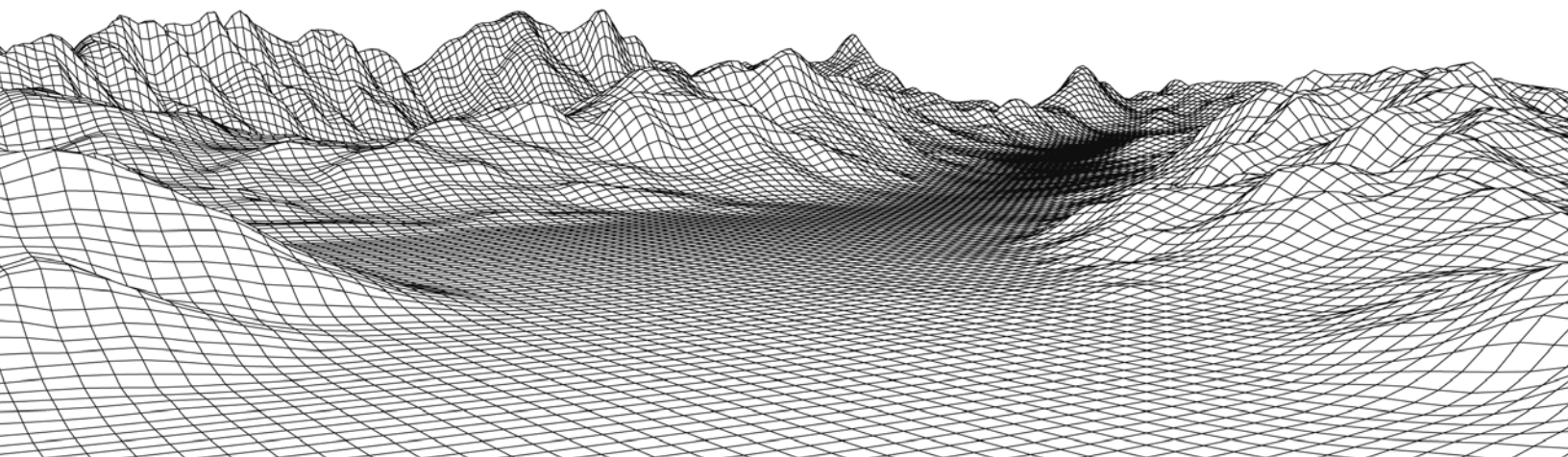


Too Many Modes

The Double-Edged Sword of
Modern Drive Modes

The Problem Papers: An in-depth look at the challenges of driving in challenging terrain.



The Situation

Sitting in the driver's seat of your brand new vehicle, you scroll through what feels like endless drive modes. Cool! But what do they all do? When should you be using them? How will they affect your range/efficiency? What about performance and safety? And why doesn't the vehicle change modes on its own?

The Proliferation of Drive Modes

Drive modes in vehicles refer to different settings or configurations that alter the behavior of the vehicle's engine, transmission, suspension, and other systems to optimize performance, efficiency, or comfort under varying driving conditions. These modes can typically be selected by the driver, allowing them to tailor the vehicle's characteristics to their preferences and the current driving situation.

As vehicle technology continues to evolve, we've seen a dramatic increase in the number and complexity of drive modes offered by modern vehicles. Particularly in the on-road/off-road space, trucks such as Rivian's R1T (up to 10 modes) and Chevrolet's Colorado (up to 5 modes) promise a diverse set of driving setups you can select while in the driver's seat. General Motors has recently unveiled driver capabilities to customize their own "My Mode" settings of characteristics such as accelerator responsiveness, suspension tuning, steering feel and motor sound¹ on their Hummer EV. While offering driving advantages in many scenarios, these wide-ranging and often redundant modes introduce a layer of complexity that can be overwhelming or even distracting for some drivers.

Understanding the Purpose of Drive Modes

Standard safety controls including Electronic Stability Control (ESC) and Anti-Lock Braking Systems (ABS) are mandated across the automotive industry, but user-selectable drive modes are going beyond safety and aim to

enhance the driver's experience. Reliant on the driver's experience to choose the correct mode, drive modes aim to optimize a vehicle's performance characteristics based on a set of control parameters. These modes promise to optimize and adjust systems such as 4WD-Auto, transmission shift points, and traction control systems. Some advanced modes are now leveraging the underlying safety systems (ECS and ABS) to further enhance vehicle performance. For simplicity of selection, many modes are named to match the environment or task they are meant for, such as "snow", "sport" or "off-road". Modern vehicles use electronic control units (ECUs) to manage these adjustments and when the driver selects a specific drive mode, the ECUs adjust the relevant parameters based on pre-programmed settings.

About Potential Motors

Potential Motors is enhancing the driving experience in challenging terrain by increasing performance, efficiency and safety with AI-powered, vision-based driver assistance technology. The specialized Potential Motors team utilizes machine learning, data science, advanced controls and vehicle dynamics simulation expertise to solve big problems in the off-road environment. Potential Motors' embedded software systems enhance the driving experience through increasing performance, safety and efficiency.

Potential Motors' core platform, Off-Road OS (OROS), integrates with a variety of vehicle types, from electric trucks to ICE side-by-sides, to provide proactive terrain analysis. The system leverages standard industry sensors to reduce integration complexity, enabling automated warnings, control and override for the most challenging and unique off-road environments.

**HEADQUARTERED IN FREDERICTON,
NEW BRUNSWICK, CANADA,**
*Potential Motors is backed by investors
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and Brightspark Ventures.*

Example drive modes:

ECO MODE: This mode optimizes the vehicle's systems for maximum fuel efficiency. Often Eco Mode includes adjustments to throttle response, transmission shift points, and air conditioning to conserve energy.

SPORT MODE: Sport mode enhances performance by adjusting the throttle response, transmission shift points, and suspension settings for a more dynamic driving experience.

COMFORT MODE: Comfort mode prioritizes a smoother and more comfortable ride, adjusting suspension settings to absorb bumps and imperfections in the road.

OFF-ROAD MODE: Designed for off-road driving, this mode adjusts traction control, throttle response, and suspension to better handle uneven terrain.

SNOW/WINTER MODE: This mode helps with traction on slippery surfaces by adjusting throttle response and engaging stability control systems.

INDIVIDUAL/CUSTOM MODE: Some vehicles allow drivers to customize their settings for various parameters, combining elements of different modes to suit their preferences.

Why so many drive modes?

Many modern vehicles today are incorporating drive modes whose primary objective is to maximize traction in a wide range of scenarios. By returning to first principles, we can see that there could be 10s or even 100s of combinations of settings from an engineering perspective based on proactive or reactive sensing of the vehicle state and terrain ahead.

Traction indicators that can be classified and used to select specific control parameters include:

1. ROUGHNESS: A measure of the unevenness or irregularities on a surface.

2. DEFORMABILITY: The ability of a material or object to change its shape in response to an applied force, such as a tire deforming on the ground it sits on.

3. FRICTION: The resistance encountered when one object moves relative to another, often due to the surfaces in contact.

Rivian's R1T All-Electric Truck

Rivian's R1T all-electric truck has up to 10 selectable drive modes that adjust suspension, torque, brake regeneration, ride height and stability control. The increasing number of modes often leaves drivers wondering when to use which setting. While some progress has been made with algorithms to learn and adapt for various drivers, this adaptation does not extend to terrain-specific changes.



→ SOURCE: www.rivian.com/r1t

Based on the real-time evaluation of traction indicators, a drive mode can be tuned for each combination. With these 3 parameters and a rating system for each, drive modes can be tuned for sub-categories, such as "Off-Road: Sand", "Off-Road: Rough Terrain", "Off-Road: Mud" and "Off-Road: Forest". But with so many possibilities, when does the amount of drive modes have diminishing returns?

Mode selection itself can be categorized as manual (driver), reactive (based on the vehicle's current state) and proactive (based on the vehicle's future state). Many systems today employ reactive technology, such as the Ford Raptor's Fox Racing Shox Reactive Technology² to automate suspension settings.

Reactive Systems Include:

- Semi-Active Suspensions
- Brake Torque Vectoring Systems
- Traction Control
- Stability Control
- Anti-Lock Braking Systems

As drive modes continue to get more intricate they can be designed not only for the type of surface being driven over but also for the topology of the terrain with hill climb/ decent, a feature that today remains at a basic level. While automating control and recommendations to the driver for modes can be an effective solution to the "too many modes" problem, whether that should be fully automated, guided, reactive, or proactive is still up for debate and largely dependent on the vehicle use case.

Modes, modes everywhere, but when to use them?

With each addition of a new drive mode to a consumer vehicle, there is an increased chance the drive modes will be misused or under-utilized by drivers. Often, drivers either do not fully understand what each mode does, or they simply neglect to switch modes when conditions change. Proper use of drive modes can be likened to riding a horse - you choose direction and speed, and the horse (vehicle) takes care of the terrain.

In off-road scenarios, for example, having a 'Rock' mode or 'Mud' mode can be extremely beneficial. These modes adjust various factors like throttle response, gear selection, and differential settings to maximize the vehicle's capability over difficult terrain. However, the need to manually switch between modes while navigating complex and rapidly changing environments can divert attention from the primary task at hand: driving.

With more modes comes more chance to be in the wrong mode, which can have big effects on safety, performance and efficiency - particularly when it comes to battery-powered vehicles. Being in 4WD with differential lock on the wrong surface will greatly reduce range (up to 20%) and driving capabilities while increasing tire wear.



SOURCE: INFINITI Drive Mode Selector

What do all these drive modes really mean?

The requirement to manually select the appropriate drive mode presents potential safety risks. In the intricate world of off-roading, the driver's attention should be focused on the terrain and not on fiddling with the vehicle's settings. This could lead to accidents or, in a less extreme scenario, a decrease in the performance or efficiency of the vehicle. When the need for a mode change is at its greatest, the driver is focused on driving and therefore has no opportunity to handle complicated settings.

The learning curve associated with these systems can be steep, especially for those not tech-savvy. As vehicles become more and more complex, the user interface should be designed to be as intuitive and straightforward as possible. However, with more modes and settings, this has increasingly become a challenge. This complexity can deter drivers from making the most out of their vehicles' capabilities.

Are automatic systems the answer?

Some vehicles have begun to integrate automatic systems that can adapt to changing conditions without any input from the driver. These systems, often known as Advanced Driver-Assistance Systems (ADAS), are increasingly being used to help mitigate the complexities of manual drive modes and improve overall driving safety and efficiency. ADAS uses a combination of various sensor technologies to understand the driving environment and adjust the vehicle's settings accordingly.

For example, certain cars can detect when it is raining and automatically activate a 'Wet' or 'Rain' mode, which might adjust the vehicle's speed, braking, and traction control settings to suit the wet conditions. However, these systems are not perfect and are primarily focused on pavement-only applications.

Potential Motors' **Off-Road Operating System (OROS)** is bridging this gap by providing automated mode selection based on machine learning and vision systems that employ cameras and other sensors to optimize the driver's experience.

Sensors often used include:

1. RADAR SENSORS: Radar sensors emit radio waves that bounce off objects and return to the sensor, providing information about the distance, size, and speed of objects around the vehicle.

2. LiDAR (LIGHT DETECTION AND RANGING) SENSORS: LiDAR works similarly to radar but uses pulses of light instead of radio waves. These sensors can create more detailed and accurate maps of the vehicle's surroundings, making them useful for understanding the terrain ahead.

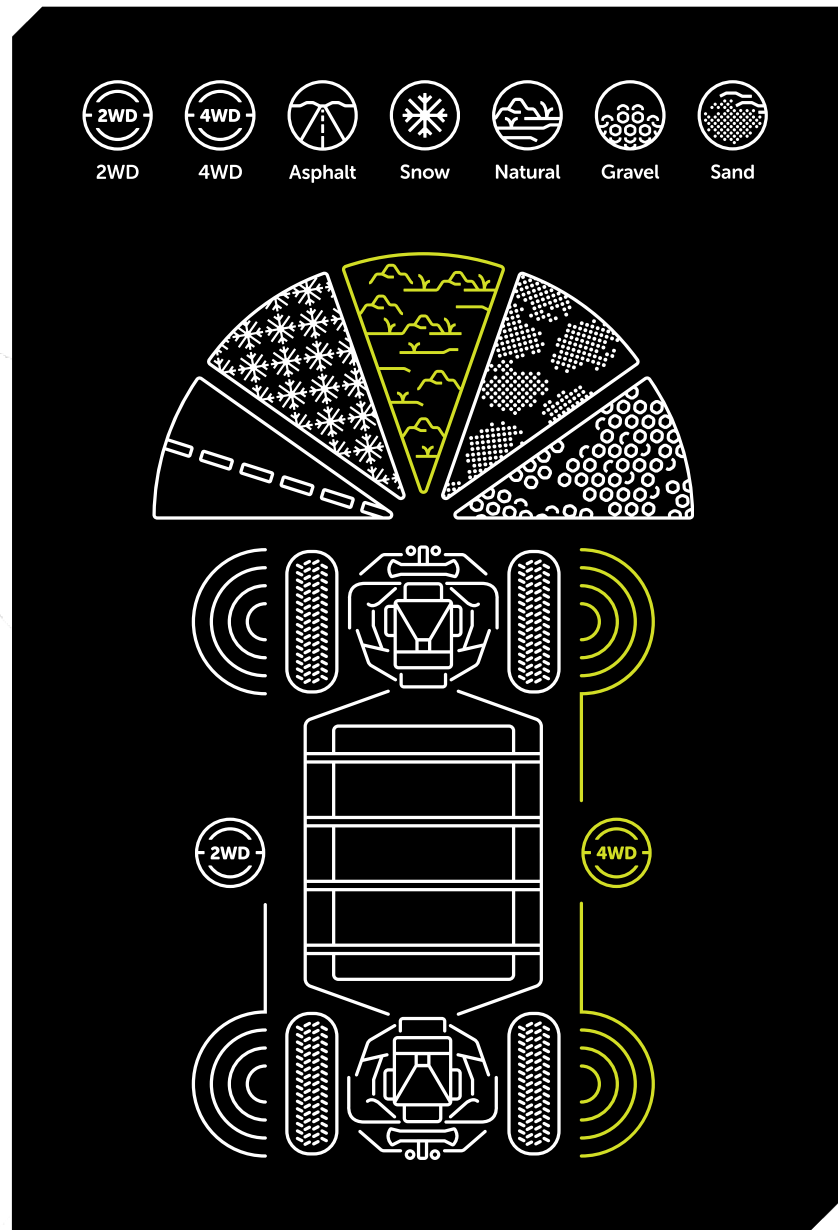
3. CAMERAS: Cameras are used to capture visual data, which can then be analyzed by the vehicle's onboard computer. Cameras are used in a wide range of systems, including lane-keeping systems, traffic sign recognition, and backup cameras.

3. INFRARED SENSORS: These sensors use infrared light to detect thermal signatures and are especially useful in low visibility conditions like fog or darkness. They can be used in night vision systems to help detect pedestrians or animals on the road.

Finding The Balance In Off-Road

As more sophistication evolves around vehicle modes, so too must the software that controls them. Potential Motor's Off-Road Operating System (OROS) allows for automated mode selection based on the proactive terrain understanding it employs. This means a driver can focus on the road (or path) ahead while the decisions of mode selection – which control suspension, drivetrain, traction control and differential lock to name a few – are left to the system to optimize.

Living as an embedded system on top of existing automotive / powersports control and safety systems, OROS can be implemented to complement modes that have already been developed. With OROS operating on an active suspension and 4WD / 2WD drivetrain, efficiency gains of up to 15% on fuel consumption (20% on battery life) were realized, all while improving the driver's capabilities off-road.



OFF-ROAD OS: Automatic Mode Selection

About Off-Road OS

Off-Road OS (OROS) by Potential Motors enables vehicles to make proactive decisions rather than being reactive, with predictive terrain analysis and solutions via automated warnings, control and override. An embedded system that enables improved control algorithms and safety modules, OROS utilizes cameras, IMU data, and custom-designed computer vision algorithms to improve performance, safety and efficiency in challenging terrain environments. The OROS suite of features, such as roll-over detection and automated mode selection, bring critical advantages to the vehicles it's employed on in mining, powersports and off-highway trucking. Want to learn more? Contact us at info@potentialmotors.com

Below: **Potential Motors** 4-motor tech demonstrator takes on all types of challenging terrain to test Off-Road OS at its limits.



The Future of Drive Modes

As we continue to navigate the complex landscape of modern vehicle technology, it's vital to consider the real-world application and practicality of these advancements. The key is to ensure that these systems serve as aids to enhance the driving experience and not as distractions that detract from it. It will require careful design, user education, and perhaps even regulatory guidance, to strike the right balance. Drive modes can be a double-edged sword - they provide significant advantages, but they're rarely utilized to their full potential. In the end, the goal should be to make our journeys, whether on the road or off it, safer, more efficient, and more enjoyable.

IF YOU'RE INTERESTED IN LEARNING HOW OFF-ROAD OS™ FROM POTENTIAL MOTORS IS TACKLING THESE ISSUES, VISIT

www.potentialmotors.com/oros or contact info@potentialmotors.com

¹ My Mode details [About Driver Mode Control | HUMMER EV | GMC Support](#)

² Ford Raptor Tech Details [2023 Ford F-150® Raptor® Truck | Model Details & Specs](#)