



# Future Truck Position Paper: 2019-3

## *Recommendations Regarding Future Commercial Vehicle Braking Systems*

Developed by the Technology & Maintenance Council's (TMC)  
Future Chassis and Brake Systems Task Force

### **ABSTRACT**

New requirements for reduced stopping distance (RSD) and stability are prompting manufacturers to consider emerging technologies in order to reduce response time in heavy-duty commercial braking systems, thereby improving overall vehicle safety and efficiency. TMC recommends accelerating research and development of future braking systems to overcome limitations of current pneumatic braking system designs, leverage emerging technologies in conjunction with those currently available in the marketplace. This position paper discusses the opportunities and potential limitations that need to be addressed and provides a baseline from which research projects can be developed.

### **INTRODUCTION**

New requirements for reduced stopping distance (RSD) and stability are prompting manufacturers to consider emerging technologies in order to reduce response time in heavy-duty commercial braking systems, thereby improving overall vehicle safety and efficiency. TMC's Future Truck Committee — through its Future Chassis and Brake Task Force — has been exploring developing technologies in braking that utilize other methods of brake actuation beyond current hydraulic and pneumatic brake systems (one such example being an electro-

mechanical braking system). TMC's position is that future braking systems will need advanced technologies to comply with anticipated RSD targets, improve driver control throughout braking applications, provide better diagnostics of braking systems, reduce maintenance costs and increase fuel efficiency. TMC believes all of these items can be achieved through advancements in technologies, which employ multiple sensors to measure heat, braking force and wheel rotation speed. In fact, most of the technology needed is already available in the industry.

The purpose of this position paper is three-fold:

- Provide recommendations of a possible future braking system other than current hydraulic and pneumatic actuated braking systems to facilitate increased awareness of developing technology,
- Offer goals for future brake design, performance, operation and reliability on trucks, buses, tractors and trailers, and;
- Provide a baseline from which TMC can undertake research into the of development of future brake systems and potentially develop on-track testing of prototype systems to demonstrate their operational capabilities, benefits and challenges.

This paper is organized into the following sections:

- Braking System Performance Requirements and Description
- RSD Compliance
- Safety Technology Interface
- Maintenance considerations
- Efficiency benefits
- Environmental Benefits
- Concerns

## **BRAKE SYSTEM PERFORMANCE REQUIREMENTS AND DESCRIPTION**

Current commercial vehicle brake systems are either hydraulically or pneumatically actuated, which is a drawback to reaching optimized performance under all road conditions. Hydraulically and pneumatically actuated brake systems have gone through several evolutions of development and electrification to provide performance improvements such as the antilock braking system (ABS), automated emergency braking (AEB), and enhanced stability control (ESC). Today's foundation brake actuation at the wheel-end utilizes either hydraulic or pneumatic technologies developed more than 50 years ago.

Advancements in actuation technology, when compared to current hydraulic and pneumatic braking systems, need to offer improved brak-

ing performance, reduced stopping distance, energy-optimized braking and advanced driver assistance systems (ADASs) that improve the overall vehicle efficiency.

Future braking systems will likely be a complete departure in actuation method from existing hydraulic and pneumatic braking systems. For example, today's current pneumatic actuators will be replaced with some type of electric actuated device at each wheel-end to provide the brake actuation. The future braking system with advancements in actuation technology will avoid brake fade issues that are inherent with current pneumatic and hydraulic braking systems. Preferably, the braking system should operate using either 12, 24 or 48 volts. The brake system also will need to have comprehensive fault tolerance if utilizing processing controller(s) that are network together using a databus.

While the Council is not prepared to offer design recommendations for such a future brake system at this time, TMC anticipates that vehicles utilizing such systems would likely employ an electronically controlled braking system (ECBS) architecture for faster response timing in which two isolated electronic signals control the service brake system. This "2E ECBS" architecture is expected to provide equivalent or improved safety performance as compared to conventional braking systems.

Redundancy should be incorporated throughout the brake system, because electronic components are not necessarily a one-to-one equivalent replacement of the parallel mechanical components of a traditional braking system. This means the system should feature two or more circuits. For example, multiple sensors at the brake pedal and parking switch will need to be utilized for comprehensive fault tolerance.

This future braking system must provide basic system functions such as service and parking brake, as well as automatic blending of brake

forces from regenerative braking or retarders. Additionally, the brake system must include functions for preventing wheel lock during service braking, engine braking or excessive wheel spin during acceleration. Future braking systems employing advanced actuation technology should also include directional stabilizing functions to prevent understeering and oversteering.

### **RSD COMPLIANCE**

While current pneumatic braking systems are reliable and safe, they have certain limitations that could be addressed through newer technologies. New requirements for reduced stopping distance and stability can be achieved by decreasing response time from brake pedal to actual braking application. TMC believes this will most likely be accomplished electrically using electronic signals on a databus versus today's hydraulic or pneumatic braking system.

Current hydraulic and pneumatic require many moving parts that must be activated by air moving through tanks, long hoses and valves before the actual pad or disc is brought into contact with the rotor/drum surface. This process can exceed 0.5 seconds, which translates to 44 feet of travel at a speed of 60 miles per hour. Advanced actuation technology would reduce the number of moving parts needed and decrease actual brake application time. This would reduce stopping distance and thereby improve overall vehicle safety and efficiency.

### **SAFETY TECHNOLOGY INTERFACE**

Current ABS and traction control systems have greatly improved overall vehicle safety. The ABS controls a small part of the chain of events in a braking application by closing an air valve to an individual or multiple wheels. All other components of the braking system must be working properly for the ABS control to impact the individual wheel. Performance problems with automatic brake (slack) adjusters, brake chamber malfunctions, and air leaks cannot be self-corrected by current brake

systems. Combining electronic application of brakes either by wire or wireless technology (e.g., Bluetooth, Wi-Fi, or perhaps Dedicated Short Range Communications) should allow better braking stability by adjusting braking force at individual wheels verses just an "on/off" application as in current braking systems.

Automated driving and platooning technologies for heavy-duty trucks will be greatly enhanced by electronically controlled braking applications. This will require compatible braking capabilities for the vehicle combination to work in unison. While this is somewhat possible with current pneumatic brake systems, it is anticipated that future braking systems with advanced actuation technology will have better brake balance and response times throughout the vehicle combination compared to current brake systems.

### **MAINTENANCE CONSIDERATIONS**

Future braking systems will monitor individual wheel responses using sensors and advanced actuation technology. Items that could be measured include braking force, heat, response times and wear status. This data would help technicians diagnose driver complaints such as pulling during braking applications, poor brake response and worn or broken components at an individual wheel. Brake component condition/wear status could be communicated over the vehicle databus, simplifying inspection and condition reporting.

Fewer moving components would reduce maintenance times by reducing or eliminating some of the following:

- Preventive maintenance tasks for brake adjustments and checks.
- Replacement of moving parts due to wear (e.g., S-cam and bushings, brake adjusters, rollers and chambers).
- CSA violations due to improper brake adjustments, air leaks and component failures.

The future braking system should allow for the use of different composite friction materials for brake pads to increase brake rotor life and reduce downtime from foundation brake maintenance issues. Having a fluid-free, advanced brake-actuated braking system is a dry brake system, which means the elimination of fluid leaks, filling, bleeding and contamination associated with current pneumatic and hydraulic systems.

### **EFFICIENCY BENEFITS**

Decreasing the need for air/pneumatics creates the possibility of removing compressors, tanks, valves and hoses from the tractor/trailer, which would improve efficiency in several areas. Fuel mileage increases would be obtained through a decrease in motor drag from compressor and lower weights of the overall tractor and trailer. Decreased tare weight will allow for more cargo and fewer loads. Maintenance and downtime can be reduced. Safer truck and trailer braking stability and functionality can result in reduced insurance and risk management costs.

### **ENVIRONMENTAL BENEFITS**

For the reasons cited previously, the future braking system should also provide potential environmental benefits through reduced demand on the vehicle powerplant and improved payload capacity to reduce fleet fuel consumption. By eliminating the demand for air dryers and valves that purge and release oils and contaminants from the air brake system, pollutants on roadways that can wash into groundwater and bodies of water would be reduced. The technology advancements in brake actuation will also need to be quieter than current pneumatic braking systems.

Eliminating air brake system noises caused from the purging and releasing of air, will result in an improved noise profile for heavy-duty

commercial vehicles in congested areas where there is close interaction with the general public, such as during delivery and service operations in early morning or evening hours.

### **CONCERNS**

TMC acknowledges that every technical innovation presents its own set of issues or concerns. These include:

- Cybersecurity of Bluetooth/Wi-Fi systems (viruses and hacking);
- Voltage/power requirements;
- Backward compatibility with current systems.
- Corrosion of electrical /electronic components caused by deicing chemicals.

### **CONCLUSION**

Future braking systems will need to meet the changing needs of the trucking industry and have the potential to improve the overall safety and efficiency of the future truck through:

- Improved braking performance for optimized stopping distance and maneuvering;
- Energy savings potential;
- Reduced braking system noise;
- Reduced brake system weight;
- Reduced environmental contaminants;
- A dry brake system with no leaks, filling or bleeding;
- Utilization of “2E” service brake control for redundancy and more responsive braking.
- Improved wheel-end diagnostics.

TMC recommends that advancements in braking actuation technologies be further researched and investigated for heavy-truck commercial vehicle applications, to find out if the new brake actuation technologies hold promise in meeting the changing requirements of the trucking industry and improving the overall safety and efficiency of the future truck.

