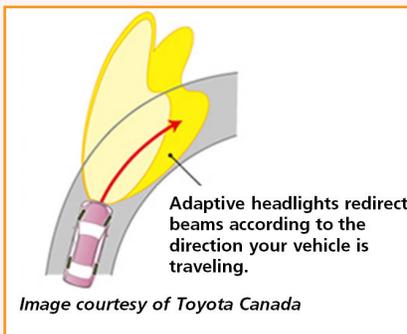


# ADAPTIVE HEADLIGHTS

You're driving along a familiar section of road, anxious to get to your destination. The sun set an hour ago and visibility has been dropping steadily as the night falls. You release the accelerator since the sharp curve in the road ahead requires that you drop your speed to a maximum of 40km/h. What you don't know is that the night is concealing a deer that has begun to cross the road just beyond the bend. Although you approach the turn at a safe speed, you are unaware of the danger ahead because you cannot see around the corner. Only as you make your turn do your headlights catch the deer. Adaptive headlights work to make situations like this safer by lighting up potential hazards or obstacles that lie around dark corners or atop hills, giving you more time to react to avoid the hazard.

## WHAT ARE ADAPTIVE HEADLIGHTS?

Adaptive headlights are designed to make driving at night safer by increasing your visibility around curves and hills. During the evening and night time, driving around corners – even at safe speeds – can be dangerous due to low visibility. Potential obstacles and hazards that are visible in normal conditions may be obscured once the sun sets. When negotiating a bend in the road, standard headlights



continue to shine straight ahead, illuminating parts of the road that you do not need to see and leaving the road ahead of you in the dark.

Adaptive headlights, on the other hand, turn their beams according to your steering input, lighting up your vehicle's path, and increasing visibility in low-light conditions. In addition to helping you see around poorly lit curves, adaptive headlights can also make cresting hills safer. When a vehicle with standard headlights crests a hill, the headlight beam temporarily points up towards the sky. This not only makes it difficult to see the road in front of you, but also makes it difficult for oncoming motorists to see you coming. In contrast, with the help of a self-levelling system, adaptive headlights consistently direct headlight beams down towards the road. For more information on how the self-levelling system works, please see the section below entitled How to adaptive headlights work?

Adaptive headlights are an example of driver assistance technology. This means that they are designed to complement your safe driving practices by offering help when you need it. Adaptive headlights cannot warn you of objects in the way, but they can make it possible to see potential dangers sooner or more easily. Adaptive headlight technology goes by a few other names, including active headlights and adaptive front-lighting systems. Despite the different names, however, each system has the same fundamental design and function.

## WHEN WOULD ADAPTIVE HEADLIGHTS BE USEFUL?

Even though fewer motorists are on the road after sunset, almost half of all serious crashes occur at

night (Aznar et al. 2011). Adaptive headlights are helpful whenever you are driving on winding roads at night, during twilight, or in other low-visibility conditions. They can address a variety of potentially dangerous situations, including the following:

- An animal lingers on the road just around a poorly lit curve.
- An oncoming vehicle negotiating a sharp curve is drifting into your lane.
- Another motorist has stopped his vehicle at the side of the road, just beyond a corner.
- You are on a narrow road at night cresting a hill, but cannot see if another vehicle is coming in the opposite direction.

By pointing your vehicle's headlights in the direction your car is moving, adaptive headlights increase your ability to see what is in front of you, whether it is around a corner or over a hill.

## HOW DO ADAPTIVE HEADLIGHTS WORK?

An adaptive headlight system is comprised of several sub-components that are monitored and controlled by an electronic control unit (ECU). Three sensors monitor the wheel speed (the speed of rotation of the vehicle's wheels), yaw (motion along the vehicle's vertical axis), and steering input of the vehicle (the angle at which the driver has positioned the steering wheel). These data are interpreted by the ECU which then sends directions to small motors attached to each headlight. These motors will move the lights to the degree specified by the electronic unit. Current adaptive headlight systems can turn up to 15 degrees per side, for a total range of 30 degrees, substantially increasing

## Your brain is your vehicle's most important safety feature.

your range of visibility. Furthermore, safety technology developers are always improving on this range of motion, so adaptive headlight systems may be available today or in the near future that can illuminate an even wider section of the road ahead.

Most adaptive headlight systems also include a self-levelling system. This system is designed to prevent your headlights from momentarily pointing too far up or too far down when your car goes over hills or large bumps. A self-levelling system includes a level sensor that determines if the car is tilted forward (when driving downhill) or backwards (when driving uphill). The headlights are then moved up or down to correct for the vehicle's forward or backward positioning.

Some adaptive headlight systems are complemented by cornering lights. These automatic systems are designed to increase visibility during very tight manoeuvres undertaken in low-light conditions. Cornering lights illuminate the sides of the vehicle when you are negotiating hairpin turns or parking, and can illuminate up to 80 degrees of space by the side of your vehicle. These lights will then automatically turn off when the vehicle has finished turning.

### ARE ADAPTIVE HEADLIGHTS EFFECTIVE?

Since adaptive headlights are a relatively new safety technology, there is a limited amount of data to measure their effectiveness. The Insurance Institute for Highway Safety (IIHS) has defined crashes where adaptive headlights would be relevant as all night-time front-to-rear collisions, single-driver, and same-direction side-swipe collisions. IIHS also limited the group of relevant crashes to those that occurred only when the driver was negotiating

a curve. Given this, IIHS estimates that adaptive headlights are relevant in 142,000 crashes per year in the United States, including 29,000 that resulted in injury and 2,480 that resulted in death (IIHS 2010).

Adaptive headlights also benefit other motorists on the road. For example, when turning around a bend in low-light conditions, standard headlights will temporarily point directly at oncoming traffic. Unlike standard headlights, adaptive headlights are designed to point more directly at the road, thereby reducing the likelihood that oncoming motorists are temporarily blinded by the headlights of others. Also, since it is unlikely that adaptive headlights will ever point directly at another motorist, the lights within adaptive headlights can be brighter and still be safe.

Many adaptive headlight systems feature bi-xenon lights. Emitting a slightly blueish tint, these lights are brighter than standard lights and offer a clearer, more distinct view of the road ahead. Also, the ionised gas used in bi-xenon lights is more energy efficient than typical halogen bulbs, which makes bi-xenon lights last longer.

### DO ADAPTIVE HEADLIGHTS HAVE ANY LIMITATIONS?

Yes. As with many other safety technologies, realizing the potential benefits of adaptive headlights depends largely on whether drivers understand the design limits and intended function of the technology and can interact appropriately with it. Adaptive headlights are designed to illuminate the road in front of you in conditions of low visibility. The system is not designed to alert you in any way of obstacles or potential road hazards. In addition, while adaptive headlights can significantly increase a driver's range of visibility, this range still has limits. What this means is that

while negotiating curves sharper than 15 degrees, you will have to slow down further in order to maintain a lit view of your path.

Transport Canada's assessment of road safety benchmarks acknowledges the dangers presented by sharp curves on roads (Transport Canada 2003). Nevertheless, there are still many curves in roads that exceed 15 degrees, even on fast roads like highways. When safely negotiating a curve requires a reduction in speed, there will be a sign alerting you of both the approaching curve and the proper speed at which to take the curve. In low visibility conditions, you may have to reduce your speed further. Driving a vehicle equipped with adaptive headlights does not make speeding around corners any safer, so you are always urged to respect the posted speed limits and to reduce your speed when going around curves.

Your adaptive headlights may work perfectly and illuminate an obstacle that you would not otherwise have seen, however you must still be able to react appropriately to that obstacle. If your reaction time is delayed for some reason (e.g., fatigue, distraction, excessive speed, inattention, or intoxication), then there is a very real danger that you will not be able to manoeuvre safely around hazards on or near the road, regardless of how much notice you get.

Feedback from drivers who own cars with adaptive headlights demonstrates a disturbing increased willingness to drive at night or at higher speeds (IIHS 2008, Braitman et al. 2010). The sense of security that safety features inspire should not lead you to drive in ways or in conditions that you would normally not feel safe driving in. Particularly, given



the crucial role of the driver in avoiding obstacles illuminated by adaptive headlights, motorists should remember that they are always encouraged to use safety technologies to complement their responsible driving practices, and not as a reason for driving less attentively or more recklessly.

### CAN I TURN MY ADAPTIVE HEADLIGHTS OFF?

Adaptive headlights will not affect any other aspect of your driving experience. The advanced headlight system is a quiet feature that is designed to be non-intrusive. Adaptive headlights automatically disengage when a vehicle is stationary or moving in reverse, so you do not need to be concerned about turning the feature on and off.

That being said, adaptive headlight systems can still be turned off. You can turn most adaptive headlight systems on or off from within the vehicle by moving a switch between OFF and AUTO. There is also typically an adaptive headlight indicator light on the vehicle's dashboard to remind you of whether the system is active or not. For more detailed instructions about turning adaptive headlights on or off, you may consult the owner's manual of your vehicle. However, you are encouraged to use good judgment when deciding to turn off any of the safety features on your vehicles.

### HOW PREVALENT ARE ADAPTIVE HEADLIGHTS?

Adaptive headlights are still relatively new, and not enough data have been collected about their effectiveness to encourage their standardization. The advanced headlight system was first introduced to the North American market in 2003. Since then, it has most often been offered as an optional feature on luxury brands, although some manufacturers offer adaptive headlights as a standard feature

on some higher-end models. However, adaptive headlights are being made available on an increasing range of vehicle makes and models.

### HOW MUCH DO ADAPTIVE HEADLIGHTS COST?

Since adaptive headlights are relatively new, the price of installing the sophisticated system is still high; an after market system can cost upwards of \$1,000. However, as more vehicle makes and models begin to feature adaptive headlights as either optional or standard, the price of the system is likely to change. There is also no anticipated effect of adaptive headlights on fuel consumption.

### REFERENCES

Visit [www.brainonboard.ca/program\\_resources/references.php](http://www.brainonboard.ca/program_resources/references.php) for a full list of references.

### WANT TO LEARN MORE?

Visit [www.brainonboard.ca](http://www.brainonboard.ca) to learn more about vehicle safety features:

- Active Safety Features
- Passive Safety Features
- Driver Assistance Technologies
- Safety Technologies in Development

Driving instructors, road safety educators, car dealers and service providers can download and order program resources and materials through the Brain on Board website. [www.brainonboard.ca/program\\_resources/](http://www.brainonboard.ca/program_resources/).



64.8% of Canadians think it's important to pay careful attention to driving, even with advanced safety features like brake assist.

Your brain is your vehicle's most important safety feature.

Visit [BrainOnBoard.ca](http://BrainOnBoard.ca) to give it a tune-up.

Toyota Vehicle Safety Education Program sponsored by:



A  education program

Program proudly supported by 

