

Complimentary Software for BAJA SAEINDIA Teams

Link: <https://www.mathworks.com/academia/student-competitions/baja-saeindia>

The screenshot shows the MathWorks Academia website. The top navigation bar includes 'Products', 'Solutions', 'Academia', 'Support', 'Community', and 'Events'. A 'Get MATLAB' button is visible on the right. Below the navigation bar is a search bar with the text 'Search MathWorks.com'. The main content area features a dark blue background with a geometric pattern. The title 'BAJA SAEINDIA' is prominently displayed. Below the title, a paragraph describes the competition: 'The BAJA SAEINDIA competition challenges student teams to design and build an off-road vehicle and compete with it in a series of static and dynamic trials. Applying Model-Based Design with MATLAB and Simulink products for system design and simulation, embedded code generation, and physical modeling helps you complete its mission.' Two call-to-action boxes are present: 'Complimentary Software' with a 'Request software' button, and 'Student Tutorials and Videos' with a 'Watch videos' button.

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Student Home MATLAB Student Examples Student Competitions Books Hardware Support

BAJA SAEINDIA

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Complimentary Software

MathWorks provides complimentary software for this competition. If your team is participating in this competition and needs software, fill out the software request form.

Request software

Student Tutorials and Videos

Learn how to use MATLAB and Simulink to design algorithms, create simulations, deploy code, and speed up software development for your projects.

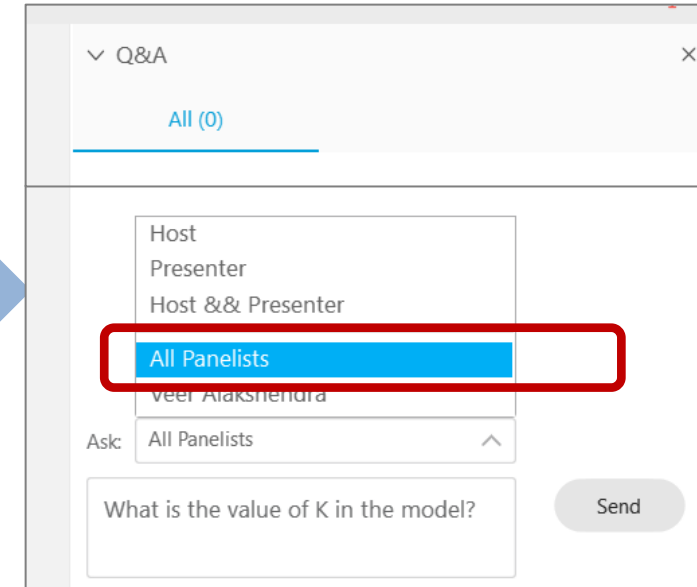
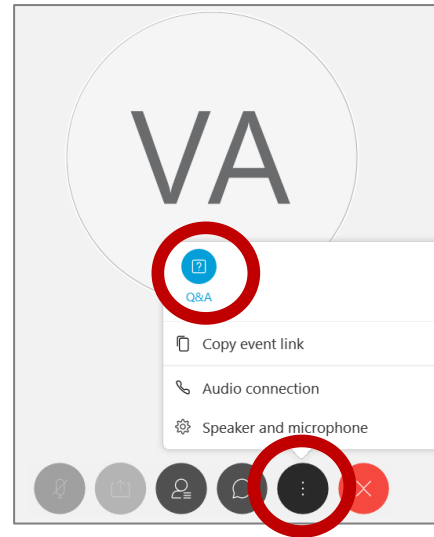
Watch videos

Designing BAJA All-Terrain Vehicles with MATLAB and Simulink

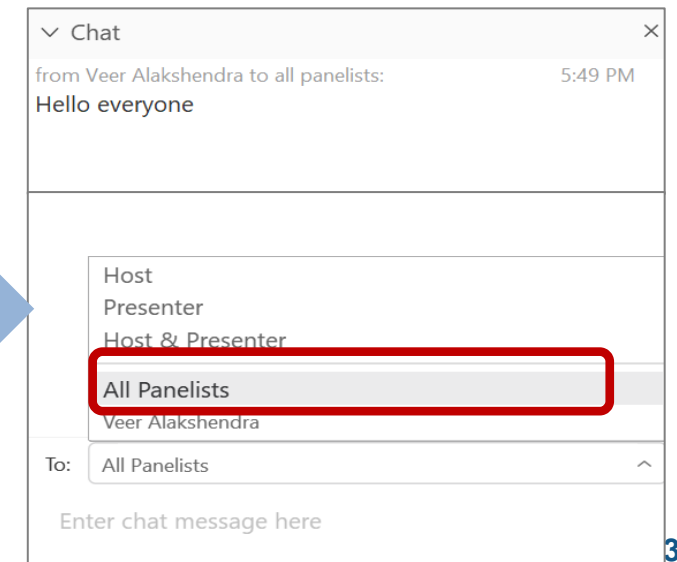
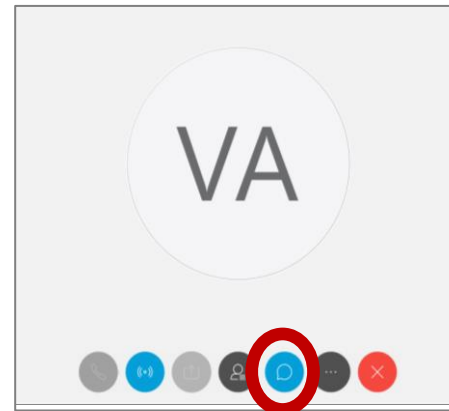
Akshat Kasana, *Team Kshatriya, VIT, Vellore*
Veer Alakshendra, *MathWorks*

During the Webinar

- Use **Q&A** to ask technical questions
 - Send the questions to “All Panelists”

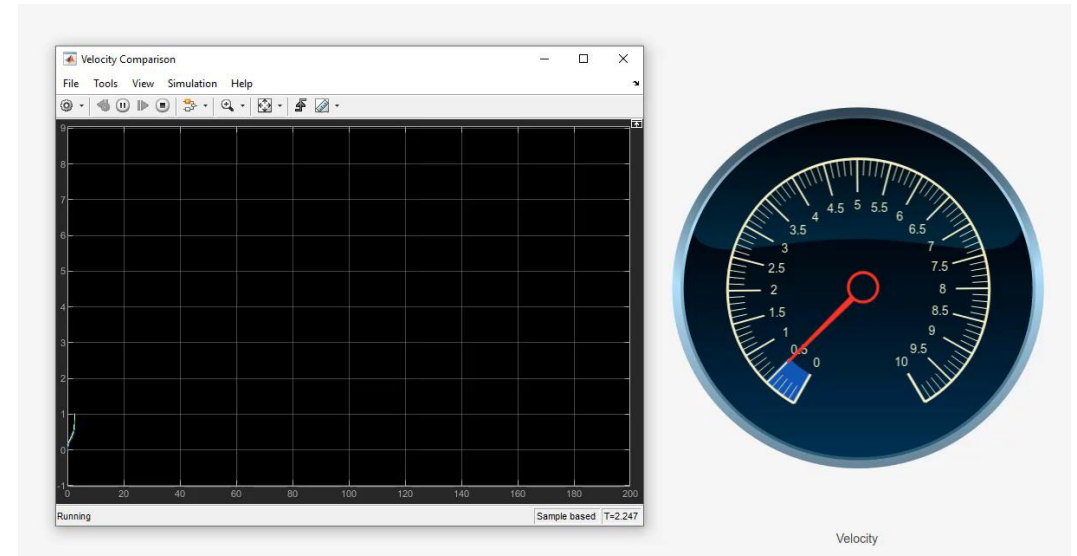
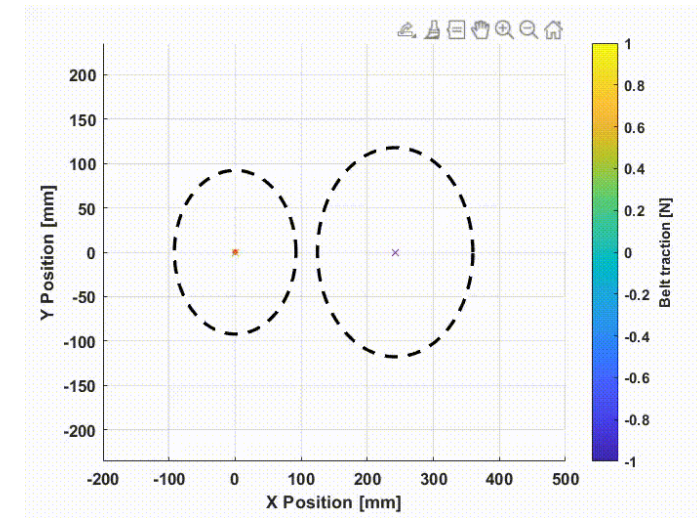


- Use **Chat Box** for all other queries
 - Send the query to “All Panelists”



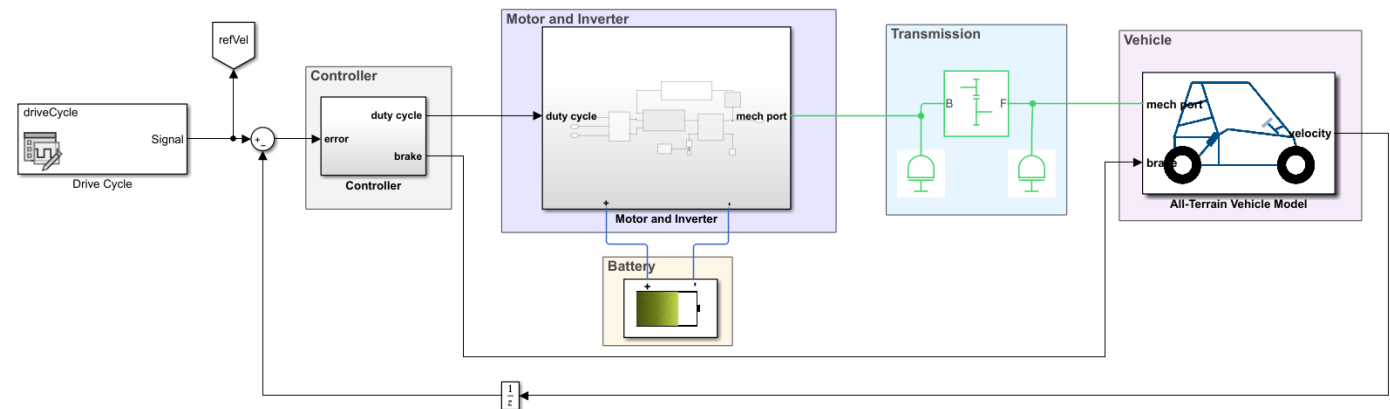
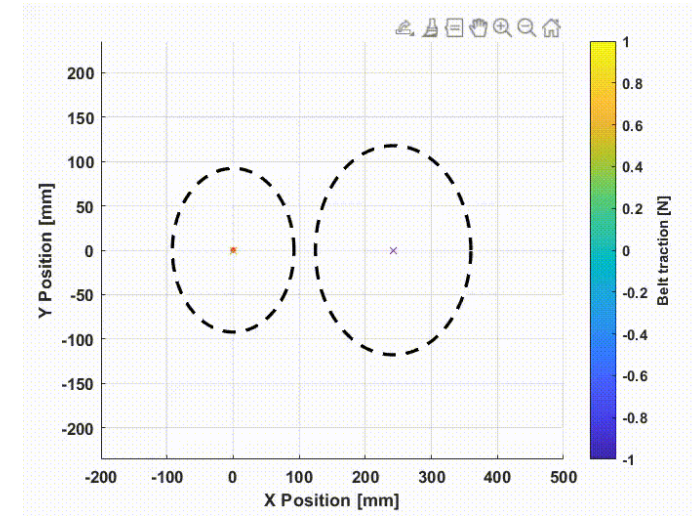
Challenges and Solution

- Component sizing and selection
- Vehicle level performance analysis and optimization



Agenda

- Introduction to MATLAB and Simulink
 - Spring mass damper system
 - Usage by teams
- Introduction to Physical Modeling
 - Battery Model
 - BAJA electric vehicle model
- Talk by Team Kshatriya
 - 4WD vehicle simulation
 - Steering ratio and lateral dynamics study
- Multibody Mechanical Systems Modeling
- Resources
- Q&A



Have you used MATLAB before?

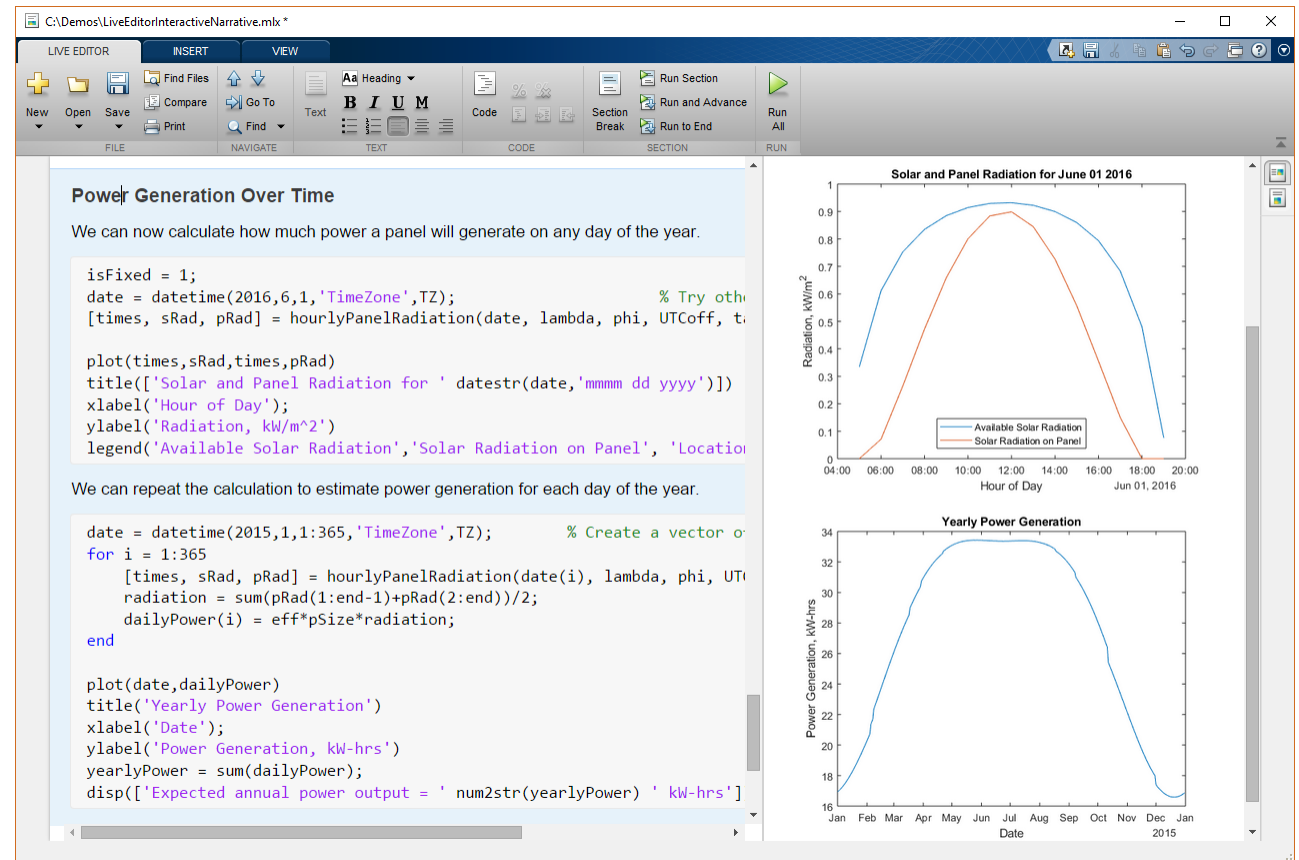
What is MATLAB?

- Programming platform designed specifically for engineers and scientists
- Matrix-based

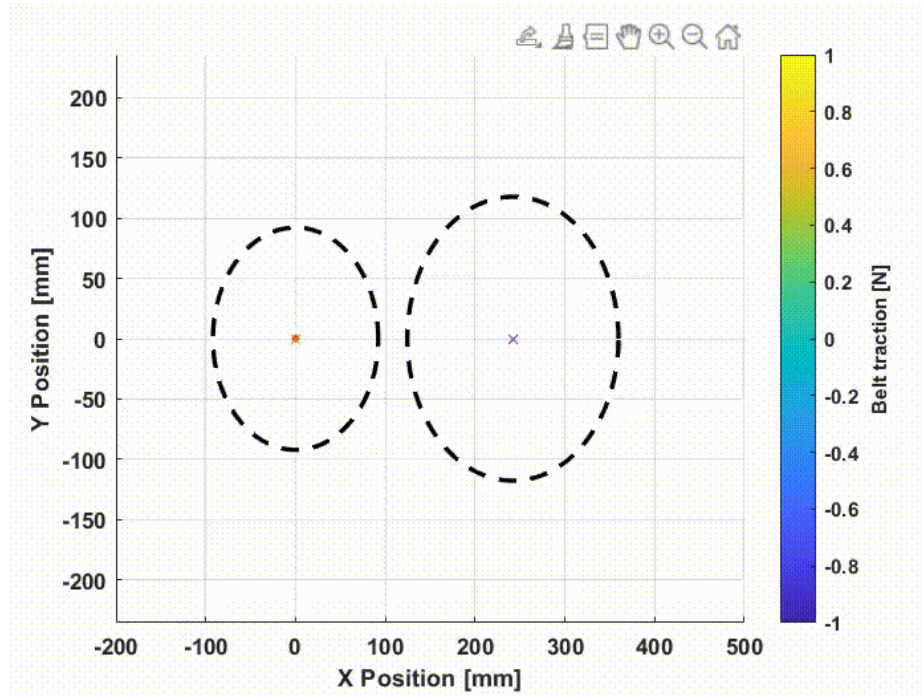
- What can you do with MATLAB?

- Analyze data
- Develop algorithms
- Create models and applications

- [MATLAB Onramp](#)



Usage by BAJA Teams



[Predicting Dynamic Behavior of a Continuously Variable Transmission using MATLAB](#)

Blog by: Alex and Lucas from the University of Brasília – Piratas do Cerrado Baja SAE Team.



Dr. Vishwanath Karad MIT World Peace University, Pune

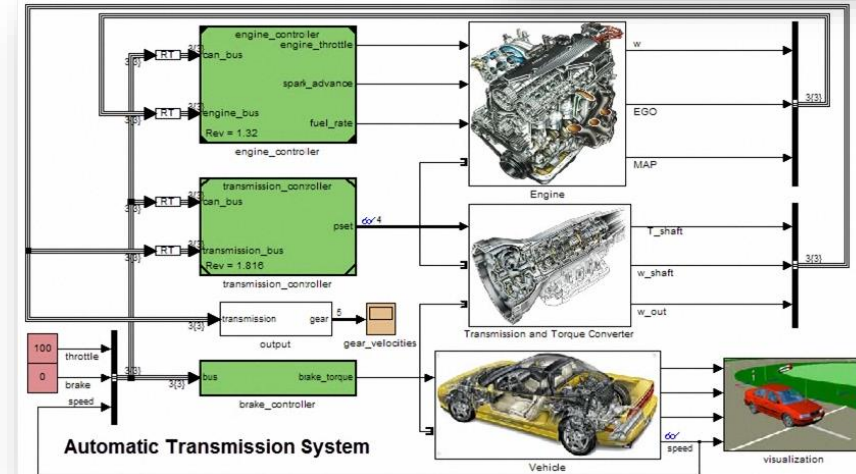
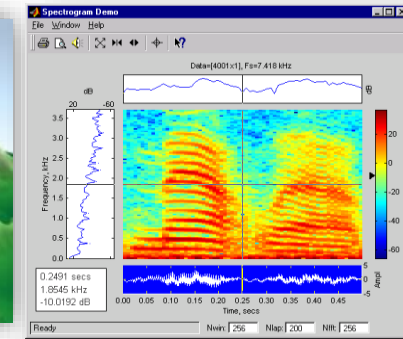
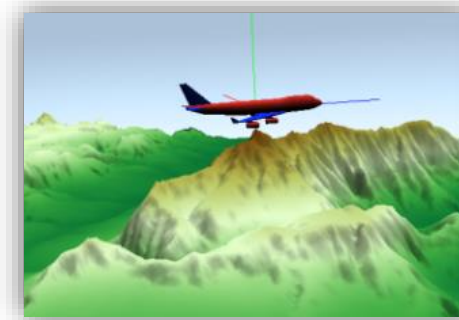
1st Place Overall, 1st Place in Overall Dynamics, 1st Place in Gradeability, 1st Place in Suspension and Traction, 1st Place in All Terrain Performance, 2nd Place in Overall Statics, 2nd Place in Acceleration, 3rd Place in Cost Event - BAJA SAEINDIA 2021

Team Piranha Racing, a team with a legacy of 12 years from MIT WPU won the BAJA SAE 2021 competition along with a total of 8 trophies. They used MATLAB to verify the pressure generated in their master cylinders, to simulate their stopping distance, and model their 4WD Powertrain through which they optimized their reduction ratio. These simulations helped the team complete their engineering product design cycle enabling them to better understand their ATV.

What is Simulink?

The leading environment for modeling, simulating and implementing dynamic and embedded systems

- Block-diagram environment
- Model, simulate, and analyze multi-domain systems
- Accurately design, implement, and test complex systems for:
 - Communications
 - Control
 - Signal processing
 - Video and image processing
- Platform for Model-Based Design
- [Simulink Onramp](#)



User Story

Nissan Improves Emission Performance and Reduces Calibration Time for Air-Fuel Ratio Controllers

“At Nissan, we have been finding new ways to speed development and improve our products with Model-Based Design for many years. Most recently, it was with the introduction of MATLAB and Simulink optimization products to reduce emissions by improving the performance of an existing AFR controller design.”

— Hiroshi Katoh, Nissan Motor Corporation

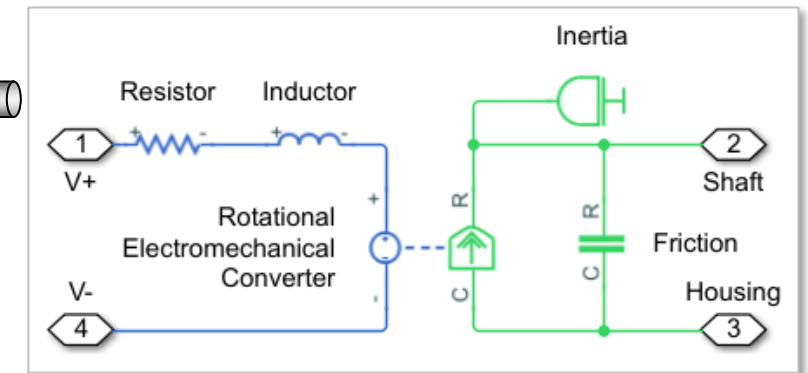
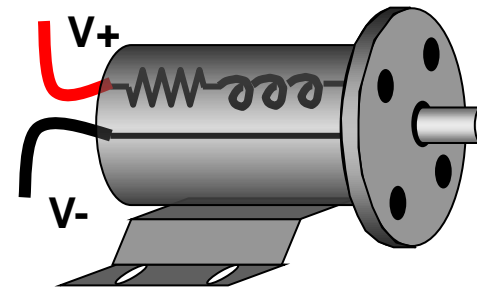
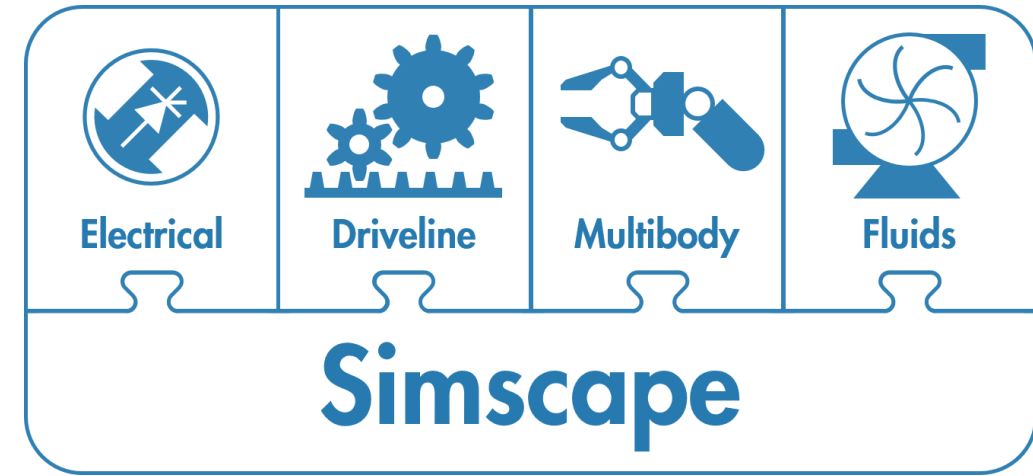


The Nissan Altima.

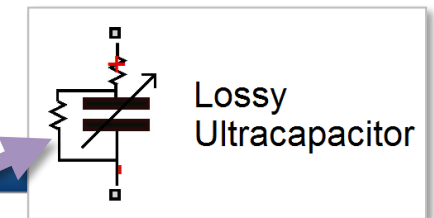
Simscape

Overview

- Enables physical modeling (acausal) of multidomain physical systems
 - Assemble a schematic
 - Equations derived automatically
 - Leverage MATLAB and Simulink
- With Simscape you can:
 - Refine requirements for system
 - Discover integration issues early
 - Design control systems and logic
 - Optimize system-level performance
 - Test embedded software without hardware prototypes



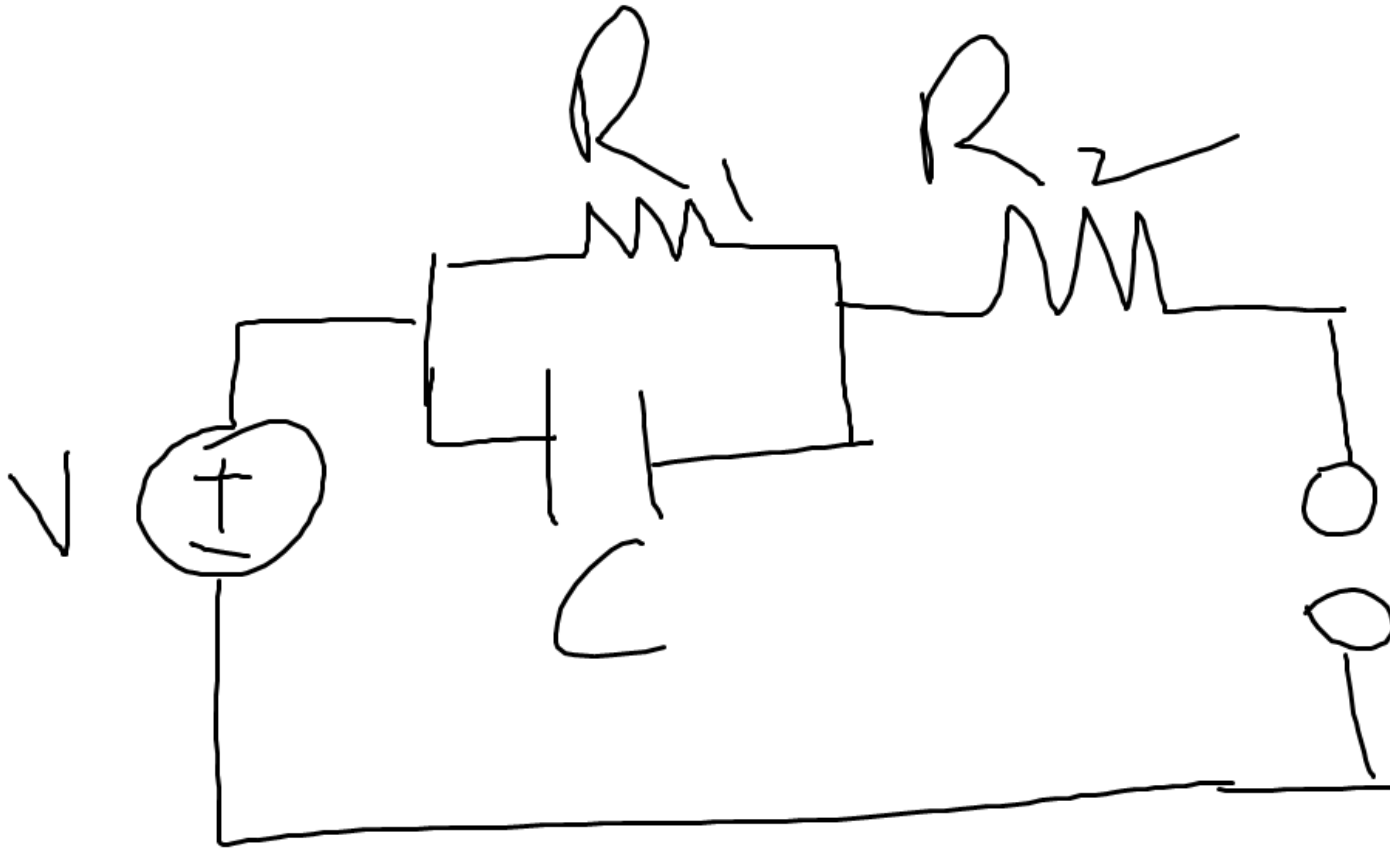
$$i = (C_0 + C_v v) \frac{dv}{dt} + \frac{v}{r_d}$$



```

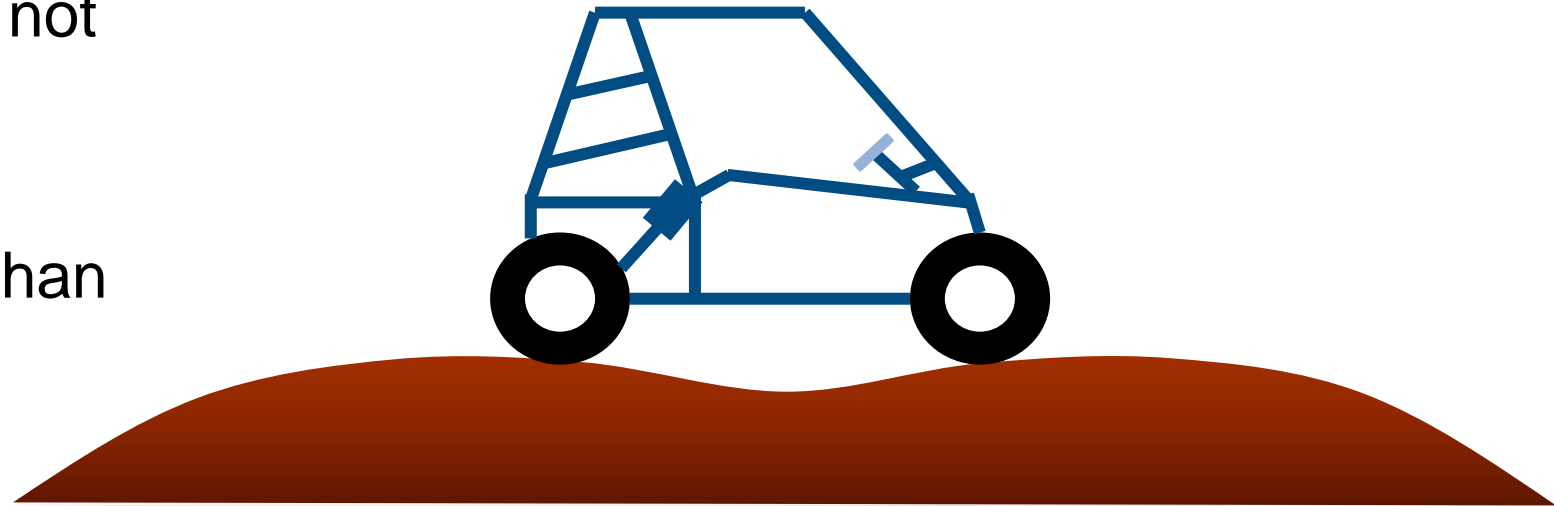
Editor - C:\+MyComponent\LossyUltraCapacitor.ssc
40 equations
41 i == (C0 + Cv*vc)*vc.der + vc/Rd;
42 v == vc + i*R;
43 end
  
```

Equivalent Circuit

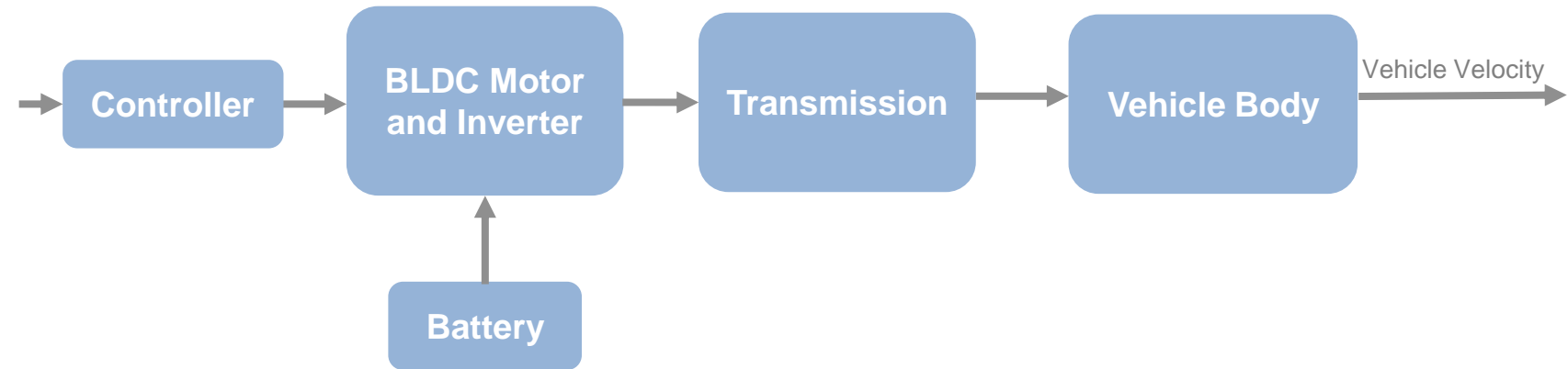


BAJA Electric All-Terrain Vehicle

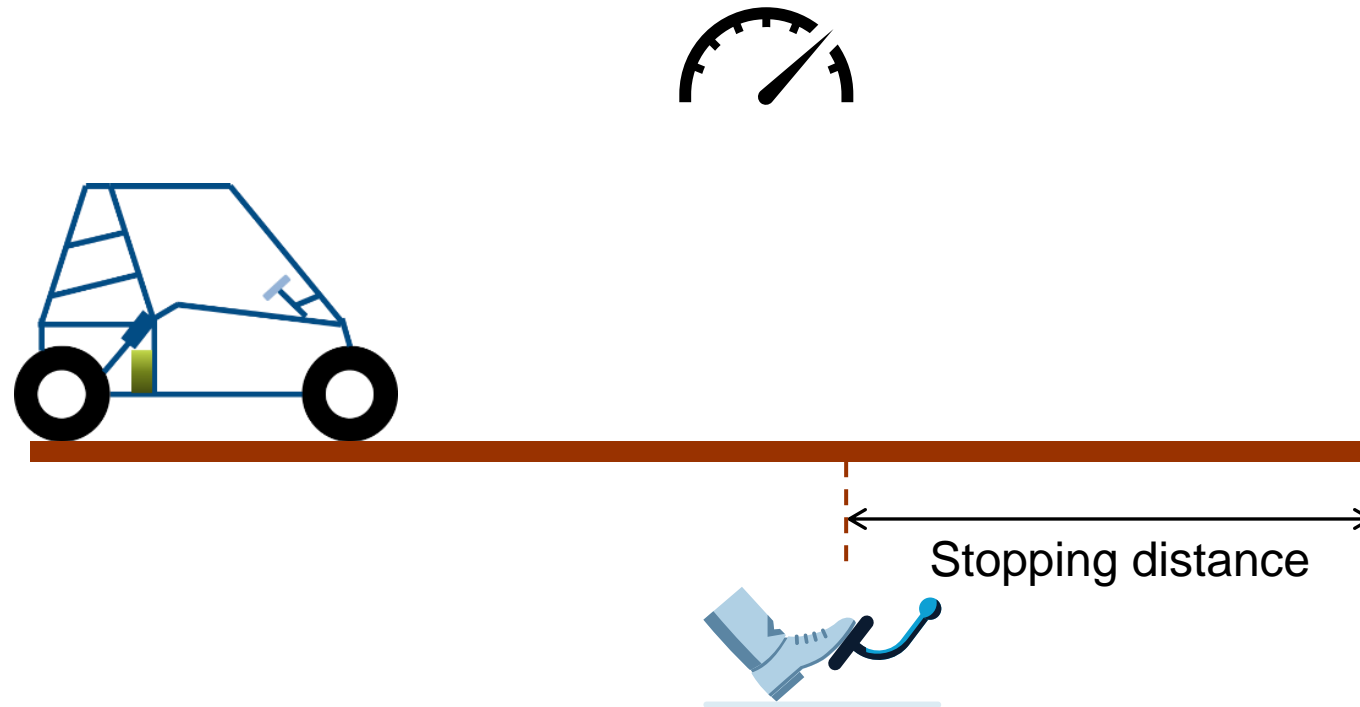
- Vehicle is driven by BLDC motor
- Battery Specifications shall not exceed 48V, 110Ah
- Maximum speed not more than 40 kmph



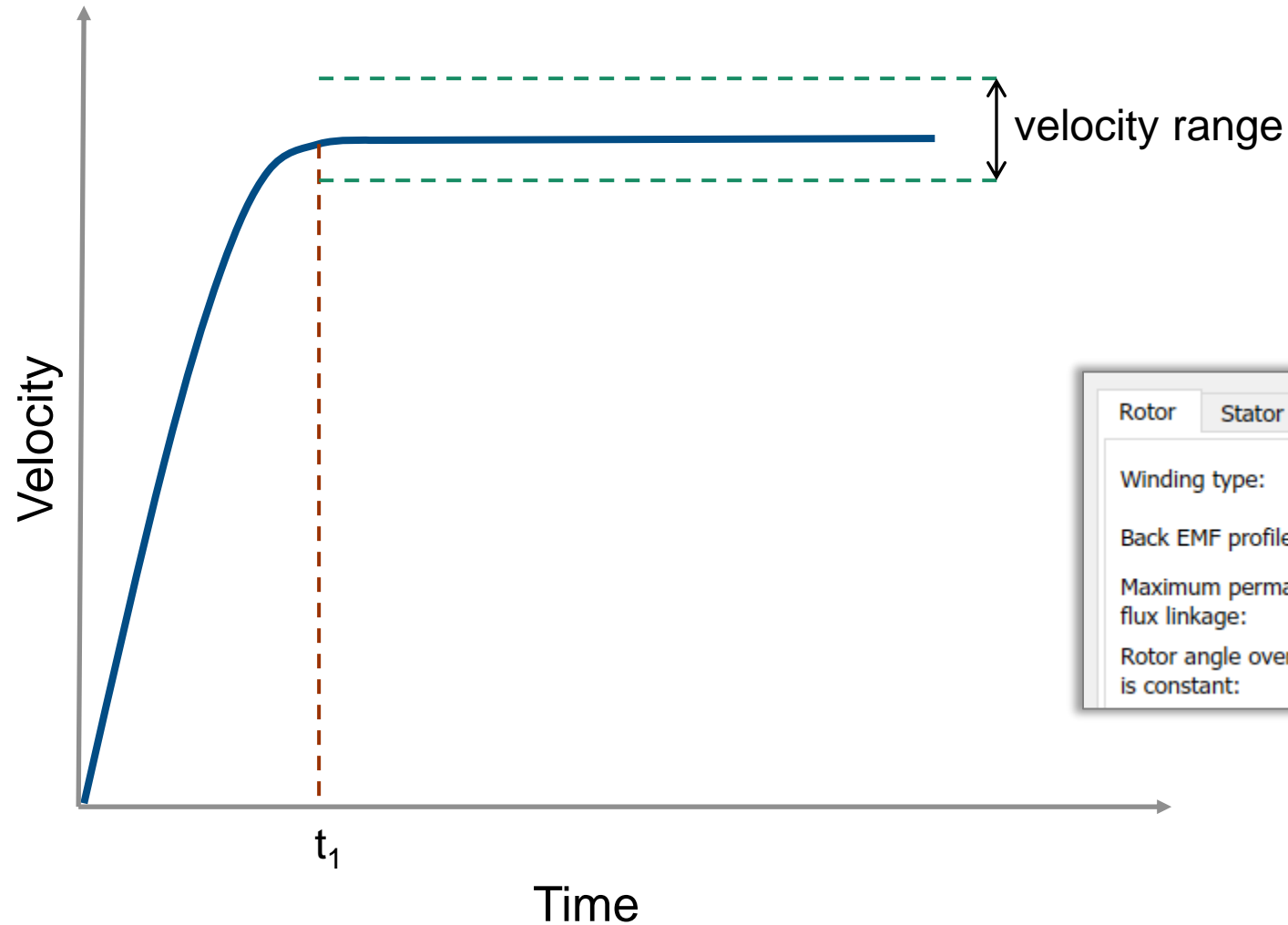
Driving Cycle Simulation



Stopping Distance



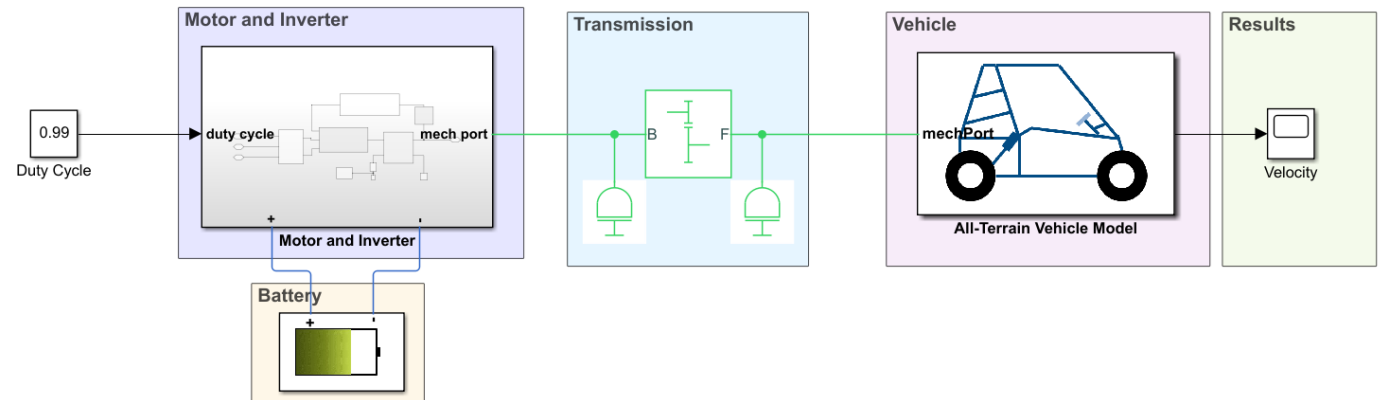
Estimating Vehicle Parameters



Rotor	Stator	Mechanical	Variables
Winding type: Wye-wound			
Back EMF profile: Perfect trapezoid - specif			
Maximum permanent magnet flux linkage: mfl			
Rotor angle over which back emf is constant: $180/(2^*$			

How to define the parameters?

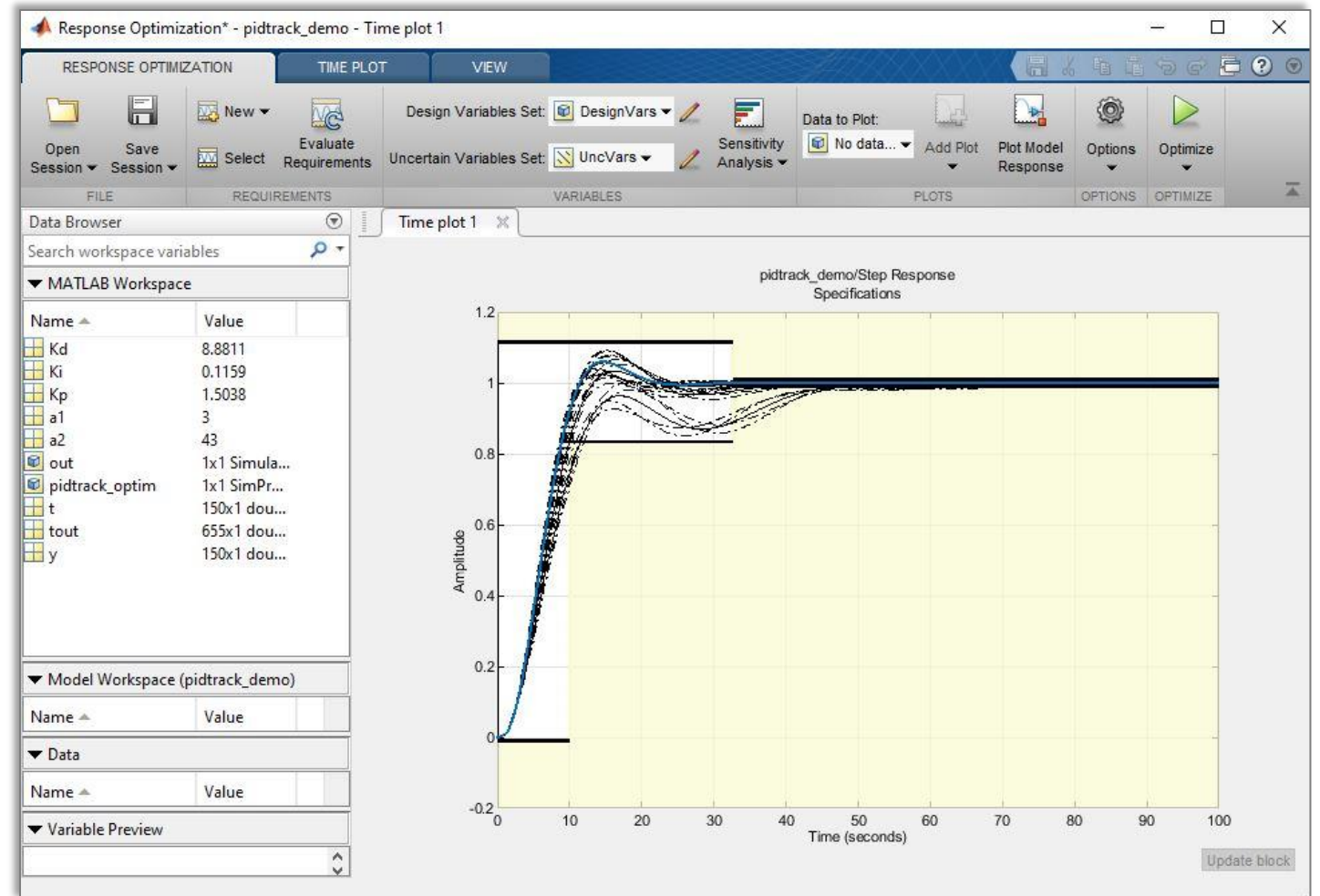
- ✓ Build the vehicle model
- ✓ Define the problem
 - ✓ Optimize the flux linkage
- ✓ Define the cost function
 - ✓ Bound the vehicle velocity (10 m/s – 12 m/s)

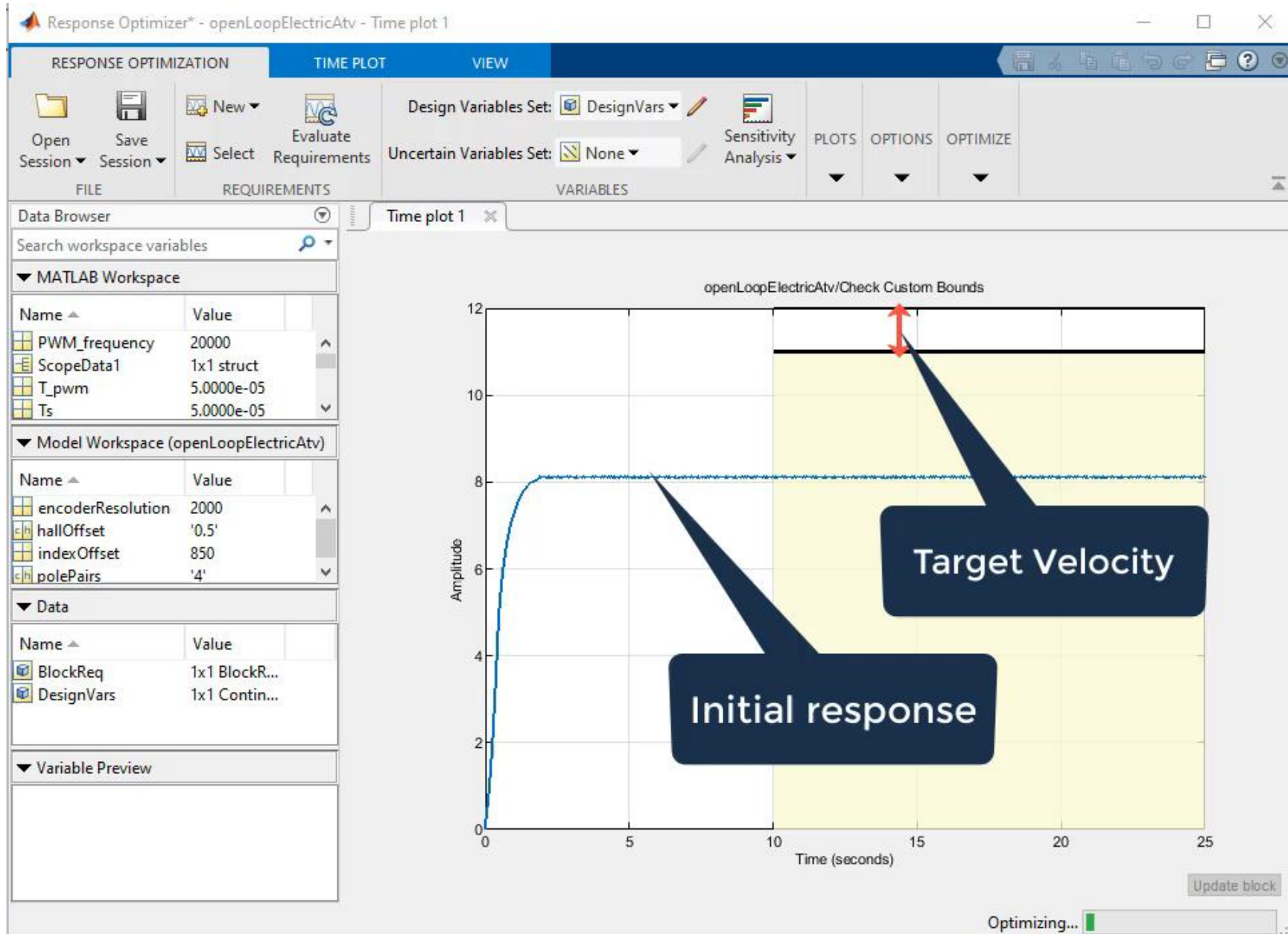


Response Optimization

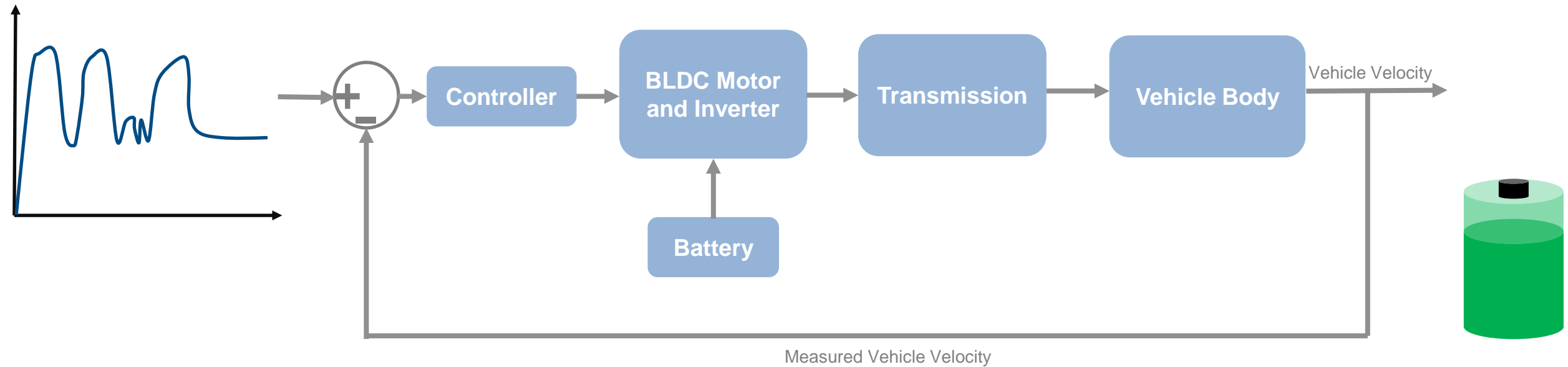
Optimize model response to satisfy design requirements

- Time-domain
- Frequency-domain
- Custom constraints
- Cost functions






Driving Cycle Simulation




Team Introduction:

- Team Kshatriya is the official BAJA SAE team of Vellore Institute of Technology, Vellore.
- Founded in 2006 by a group of students, Team Kshatriya, was the first all student motorsport team in India.
- Design, manufacture and test single-seater All Terrain Vehicles, while keeping in mind all the regulation of the completion.
- Amongst the longest running m-BAJA team of India and has been participating in BAJA SAE India since its inception, a legacy of 15 years.





VIT[®]
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)




1 RANK

OVERALL STATIC (OUT OF 150 TEAMS)

2 RANK MANUFACTURING

2 RANK CAE

TOP 10
DESIGN 4TH SALES 10TH
COST 7TH PRELIMS 5TH



1. Performing the full 4WD vehicle simulation

- **AIM:**
 - The goal was to understand how a 4WD ATV accelerates compared to a RWD ATV

- **METHOD:**
 - Model the driveline of RWD and 4WD ATV while keeping all the other factors similar in the simulation environment and then compare the performance with the help of Data Logger

1. Performing the full 4WD vehicle simulation

- Limitations and Further Development:
 - Tire model can be improved with the support from tire manufactures providing data
 - Road/soil interaction with the tire can also be done to increase model fidelity
 - Engine model data can be crosschecked with actual dyno-test data

- Testing:
 - Use sensors/transponder to measure time accurately
 - Keep the test location and environment same for all iterations of a test cycle

2. Study of Steering Ratio and Lateral Dynamics

- **AIM:**
 - The goal was to understand how the ATV will respond on a range of different steering tests and compare the results of various steering ratios

- **METHOD:**
 - Model the ATV using a 3-DOF blockset and Kinematic Steering blockset
 - Setup different steering test and measure the net lateral load transfer at various speeds

2. Study of Steering Ratio and Lateral Dynamics

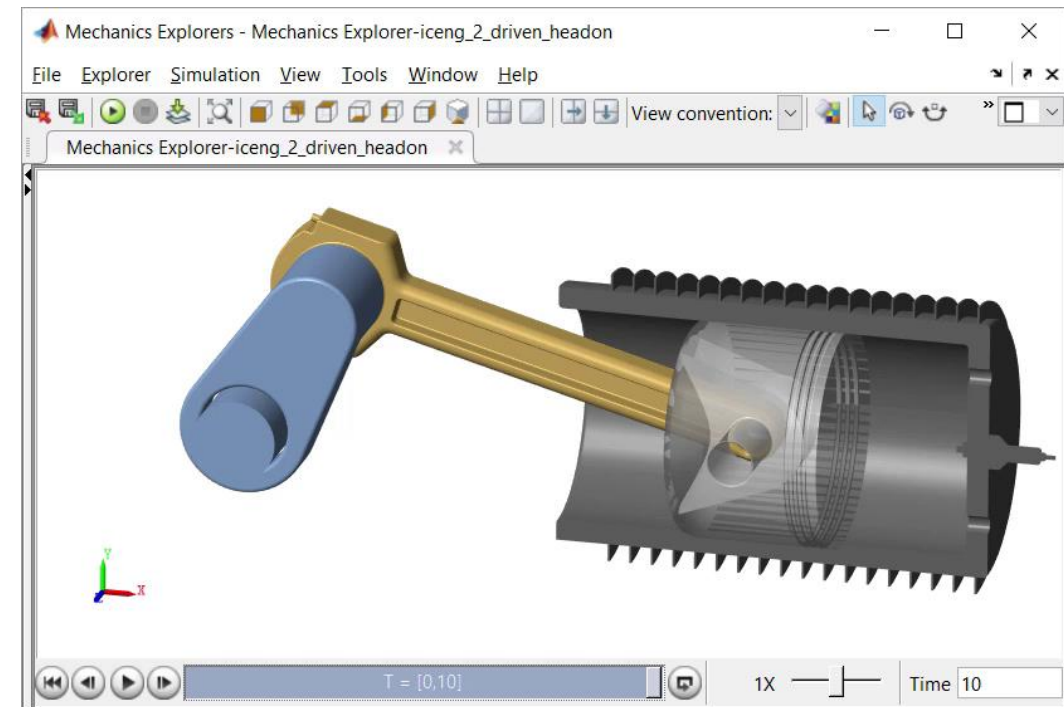
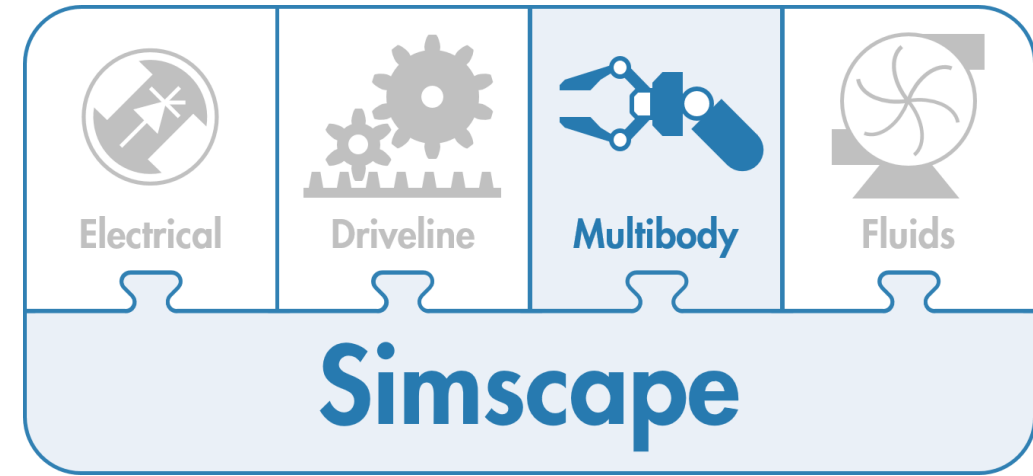
- Limitations and Further Development:
 - The current model only accounts for a corner taken at a constant velocity.
 - Roll and pitch of the ATV can be included in the model with a higher DOF blockset
 - Tire model can be improved with the support from tire manufactures providing data
 - Road/soil interaction with the tire can also be done to increase model fidelity

- Testing:
 - Use sensors/transponder to measure time accurately
 - Set same track as the ones used on the model
 - Map the steering and pedal response of the driver and use the same for testing
 - Keep the test location and environment same for all iterations of a test cycle

Simscape Multibody

Overview

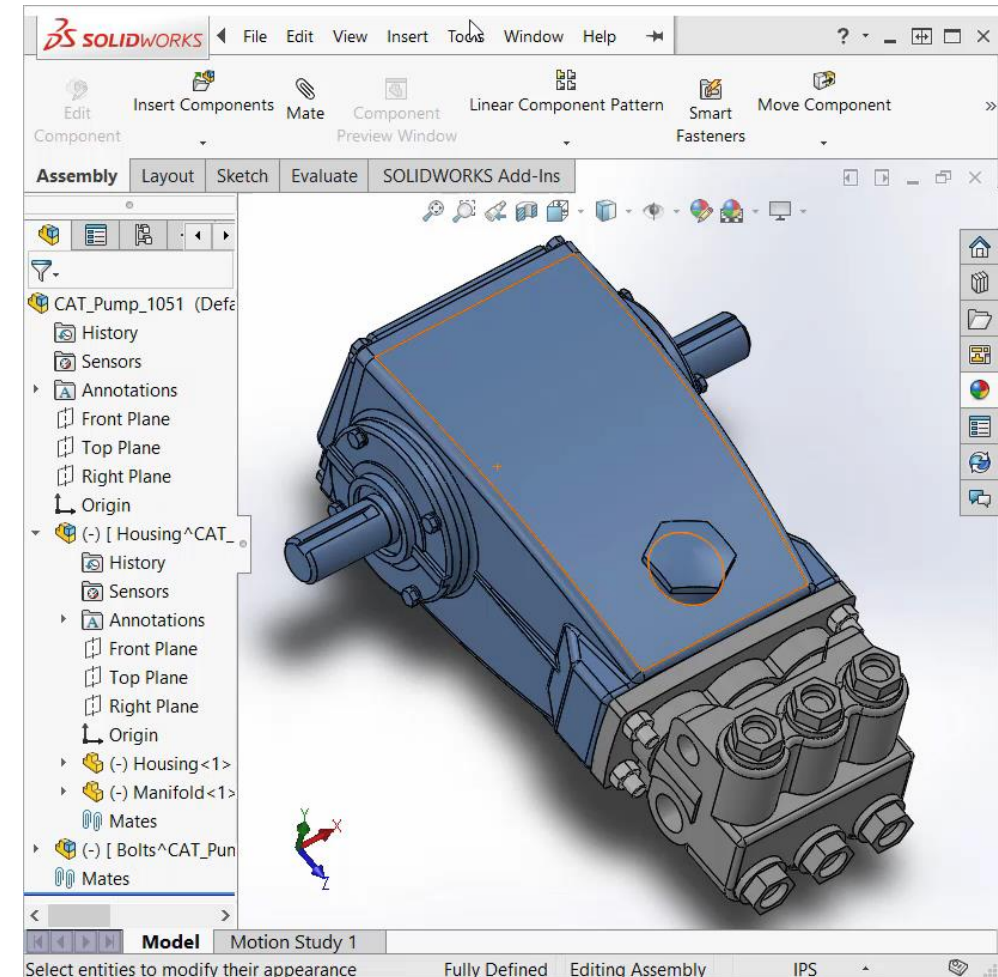
- Enables multibody simulation of 3D mechanical systems
 - Assemble bodies and joints including import from CAD
 - No need to derive and program equations
- With Simscape Multibody you can:
 - Refine requirements for mechanical system
 - Discover integration issues early
 - Design control algorithms and logic
 - Test embedded software without hardware prototypes



Simscape Multibody Modeling Environment

Part Definition, CAD Import, Constraints, Forces, Visualization

- Import CAD assemblies
 - Part definitions
 - Converts mate definitions to joints
 - SOLIDWORKS, Inventor, Onshape, and PTC Creo® (Pro/ENGINEER®)
- Import CAD Parts
 - CATIA, NX, SolidEdge, and others
 - STEP files



Recap: Which Tools To Use?

Software Tool	When To Choose
MATLAB + Simulink	<ul style="list-style-type: none"> • System equations are already known or can be derived • <i>“Need a calculator to solve my equations and process results”</i>
Simscape	<ul style="list-style-type: none"> • Model mechanisms (motors, shifter actuators, etc.) • Model multidomain systems (mechatronic, fluid, thermal) • Reduce visual complexity: model without deriving equations
Simscape Multibody	<ul style="list-style-type: none"> • Model 3D rigid body systems (suspension, steering, etc.) • Import kinematic models from CAD and add dynamics

... and you can combine them all!

Complimentary Software for BAJA SAEINDIA Teams

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MathWorks® Products Solutions Academia Support Community Events Get MATLAB

Academia Search MathWorks.com

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BAJA SAEINDIA

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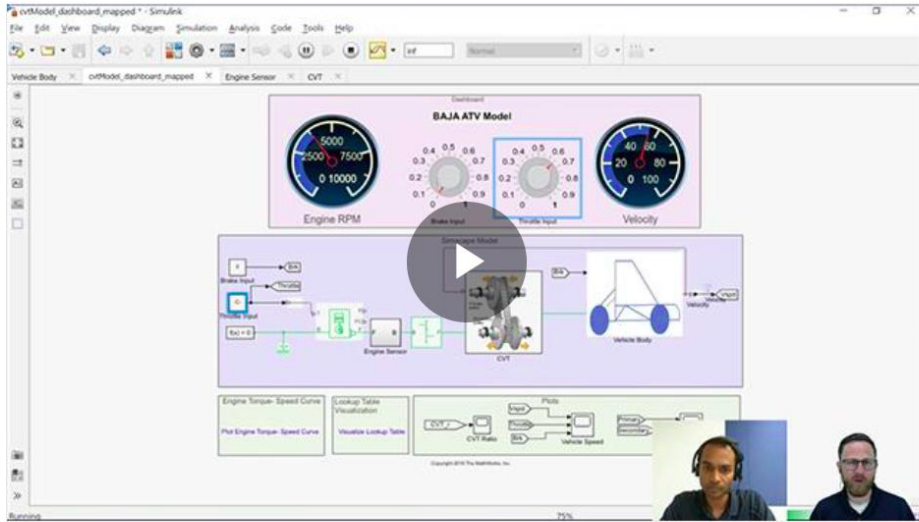
Request software

Student Tutorials and Videos

Learn how to use MATLAB and Simulink to design algorithms, create simulations, deploy code, and speed up software development for your projects.

Watch videos

Tutorial Videos for BAJA Competition



Description Related Resources

Modeling of a Continuously Variable Transmission (CVT) BAJA All-Terrain Vehicle (ATV)

Link: <https://www.mathworks.com/videos/modeling-a-vehicle-with-continuously-variable-transmission-1554467867519.html>



Description Full Transcript Related Resources

Model and Simulate an Electric All-Terrain Vehicle with Simscape

Link: <https://www.mathworks.com/videos/model-and-simulate-an-electric-all-terrain-vehicle-with-simscape-1618894089707.html>

File Exchange Links

File Exchange

Electric Vehicle Powered by BLDC Motor

version 1.0 (233 KB) by MathWorks Student Competitions Team **STAFF**

This submission contains a set of models to show the implementation of electric all-terrain vehicles powered by BLDC motor.

<https://github.com/mathworks/electric-all-terrain-vehicle>

★★★★★ 0 Ratings

11 Downloads ⓘ

Updated 23 Oct 2020

[view license on GitHub](#)

[+ Follow](#) [Download from GitHub](#)

Overview Models

Link:

<https://www.mathworks.com/matlabcentral/fileexchange/81623-electric-vehicle-powered-by-bldc-motor>

File Exchange

BAJA All-Terrain Vehicle (ATV) Model

version 1.0.0 (580 KB) by MathWorks Student Competitions Team **STAFF**

The file contained includes BAJA ATV model with Continuously Variable Transmission(CVT).

★★★★★ 4 Ratings

46 Downloads ⓘ

Updated 01 Apr 2019

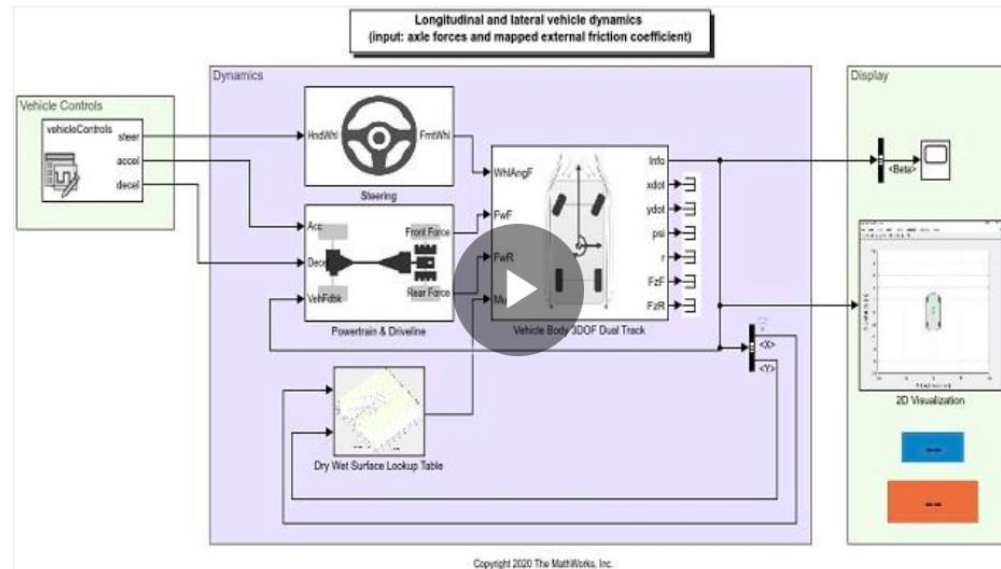
[View License](#)

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Link:

<https://www.mathworks.com/matlabcentral/fileexchange/70576-baja-all-terrain-vehicle-atv-model>

Tutorial Videos for BAJA Competition



Description

[Related Resources](#)

Simulating Longitudinal and Lateral Vehicle Dynamics

Link: <https://www.mathworks.com/videos/matlab-and-simulink-racing-lounge-simulating-longitudinal-and-lateral-vehicle-dynamics-1576843468042.html>

Vehicle Path Tracking Using Pure Pursuit



Vehicle Path Tracking Using Pure Pursuit Controller

Link: <https://www.mathworks.com/videos/vehicle-path-tracking-using-pure-pursuit-controller-1595330917925.html>

Student Competition Tutorials and Videos



Learn how to use MATLAB and Simulink to solve competition tasks

» Get started now

<https://www.mathworks.com/academia/student-competitions/tutorials-videos.html>



Building Interactive Design Tools

Aerospace

Learn how to use MATLAB and Simulink to design airplanes, unmanned aerial vehicles, and other aerospace vehicles for student projects. MathWorks experts and users share information on how to perform engineering design calculations, develop simulation models, and deploy code to hardware targets.

🕒 Access videos (4 Videos)

The Winner's Circle



See how students are winning competitions worldwide with MATLAB and Simulink

» Explore student projects

<https://www.mathworks.com/academia/superstar-students.html>

The Winner's Circle

Cool projects. Raw talent. The right tools. With these ingredients student competition teams are winning competitions worldwide and shaping the future of automotive design, aerospace engineering, robotics, and many other technical fields.

[Get support for your team](#)



Robotics



Government College of Engineering Aurangabad

MathWorks Modeling Award- DD ROBOCON India 2019

We used MATLAB & SIMULINK for

- Modelling and Simulation of Dynamic behaviour of autonomous robot
- Analysis of gait and the algorithms for autonomous robot
- Designing the control system.
- Calculating trajectory of Shagai with different angles and velocities for manual robot
- Transition of autonomous robot to different zones according to color of zone.

» [Our facebook page](#)
» [Our Instagram page](#)

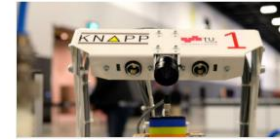


Eindhoven University of Technology

1st Place - Soccer Middle Size League RoboCup 2019

Tech United, the robot soccer team from Eindhoven University of Technology, won 1st Place in the RoboCup Soccer Middle Size League 2019 in Sydney, Australia. The team uses MATLAB and Simulink to develop and generate real-time control software for their robot soccer players. This allows the team to rapidly develop complex software, ranging from vision to real-time motion control to strategy software.

» [Team website](#)
» [Watch a recap of the final match](#)

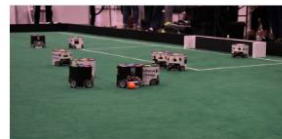


Technische Universität Graz

2nd Place - Logistics League RoboCup 2019

Team GRIPS achieved 2nd place at the RoboCup Logistics League competition 2019 in Sydney. MATLAB and Simulink were used in the parameter tuning process for several control loops. The team plans to integrate MATLAB even more in the software stack by connecting to the Robot Operating System (ROS). This will enable the team to conveniently implement more sophisticated control algorithms.

» [Team GRIPS Website](#)
» [Team GRIPS Facebook page](#)
» [RoboCup Logistics League](#)



Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)

2nd Place - Soccer Small Size League RoboCup 2019

ER-Force is a RoboCup Soccer Small Size League team that came in second place in this year's international event in Sydney, Australia. They used MATLAB to develop, simulate, and optimize their motion control systems for their autonomous soccer robots.

Efficient and precise motor control is crucial in the competitive RoboCup environment and



Shattuck Public School

2nd Place BEST Award – Frontier Trails BEST Regional Robotics Championship 2018

The team at Shattuck Public School used Simulink to provide a simulation of their robot structures to help them design and build an effective robot. This year's goal was to build a robot that might help clean up the oceans, and it was an exciting challenge.



Eastwood/Cornerstone Schools, Montgomery, AL

3rd Place Game Winners – South's BEST Regional Robotics Championship 2018

Gears, Inc. Robotics team, from Eastwood/Cornerstone Schools, won the Simulink Design Award at the South's BEST Regional Robotics Championship. They used Simulink and Stateflow to program their robot's drive and control functions, allowing it to collect trash from a simulated ocean environment. The award was given based on the design and sophistication of the Simulink model, as well as

Student Competition Communities

Overview



[Video series](#) - [Facebook Group](#)



[Video series](#) - [Facebook Group](#)

[Student Lounge blog](#)
(for all competitions)

Student Communities Engagement

- **100+ videos** for automotive and robotics
- **19k+ members** across 2 Facebook groups
- Dedicated e-mails:
 - roboticsarena@mathworks.com
 - racinglounge@mathworks.com

What Can You Do with the Mobile Robotics Simulation Toolbox?

Waypoints

Pose $[x; y; \theta]$ (Position and orientation)

Trajectory

Feedback

Simulating Mobile Robots with MATLAB and Simulink

From the series: MATLAB and Simulink Robotics Arena

Sebastian Castro, MathWorks

Sebastian Castro shows you how to get started with the Mobile Robotics Simulation Toolbox entry on the MATLAB Central File Exchange.

This toolbox contains functionality to simulate mobile robot kinematics and sensors in a 2D environment using MATLAB™ code and Simulink™ models. You can simulate the robot's motion and sensor data in a 2D environment before implementing the algorithms in simulation before im...

MATLAB and Simulink Racing Lounge

Sebastian

Home Create

INVOKE MEMBERS Embed Invite

+ Enter name or email address...

MEMBERS 5,700 Members

You have 28 new members this week. Write a post to welcome them. Write Post

SUGGESTED MEMBERS Hide

Friends

Stephen Pocher Invite Member

Simon Batzner Invite Member

Gregory Mair Invite Member

See More

DESCRIPTION Edit

Dear Racing Teams, based on the success of the MATLAB and Simulink... See More

GROUP TYPE Project

LOCATION Edit

Munich, Germany

Christoph Hahn shared a video. Admin · February 12 at 8:56 AM

Great job TUfast Eco Team!

19,891 Views

MATLAB February 12 at 6:57 AM

See how to build an autonomous car with Simulink! <http://ow.ly/J130nEPao> TUfast Eco Team created this one

26 1 Comment 1 Share

Like Comment Share

Mohammed Sultan Salar Khan Ramiz Masroor 1

Like Reply 1w

Student Communities

MATLAB Central

- 50+ blog posts on [Racing Lounge blog](#)
- 50+ File Exchange entries from [MathWorks Student Competitions Team](#)
- MATLAB Answers tags
 - [roboticsarena](#)
 - [racinglounge](#)

Racing Lounge
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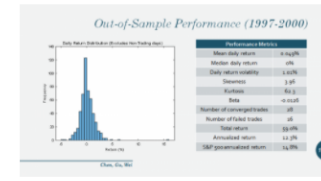
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PRMIA Risk Management Challenge 2020: Going Virtual in a RISKY Challenge
Posted by **Neha Goel**, February 1, 2021



Today's guest blogger is John Elhilow, who's here to share the results of the 2020 PRMIA Risk Management Challenge and to encourage University students to participate in the 2021 challenge! [Learn...](#) [read more](#) >>

Category: MATLAB, Team achievements [Send](#) [Tweet](#) [Share](#) [Share 6](#)

MATLAB, Machine Learning & Movies... The Perfect Combination
Posted by **Connell D'Souza**, January 14, 2021

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MATLAB and Simulink Robotics Arena: Walking Robot version 4.0 by MathWorks Student Competitions Team STAFF

Example files for MATLAB and Simulink Robotics Arena walking robot videos.

- [fx_startupWalkingRobot.m](#)
- [fx_plotWalkingTraj.m](#)
- [fx_robotParametersClrf.m](#)
- [fx_walkingRobot3DMPC.slx](#)
- [fx_walkingRobot3DPath.slx](#)

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Mobile Robotics Simulation Toolbox version 2.2 by MathWorks Student Competitions Team STAFF

MATLAB and Simulink utilities for vehicle kinematics, visualization, and sensor simulation.

- [mrsDiffDrivePurePursuitModel.slx](#)
- [mrsDiffDriveWaypointLogicModel.slx](#)
- [mrsFourWheelPurePursuitModel.slx](#)
- [mrsObjectTrackingModel.slx](#)
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Getting Started with MATLAB, Simulink, and ROS version 1.3.0 by MathWorks Student Competitions Team STAFF

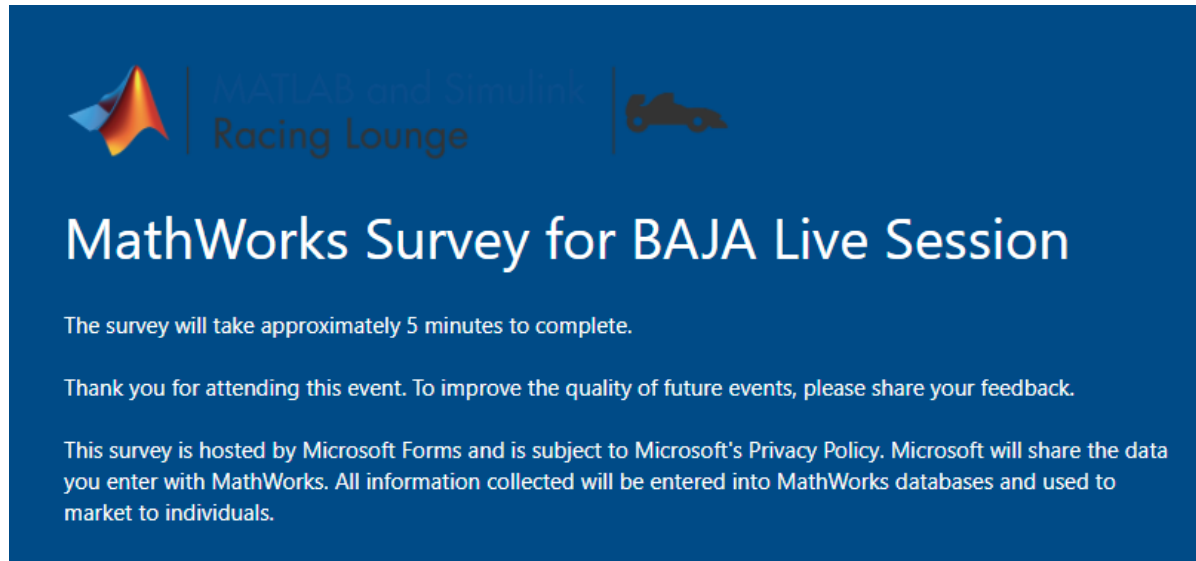
Resources for getting started with MATLAB and Simulink and the Robot Operating System (ROS).



- [fx_loadIpAddresses.m](#) - Modify the IP addresses of your ROS enabled robots/simulators here
- [fx_startupDemo.m](#)
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