

ONE-PEDAL DRIVING RAPID FEATURE DEVELOPMENT WITH SIMULINK

MATHWORKS AUTOMOTIVE CONFERENCE
MAY 9, 2017



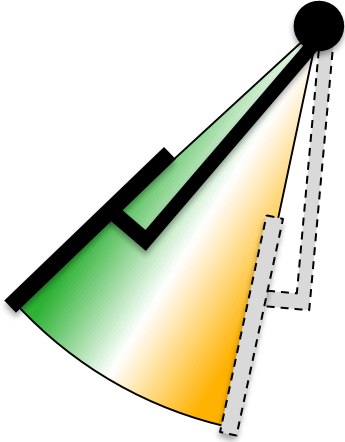
Nathaniel Michaluk

Control Algorithm Engineer, Global Electrification Controls

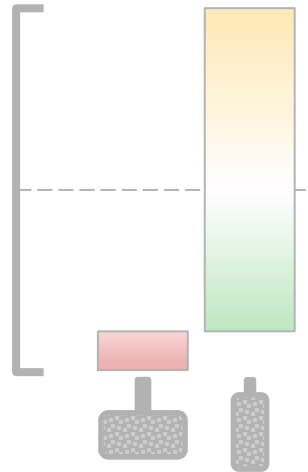
GENERAL MOTORS
GLOBAL PROPULSION SYSTEMS

This talk will introduce One-Pedal Driving, highlight its benefits, and describe Simulink's role in its development

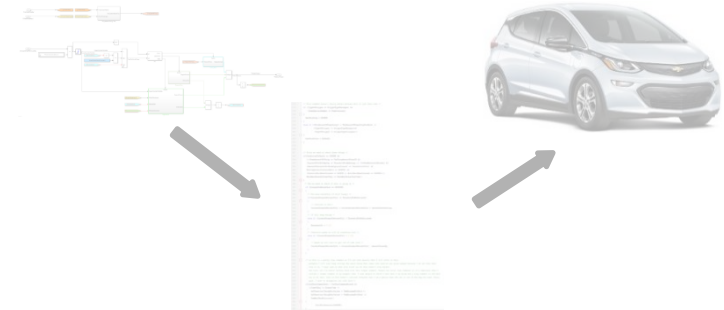
1. One-Pedal Driving Basics



2. Benefits of One-Pedal Driving

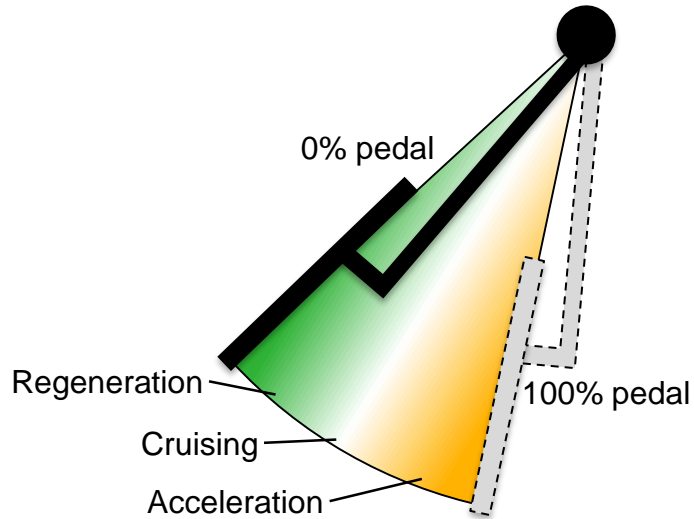


3. Feature Development with Simulink



One-Pedal Driving allows for most driving to be performed without leaving the accelerator

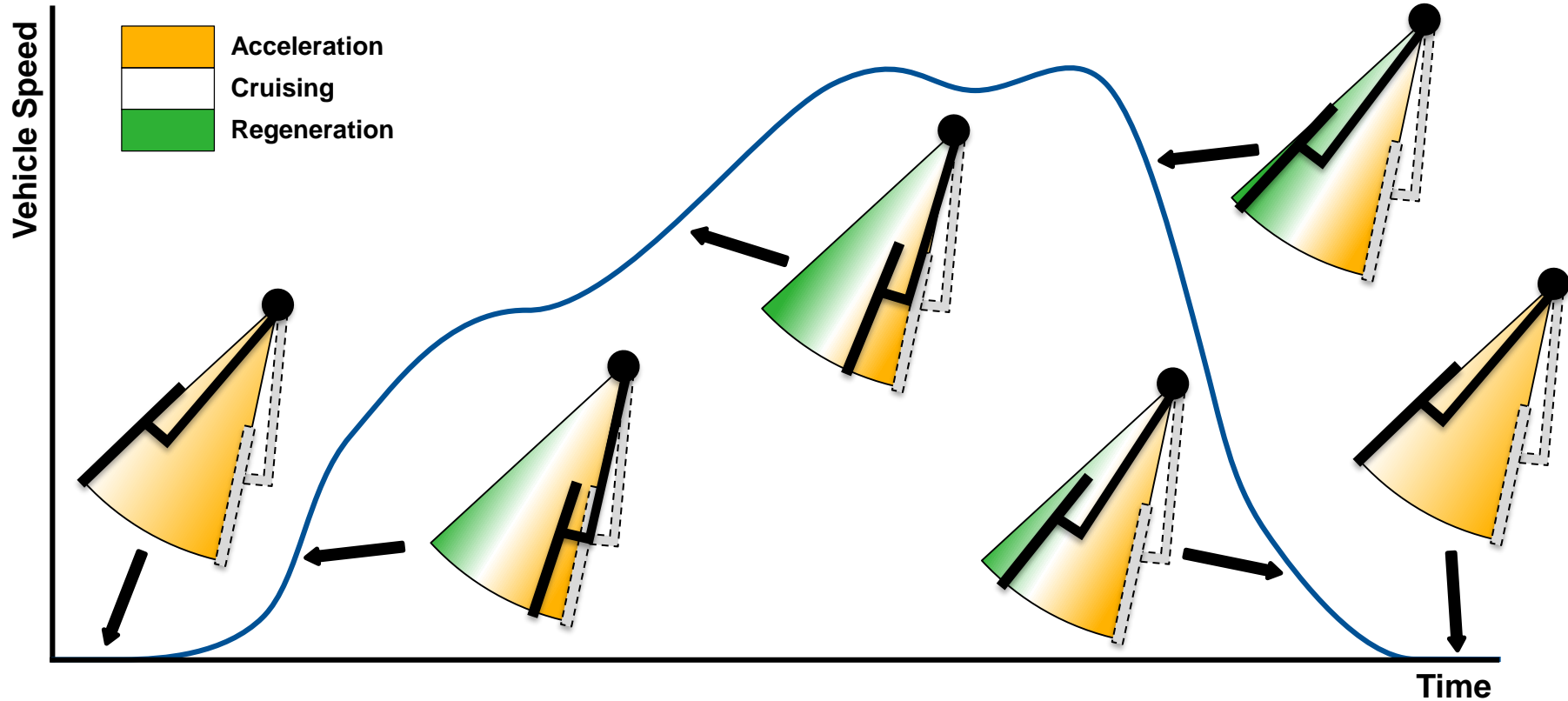
Strong coast regeneration provides confident braking levels



The vehicle stops smoothly and holds stops with One-Pedal Driving



The acceleration pedal dynamically adjusts to provide responsive propulsion and braking



With One-Pedal Driving, the Bolt EV can achieve a stop on most grades

Level Roads



Uphill Roads



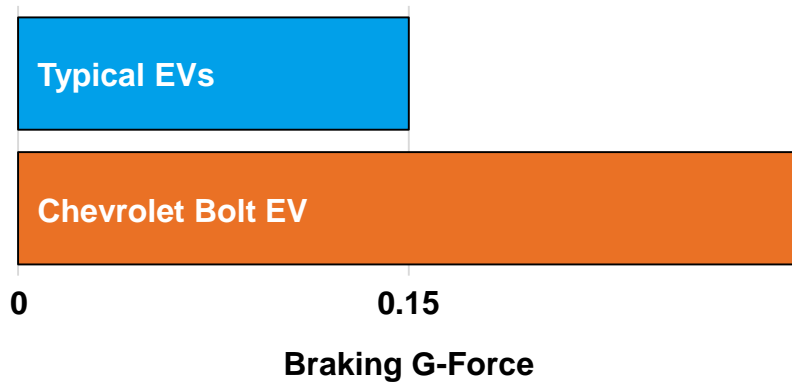
Slight Downhill Roads



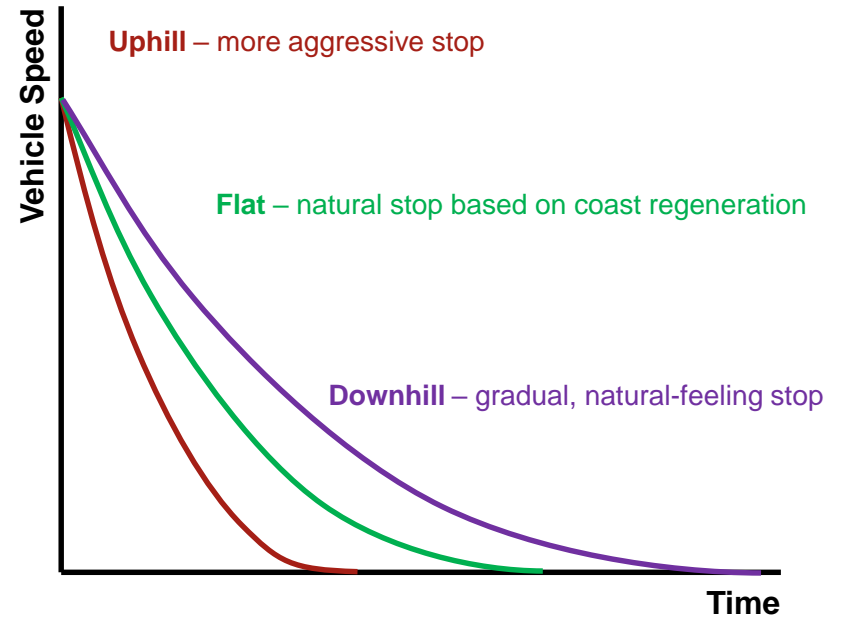
One-Pedal Driving is realized through two key aspects

Strong coast regeneration

Maximum Coast Regeneration



Speed trajectory control for complete stops



One-Pedal Driving is part of a customized driving experience

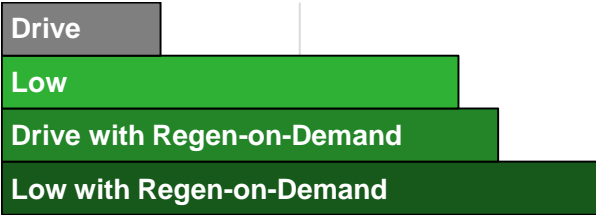
Activate One-Pedal Driving by shifting to “Low”

Temporarily activate One-Pedal Driving by holding the Regen-on-Demand paddle

Use both together for the highest level of regeneration



Coast (Zero Pedal) Regeneration



Convenience features assist the driver when using One-Pedal Driving



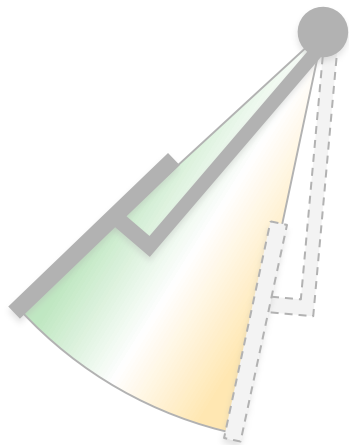
The vehicle will remain at stop upon releasing the regen paddle

If the driver begins to exit, the vehicle will automatically apply the park brake or shift to park

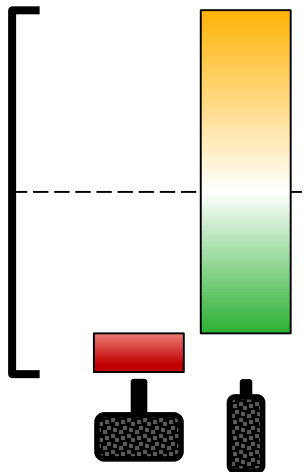


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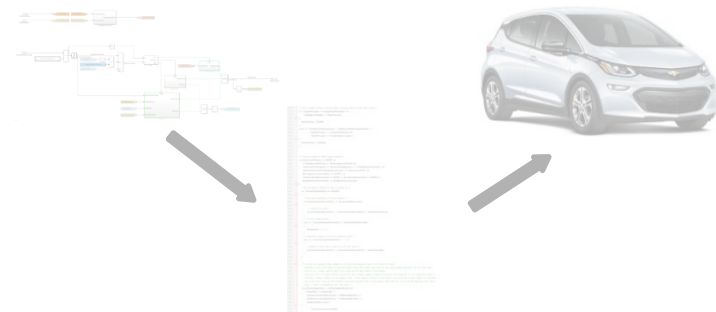
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2. Benefits of One-Pedal Driving

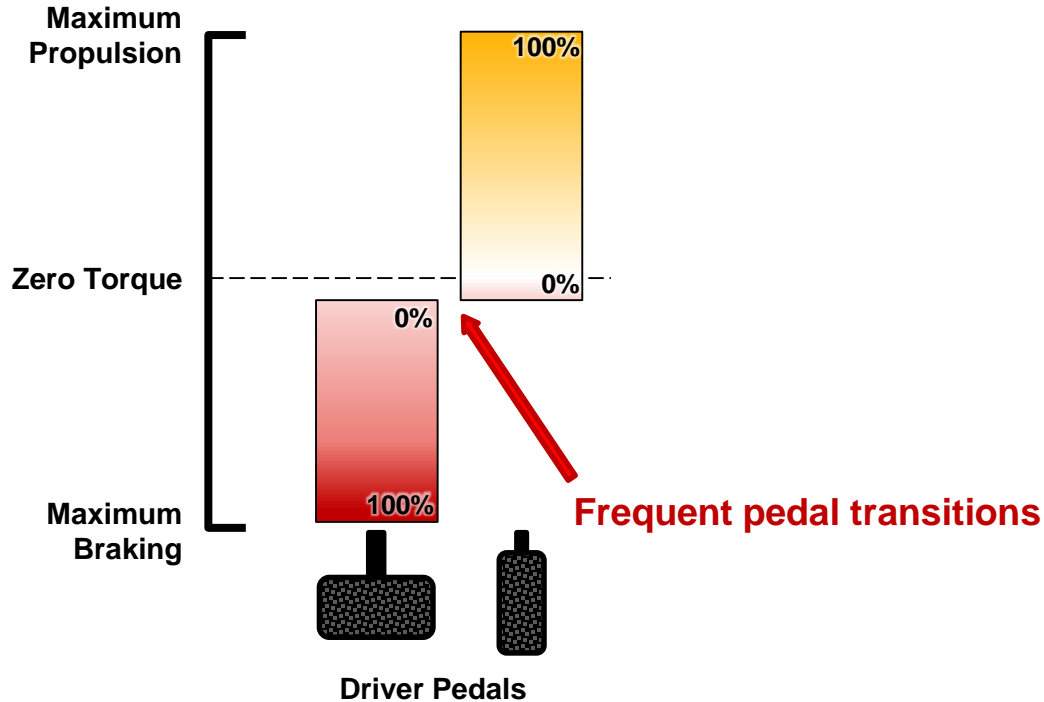


3. Feature Development with Simulink

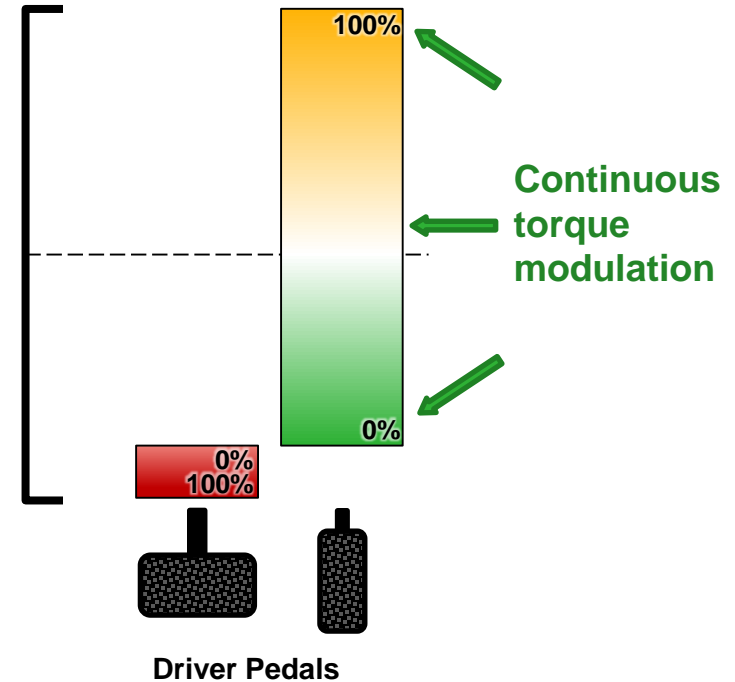


Ease-of-use – provides continuous control with fewer pedal transitions

Conventional Driving

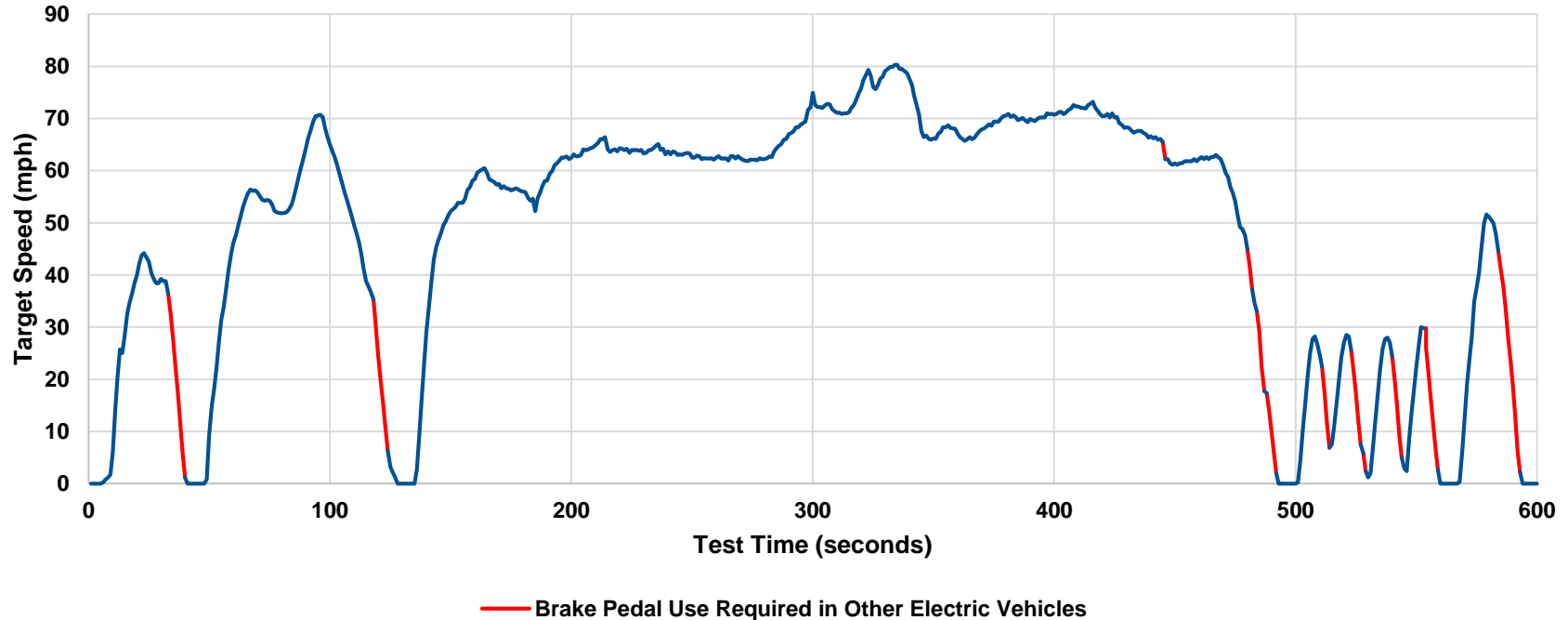


One-Pedal Driving



Energy savings – One-Pedal Driving improves real-world EV range by increasing regeneration without expensive blended braking systems

Example: Additional Energy Capture with One-Pedal Driving US06 Aggressive Driving Cycle

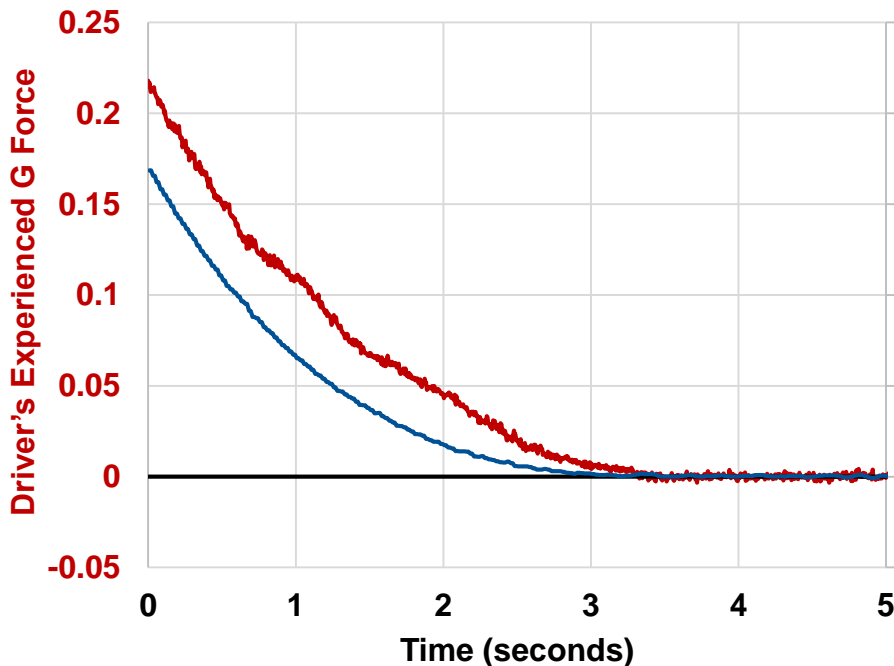


Performance – effortlessly smooth driving on winding roads

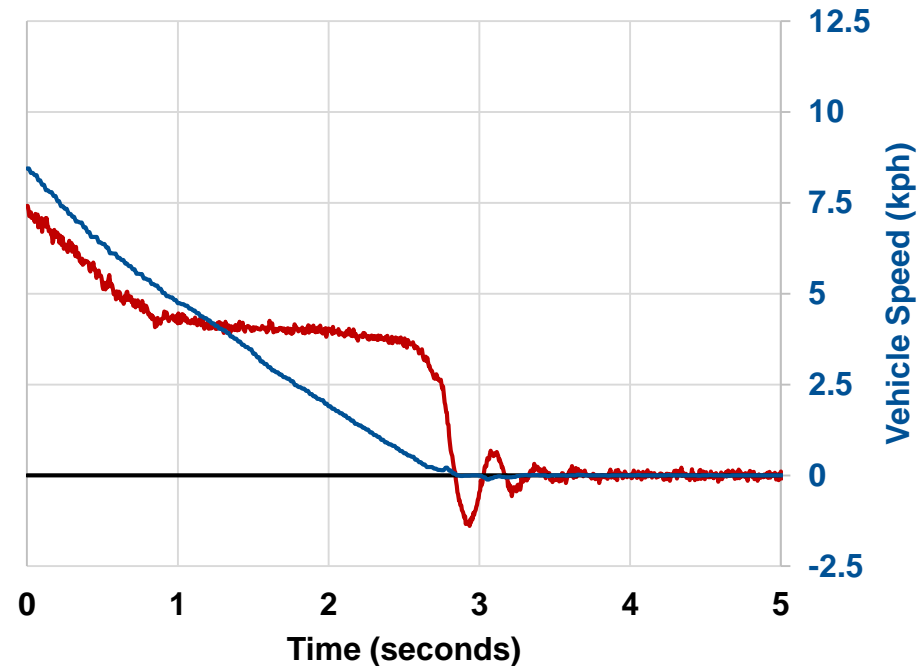


Performance – jerk-free stops with no skill required

Complete Stop with One-Pedal Driving



Complete Stop using Brakes



— Vehicle Speed

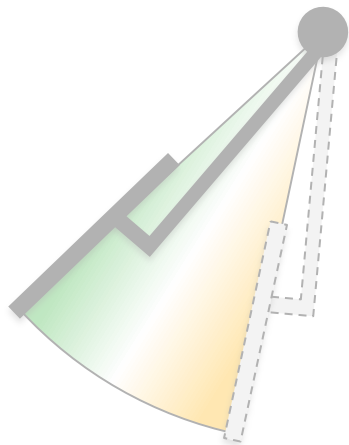
— Driver's Experienced G Force

FUN – an electric-only experience that you will never want to give up!

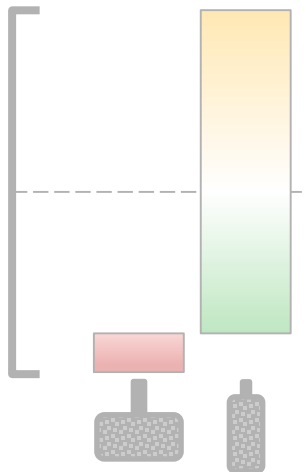


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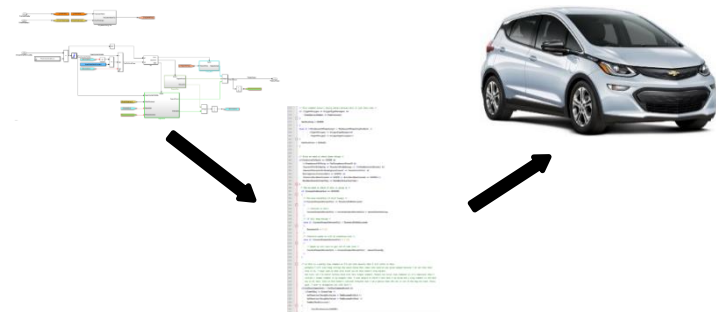
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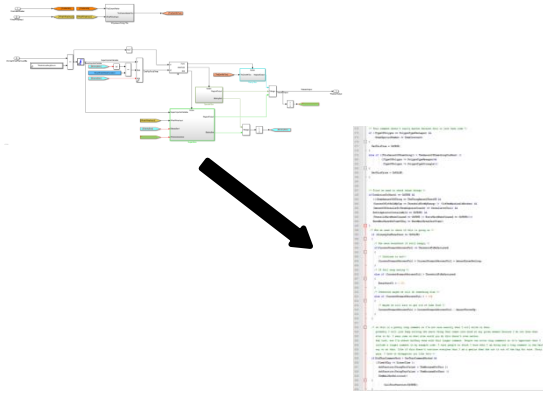


3. Feature Development with Simulink

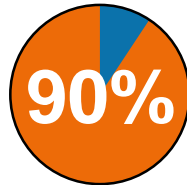
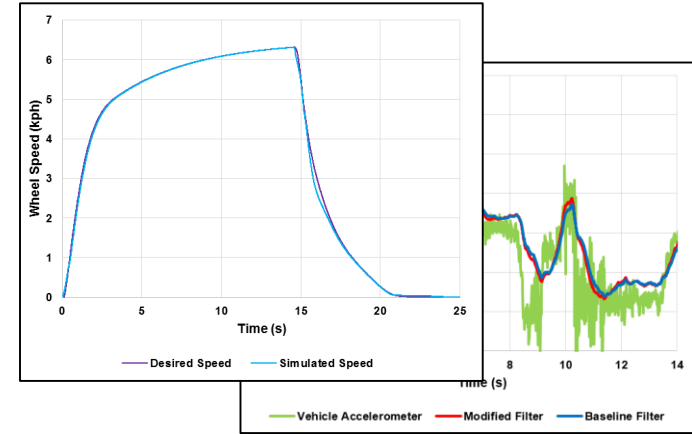


Simulink was a key enabler for a short development cycle of One-Pedal Driving

For its software creation capabilities

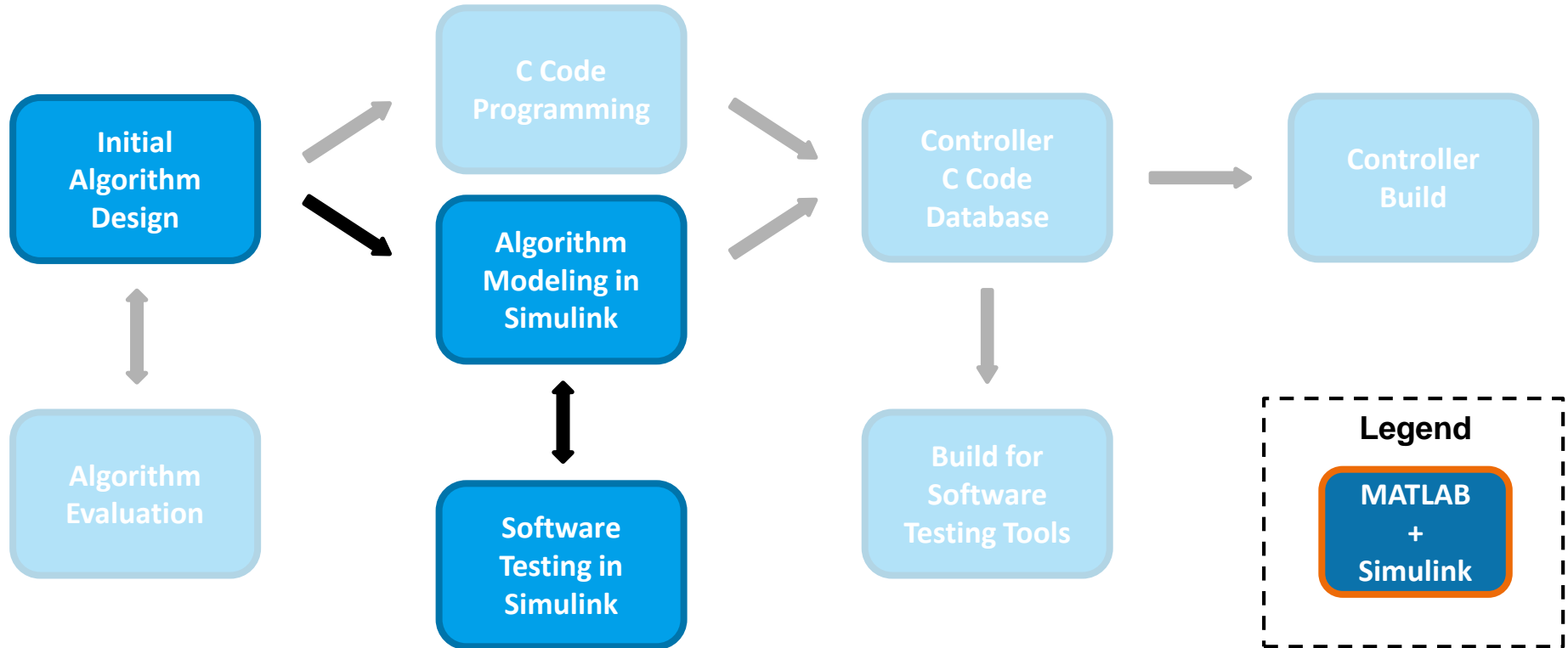


As a support tool for control system development



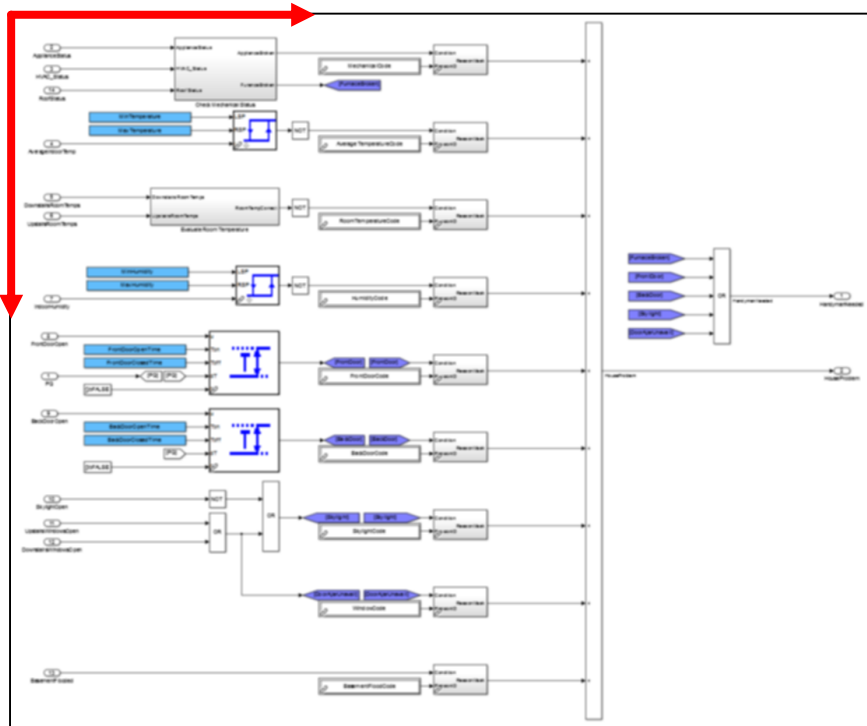
of One-Pedal Driving software written in Simulink

Simulink's capabilities prove useful throughout the entire software development process



Simulink modeling facilitates the brainstorming, creation, and review of algorithms

Visual content in two dimensions

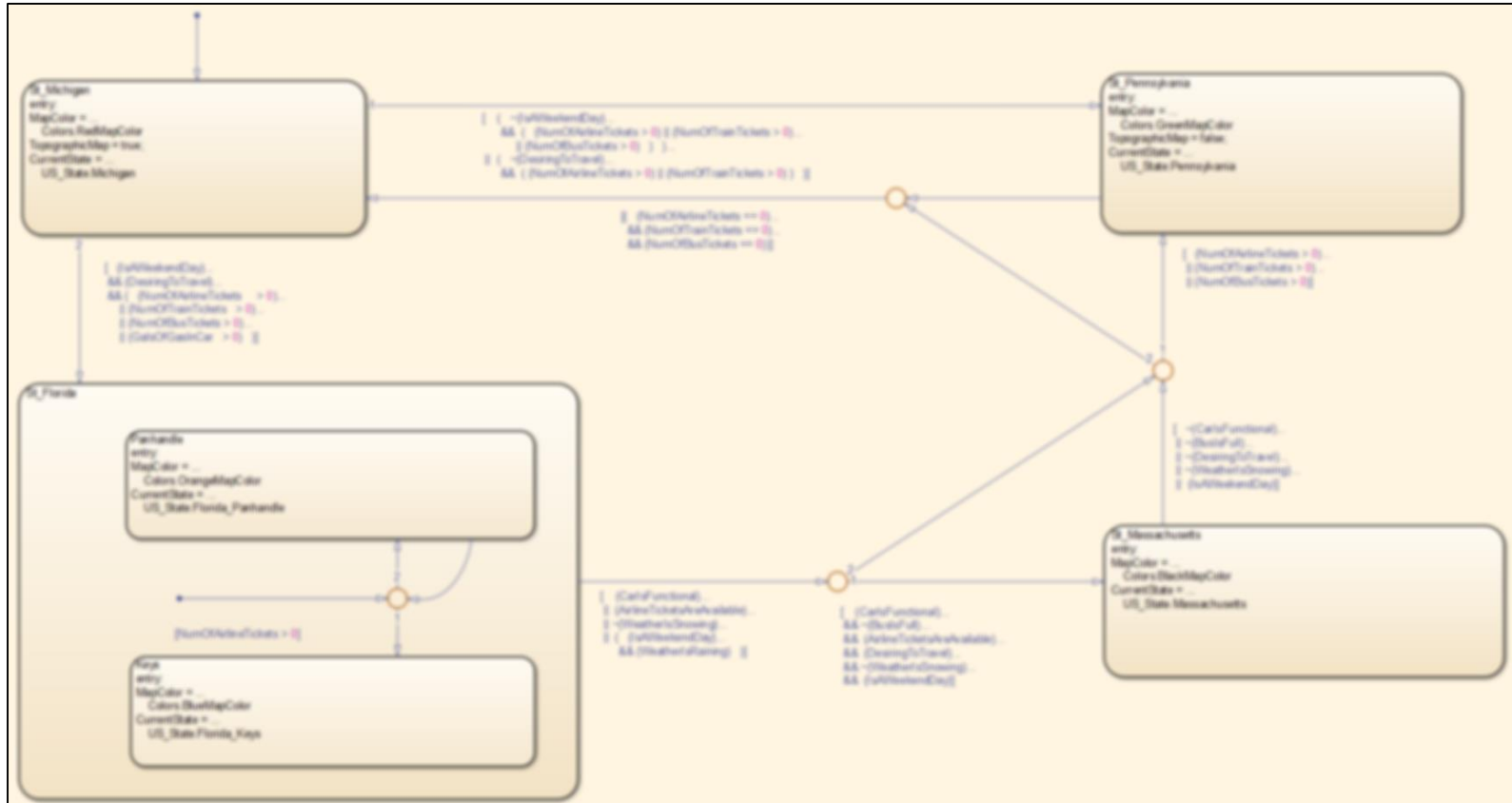


Textual content in one dimension

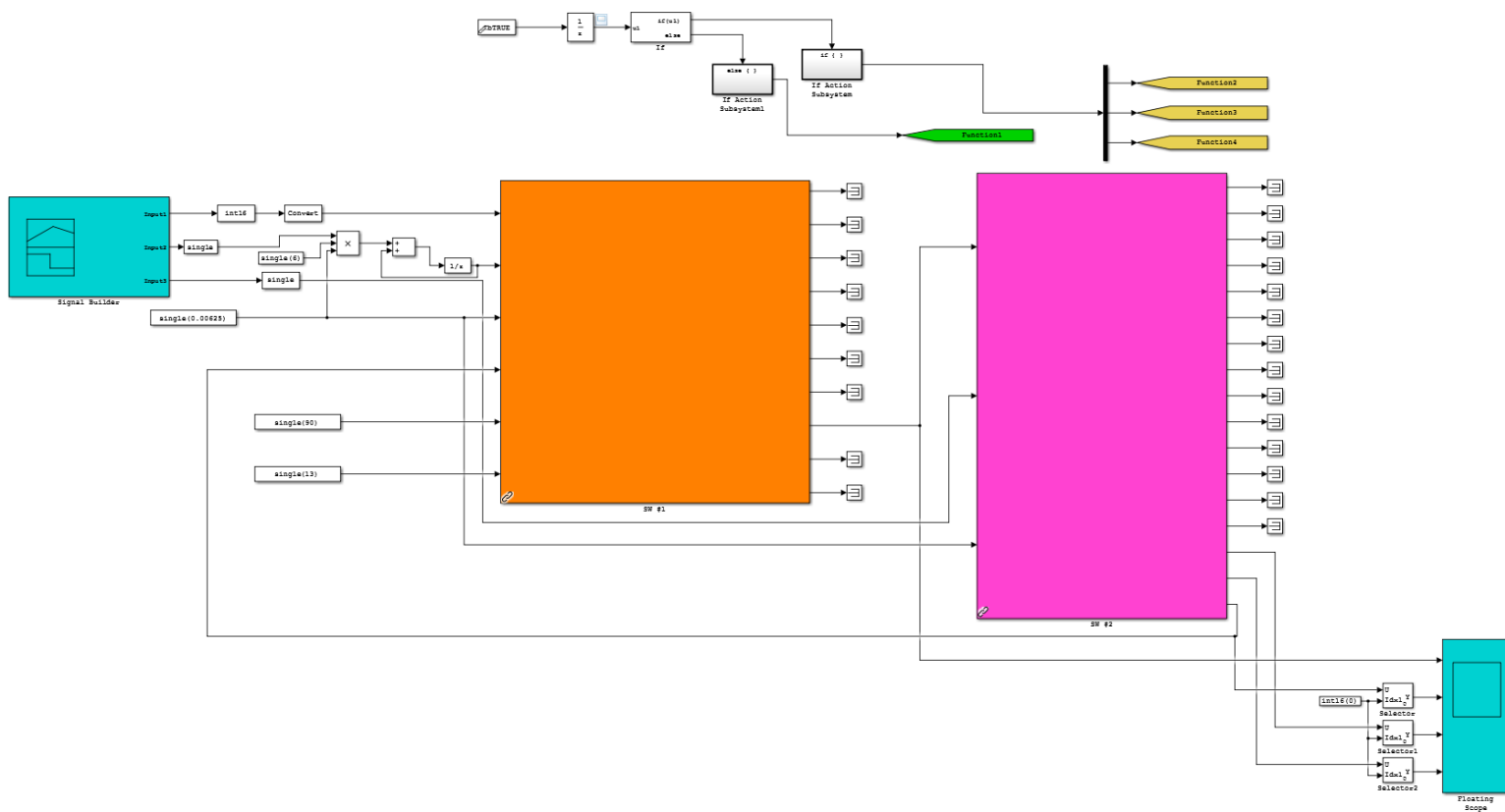
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3     (SomeSpecialValue == SomeConstant)
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5     SetThisFlow = OUTPUT;
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Stateflow provided a concise way to create and review a complex state machine in the One-Pedal Driving software

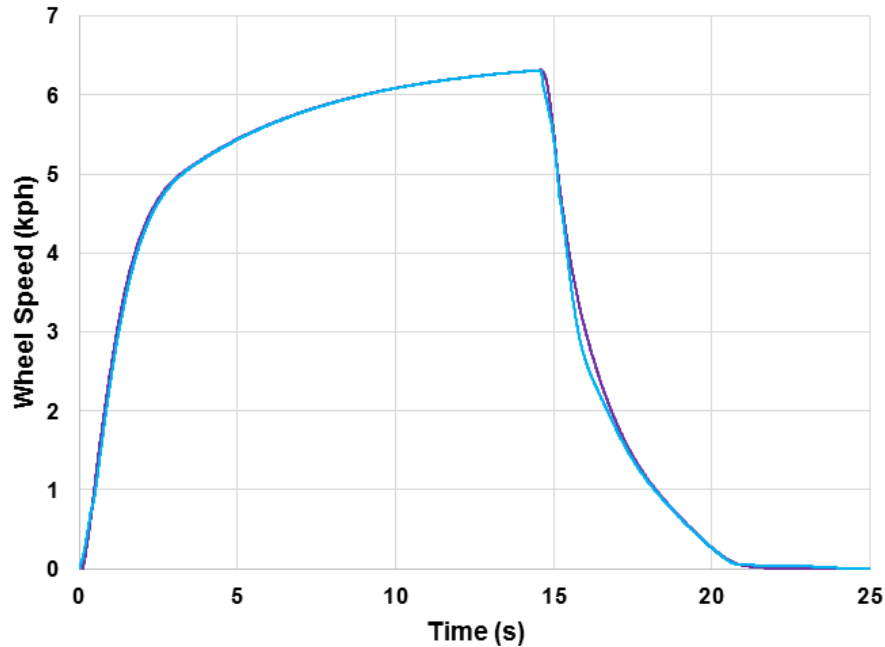


Simulink enables quick iteration because software can be created, tested, and modified all in the same environment



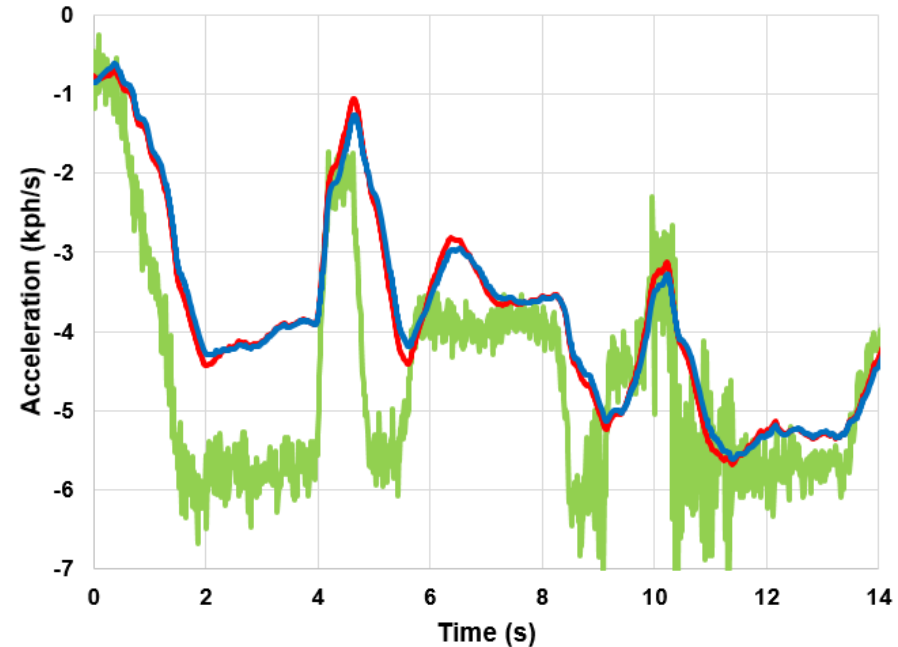
Simulink provides powerful support for control system development

Predict vehicle performance



— Desired Speed — Simulated Speed

Tune calibrations with real-world data



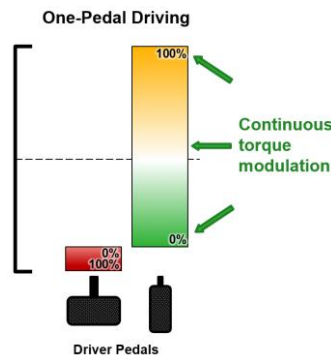
— Vehicle Accelerometer — Modified Filter — Baseline Filter

In summary, One-Pedal Driving is a superior driving experience, rapidly brought to market with the development capability of Simulink



1. **One-Pedal Driving lets most Bolt EV driving be performed without switching pedals**

2. **One-Pedal Driving provides better driveability and increases regeneration to improve range**



3. **Simulink enables rapid control algorithm creation through two coordinated avenues:**
 - iii. For algorithm creation, review, and testing
 - iv. As a tool to support control system development

