ONE-PEDAL DRIVING
RAPID FEATURE DEVELOPMENT WITH SIMULINK

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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**

- Uphill – more aggressive stop
- Flat – natural stop based on coast regeneration
- Downhill – gradual, natural-feeling stop

**Maximum Coast Regeneration**

- Typical EVs
- Chevrolet Bolt EV

**Speed trajectory control for complete stops**

<table>
<thead>
<tr>
<th>Braking G-Force</th>
<th>Vehicle Speed</th>
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<tbody>
<tr>
<td>0</td>
<td></td>
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<tr>
<td>0.15</td>
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**Graph**

- X-axis: Time
- Y-axis: Vehicle Speed
- Different trajectories for Uphill, Flat, and Downhill conditions
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

<table>
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<th>Drive</th>
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<tr>
<td>Low</td>
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<tr>
<td>Drive with Regen-on-Demand</td>
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<td>Low with Regen-on-Demand</td>
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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.
This talk will introduce One-Pedal Driving, highlight its benefits, and describe Simulink’s role in its development

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

Conventional Driving
- Maximum Propulsion
  - 100%
- Zero Torque
  - 0%
- Maximum Braking
  - 100%
  - Frequent pedal transitions

One-Pedal Driving
- Maximum Propulsion
  - 100%
  - Continuous torque modulation
- Zero Torque
  - 0%
- Maximum Braking
  - 100%
  - Driver Pedals
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

![Chart showing Target Speed (mph) vs. Test Time (seconds) with a red line indicating brake pedal use required in other electric vehicles.](chart.png)
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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2. Benefits of One-Pedal Driving

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

90% 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.
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

Tune calibrations with real-world data

Wheel Speed (kph)

Time (s)

- Desired Speed
- Simulated Speed

Acceleration (kph/s)

Time (s)

- 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