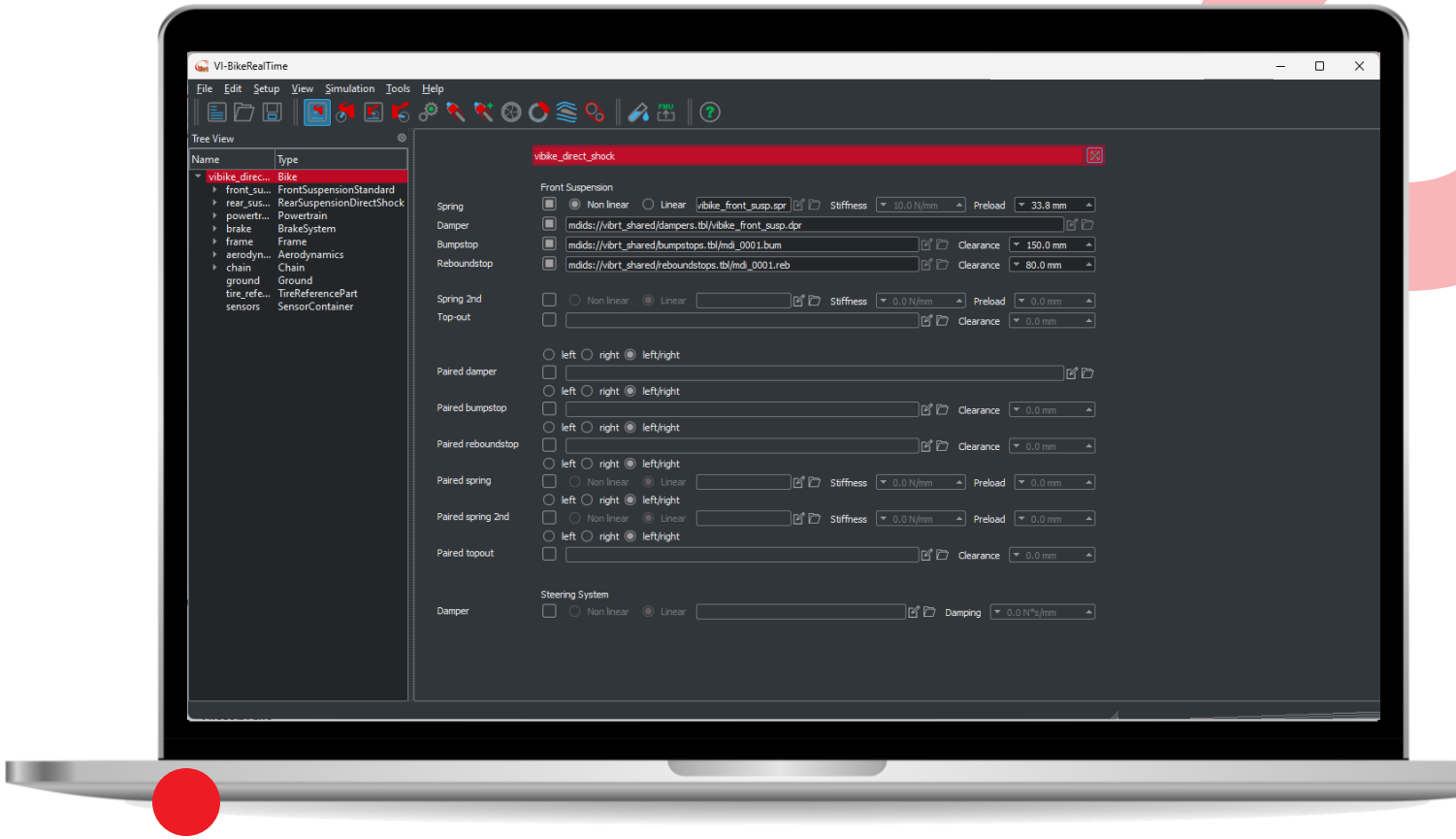




VI-BIKEREALTIME GRAPHICAL USER INTERFACE

VI-BRT GUI:

- Front Suspension Setup
- Front Suspension
- Rear Suspension Setup
- Rear Suspension
- Powertrain Setup
- Frame
- Additional Parts
- Wheels
- Brakes
- Aerodynamics
- Transmission
- User Sensors
- Simulation
- Post-processing



VI-BIKEREALTIME SIMULATIONS

Simulations panel

- **Dynamic Analyses** (VDF)
- **Suspension Analyses** (test-rig)
- **SpeedGenMoto** (speed static profile evaluation)
- **MaxPerformanceMoto** (compute bike max performance)
- **PressManeuverMoto** (compute bike max performance)

VI-BIKEREALTIME SIMULATIONS

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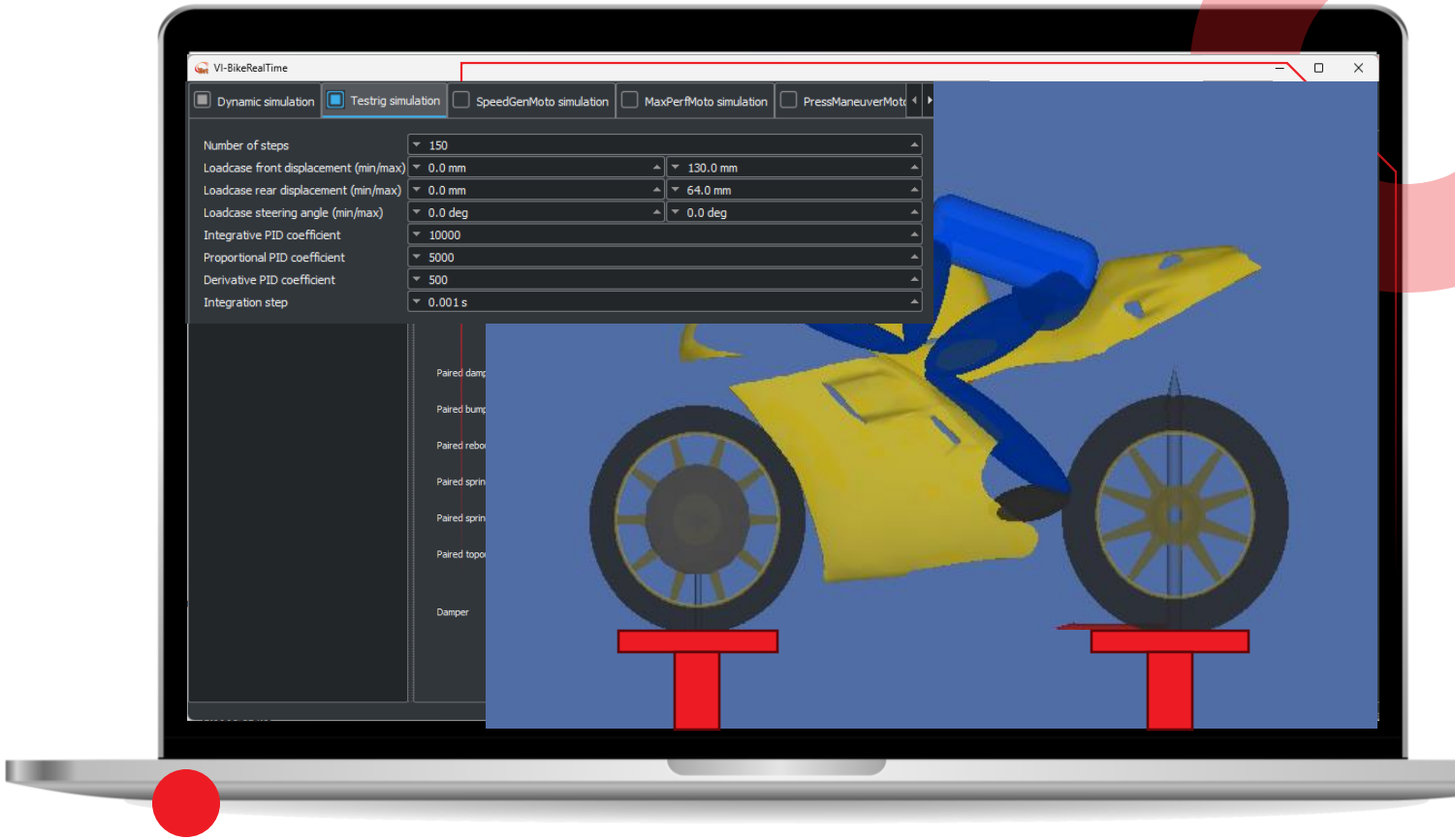


VI-BIKEREALTIME SIMULATIONS

Simulations panel

- **Dynamic Analyses** (VDF)
- **Suspension Analyses** (test-rig)
- **SpeedGenMoto** (speed static profile evaluation)
- **MaxPerformanceMoto** (compute bike max performance)
- **PressManeuverMoto** (compute bike max performance without hitting cones)

VI-BIKEREALTIME MODULES

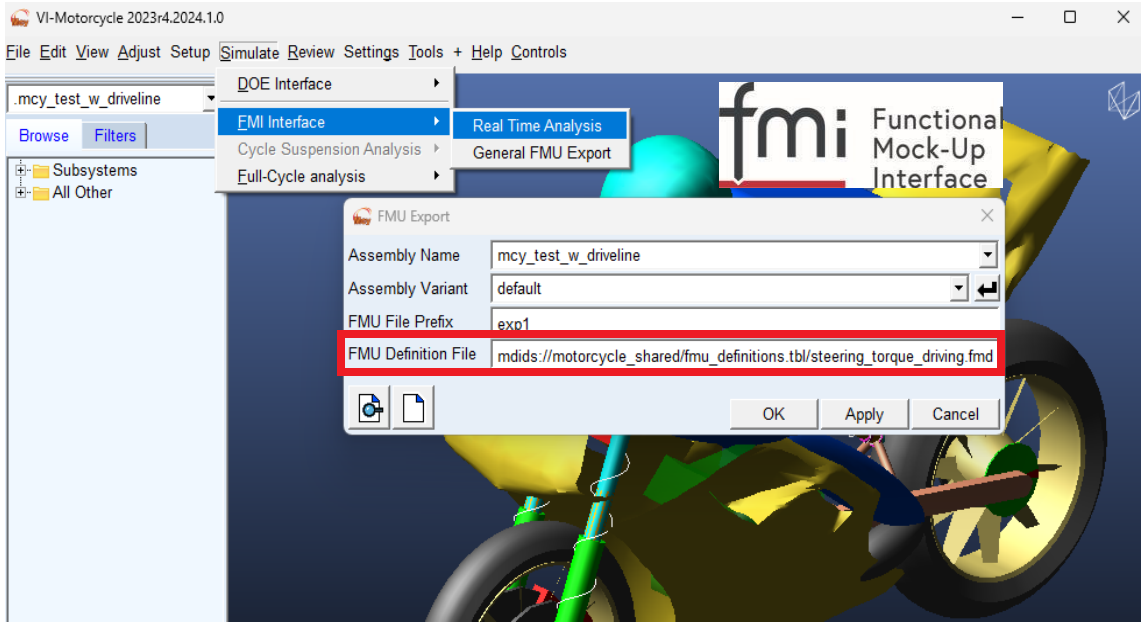
Additional Modules:

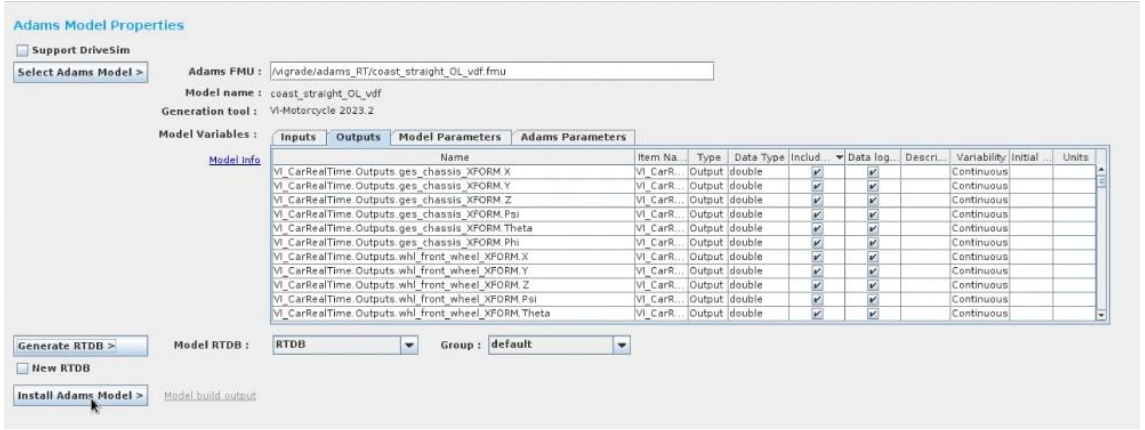
- **VI-EventBuilder** for creating and editing event files (VDF)
- **VI-Rider** the advanced rider model for vehicle lateral/longitudinal control
- **VI-Tire** the interface to the tire model
- **VI-TireLimits** for checking tire file (TIR) performance
- **VI-Road** for road data file (RDF) management
- **VI-Animator** for results post-processing
- **VI-BRT Matlab/Simulink cosimulation** for cosimulation with controls systems developed in MATLAB/Simulink

VI-MOTORCYCLE 2024.2

WHAT'S NEW

- FMU Export (FMI 2.0)
  - SIMulation Workbench® – VI-DriveSim
  - FMD file to configure I/O interface
  - VI-Motorcycle Solver for Linux

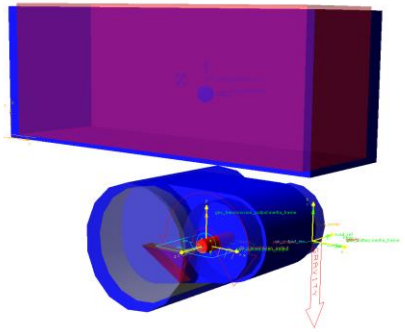


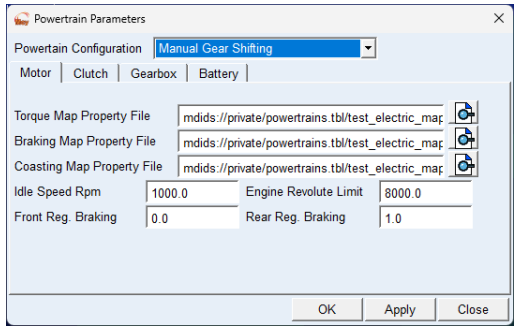


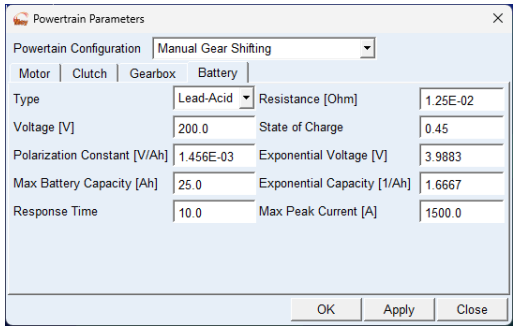
VI-MOTORCYCLE 2024.2

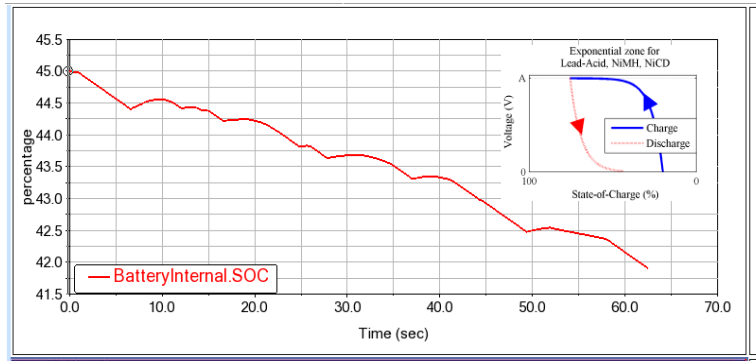
WHAT'S NEW

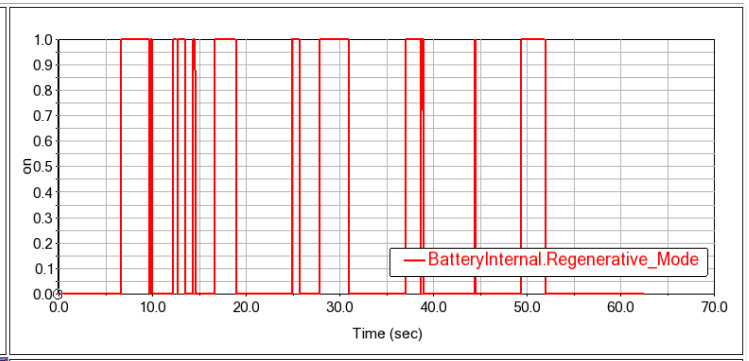
- New Electric Powertrain Template
  - E-motor
    - Torque Map
    - Braking Map
    - Coasting Map
    - Regeneration
  - Battery Model
    - Charge/Discharge
  - Custom Dialog Box

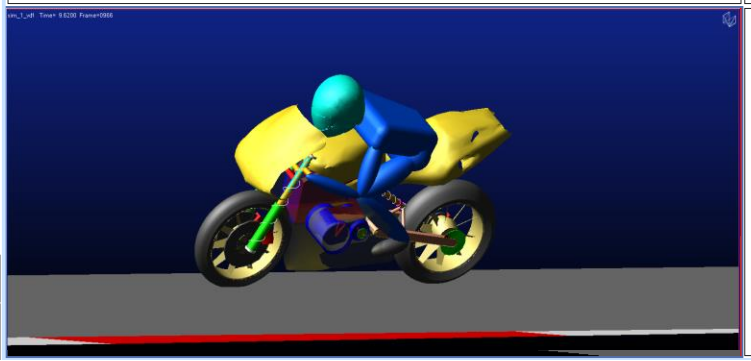


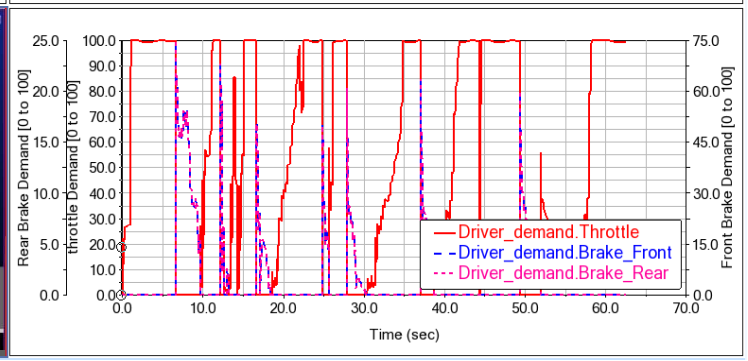












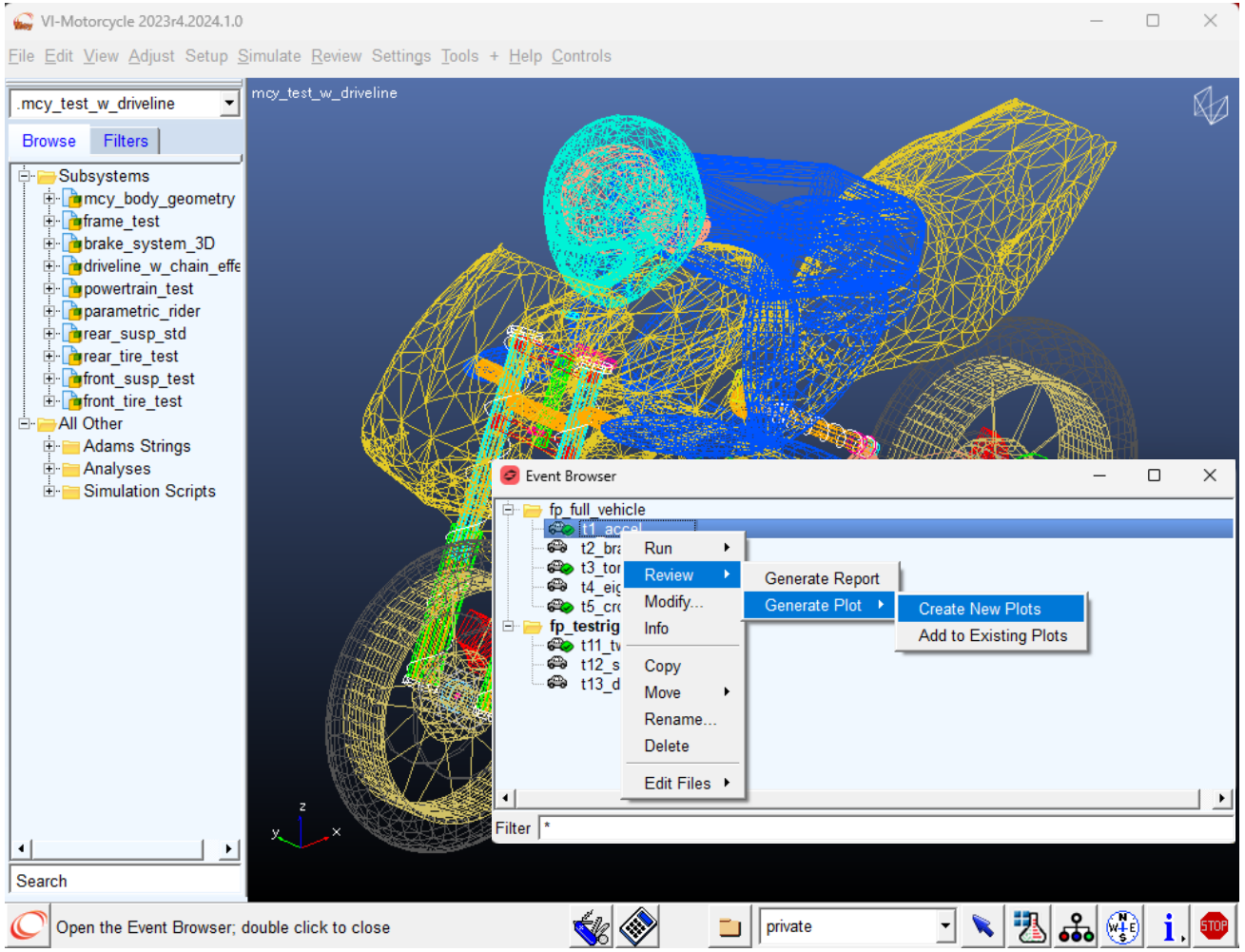
VI-MOTORCYCLE 2024.2

WHAT'S NEW

- Based on Adams 2023.4.1

- Event Browser Integration
  - Fingerprints
  - Automatic Plots
  - Replace Assembly in Events

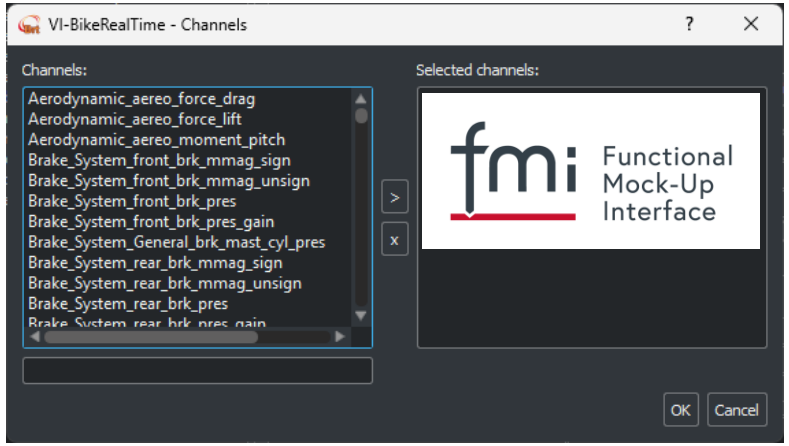
- Bug fixing

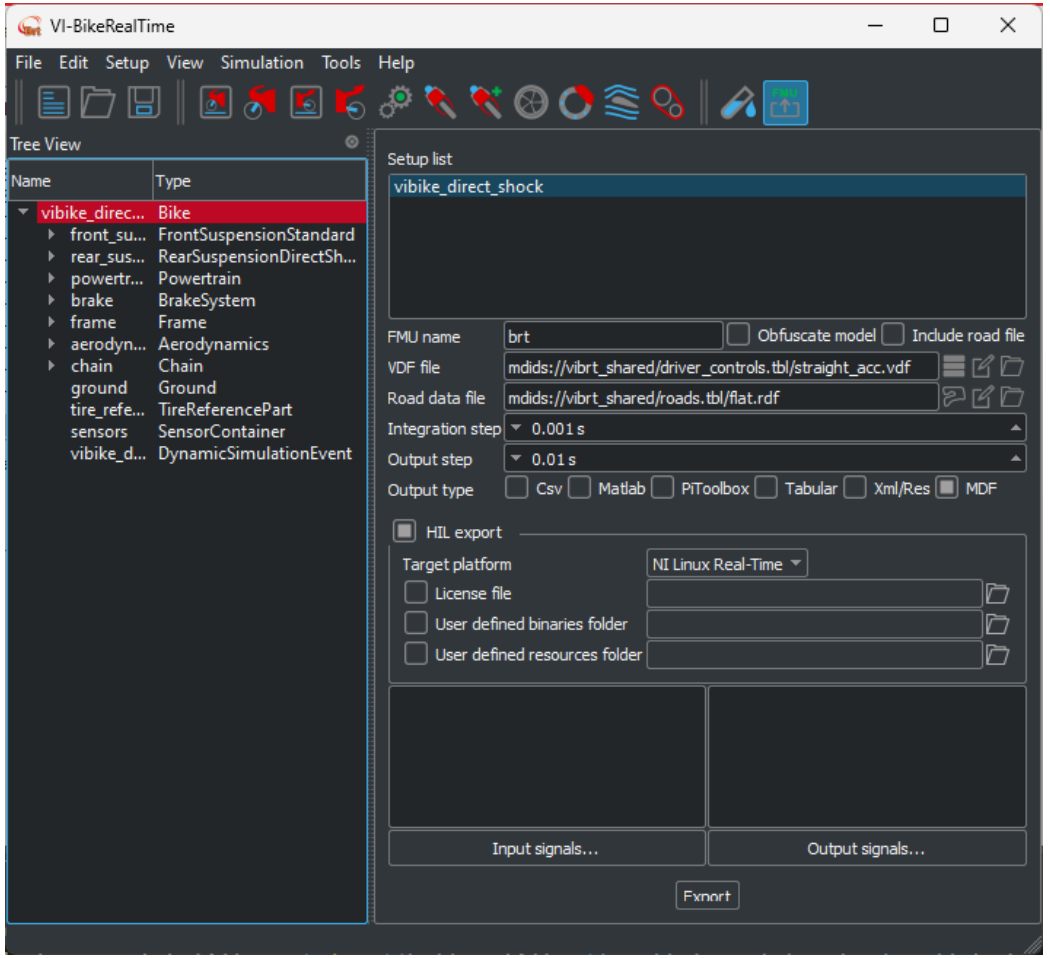


VI-BIKEREALTIME 2024.2

WHAT'S NEW

- FMU Export (FMI 2.0.3)
  - NI Linux Real Time
  - Event as cosimulation tool-coupling
  - Dialog box to configure I/O interface

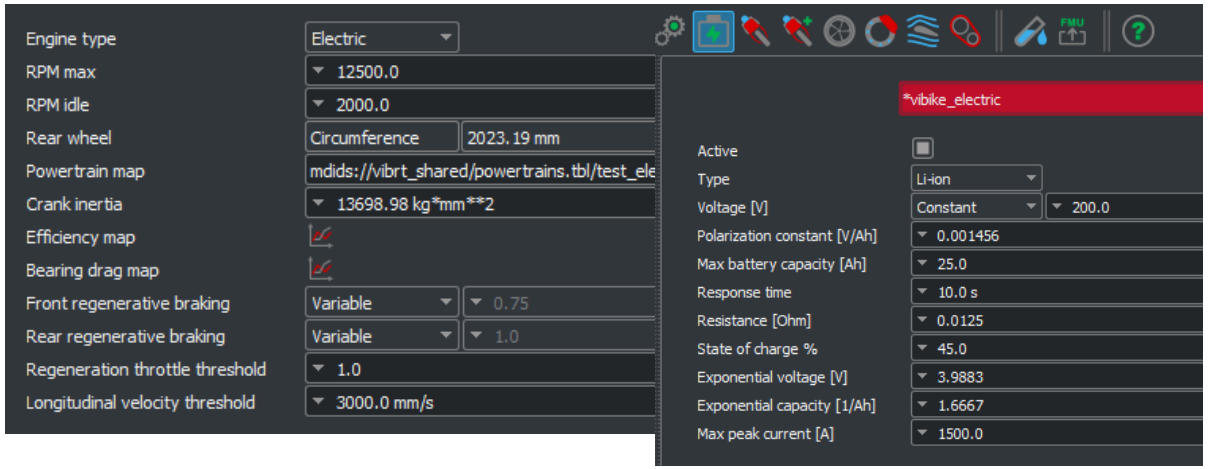


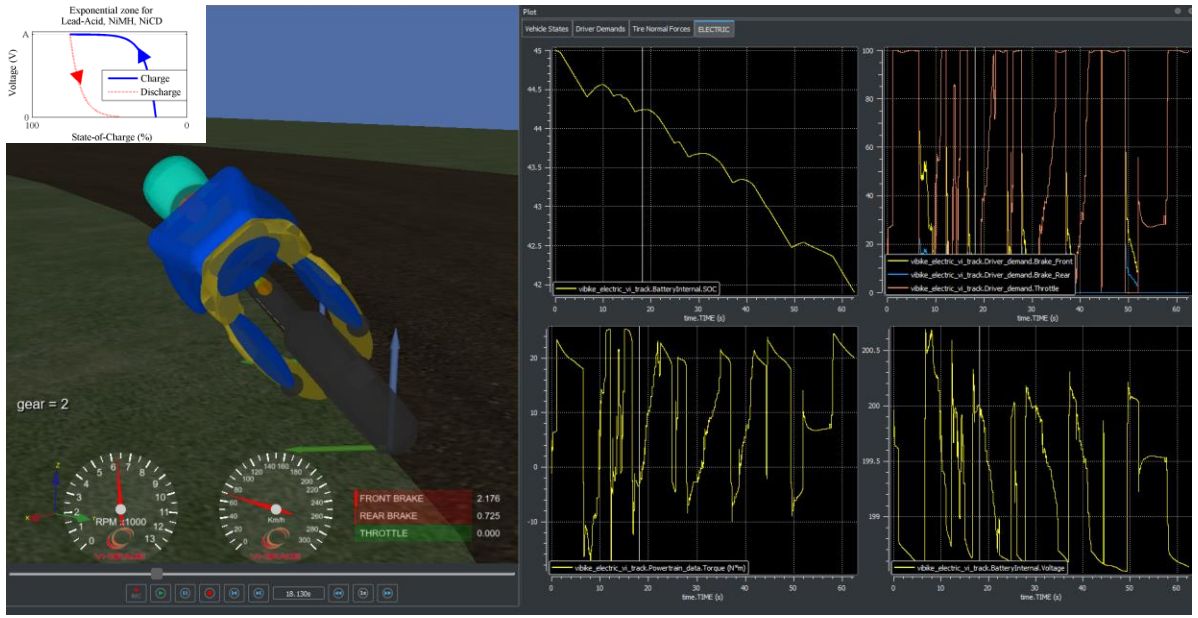


VI-BIKEREALTIME 2024.2

WHAT'S NEW

- Powertrain Enhancements
  - Electric Engine
  - Battery Model
  - Automatic Transmission
  - Dual Clutch





VI-BIKEREALTIME 2024.2

WHAT'S NEW

- New Output File Format: MDF4
  - Based on ASAM MDF 4.0 Standard
  - Writing: >10 times faster than XML
  - Reading: >5 times faster than XML