

The U.S. Department of Transportation has established a goal to reduce the highway fatality rate to no more than 1.0 fatalities per 100 million vehicle miles traveled by the end of 2008. Each of the Department's highway safety agencies have individual reduction targets that will contribute to this 2008 target. Federal Motor Carrier Safety Administration's (FMCSA) aim is to reduce the large truck fatality rate by 41 percent from 1996 to 2008, to 1.65 fatalities in truck crashes per 100 million miles of truck travel.

The Office of Bus and Truck Standards and Operations, which produced this Tech Brief, develops and promotes national motor carrier safety program goals, priorities, and initiatives. It provides technical expertise and advice in the development and deployment of motor carrier safety programs, including the development of regulations. The Office determines national motor carrier safety operational program requirements, standards, and procedures for vehicle and roadside operations, driver and carrier operations, and bus safety.



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Federal Motor Carrier Safety Administration

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# Commercial Motor Vehicle Tire Pressure Sensors

## Project Funding

Under Section 5117 of the Transportation Equity Act for the 21st Century of 1998 (TEA-21), Congress required the U.S. Department of Transportation to "conduct research on the deployment of a system of advanced sensors and signal processors in trucks and tractor-trailers to determine axle and wheel alignment, monitor collision alarm, check tire pressure and tire balance conditions, measure and detect load distribution in the vehicle, and adjust automatic braking systems."

As a result of a comprehensive technology scan, as well as numerous interviews with key industry stakeholders such as truck manufacturers, fleet operators, suppliers, and regulators, a variety of research areas were identified, including the design, functionality, and performance of tire pressure monitoring and inflation systems for commercial motor vehicle applications.

## Background

The load-carrying capability of a tire is critically linked to the inflation pressure. Fleet operators will generally select a particular "target pressure" for their trucks based on the unique load, operating, and environmental conditions in which they operate. If not properly inflated, the useful tire life, as well as safety, is compromised.

The act of tire pressure maintenance is labor and time intensive. An 18-wheeled vehicle can take from 20 to 30 minutes to check all of the tires and inflate perhaps two or three tires that may be low on air. To complete this task once each week on every tractor and trailer becomes a challenge for many fleet operators. As a result, tires are often improperly inflated.

Very little empirical data exists with regard to actual tire pressure maintenance practices on commercial motor vehicles, and the extent of the "problem" (improper inflation) is not well understood. Over the last several years, new approaches and technologies have been developed for the commercial motor vehicle market to help improve tire maintenance practices, including automatic tire inflation systems and various types of tire monitoring systems. However, fleet maintenance managers often lack the information to determine if such systems will offer a reasonable return on their investment.

## Objectives of the Research

The primary objectives of this project were to develop and document the impacts of tire inflation maintenance practices on commercial motor vehicle operating costs and safety, and to provide a quantitative estimate of the potential benefits of tire pressure monitoring sensors and automatic inflation systems.

## Overview of Project Approach

Work on this project consisted of the following sub-tasks:

- Gather and synthesize existing research in order to characterize the impact of improper tire inflation upon fuel economy, tire wear, and safety.
- Work cooperatively with the Technology and Maintenance Council (TMC) to synthesize existing tire pressure survey data from a wide variety of fleets.
- Conduct original research and tire inflation field data collection for the owner-operator segment.
- Analyze tire inflation survey data from the above two sources to statistically characterize the degree to which commercial motor vehicle tires are improperly inflated in the general commercial vehicle population.
- Gather information from numerous vendors and suppliers of tire pressure monitoring and automatic inflation systems.
- Develop six different hypothetical fleet operating scenarios to use as a construct for evaluating the costs and benefits of tire pressure monitoring and inflation systems.

Much of the information gathered for this project was obtained via computerized literature research, and through a review of technical material from organizations such as the Society of Automotive Engineers (SAE), the National Highway Traffic Safety Administration (NHTSA), TMC, and other industry associations. In addition, numerous industry stakeholders were contacted and interviewed.

## Commercial Motor Vehicle Tire Maintenance Practices

The following summarizes the key observations and conclusions about tire inflation condition and maintenance practices of commercial motor vehicles as observed from the sample tire pressure data collected:

- Approximately 7.08% of all tires are underinflated by 20 psi or more. Only 44.15% of all tires are within  $\pm 5$  psi of their target pressure.
- For-hire carriers' (truckload (TL), less-than truckload (LTL), and owner-operators) vehicles generally reflected better tire inflation maintenance practices than private carriers' vehicles. As a group, for-hire carriers sampled had 7.01% of all tractor tires underinflated by 20 psi or more. In contrast, the private carriers sampled had 13.21% of all tractor tires underinflated by 20 psi or more.
- Tire inflation maintenance practices correlate closely with the size of the fleet. For tractors, fleets with 50 power units or less have 19.07% of their tires underinflated by 20 psi or more, while fleets of greater than 3,000 power units have only 2.06% of their tires underinflated by 20 psi or more. Similarly, motorcoach fleets with less than 50 power units have 11.75% of their tires underinflated by 20 psi or more, while fleets with over 500 power units have only 2.09% of their tires underinflated by 20 psi or more.
- Transit bus operators have better tire pressure maintenance than chartered motorcoach operators based on the sample data. Only 3.09% of transit bus tires are underinflated by 20 psi or more, while 9.37% of chartered motorcoach tires are underinflated by 20 psi or more. Additionally, 49.88% of transit bus tires are within  $\pm 5$  psi of target (a very high percentage), compared with only 34.22% of chartered motorcoach tires.
- Tractors and trailers have a significant challenge with mismatched dual tires. Approximately 20% of all tractor dual tire assemblies have tires that differ in pressure by more than 5 psi. One out of four trailer dual assemblies (25%) have tires that differ in pressure by more than 5 psi.

## Economic Analyses of Tire Pressure Monitoring & Inflation Systems

The following table shows the economic consequences of tire pressure monitors and the costs which tire pressure monitors may be able to reduce.

Economic consequences of incorrect inflation pressures	Tire pressure monitors may be able to reduce
<ul style="list-style-type: none"> <li>• Increased tire wear</li> <li>• Reduced tire life</li> <li>• Reduced fuel economy</li> <li>• Road calls</li> </ul>	<ul style="list-style-type: none"> <li>• System procurement costs</li> <li>• System maintenance costs</li> <li>• Total direct costs avoided with properly maintained tires</li> <li>• Tire installation costs and associated downtime</li> <li>• Costs from improved safety</li> </ul>

Key observations from the cost-benefit analyses are as follows:

- Tire-related costs are the single largest maintenance cost item for commercial vehicle fleet operators. Nationwide, the average tire-related costs per tractor-trailer are about 1.9 cents per mile, or about \$2,375 for a 125,000 annual mileage operation.
- For the average fleet operator in the United States, improper tire inflation increases the annual procurement costs for both new and retreaded tires by about 10% to 13%.
- Fuel economy loss due to improper tire inflation is about 0.6% for typical TL and LTL operations.
- Improper tire inflation is likely responsible for about one roadcall per year per tractor-trailer combination due to weakened and worn tires.
- For a typical TL or LTL operator, improper tire inflation increases the total operating costs by about \$750 annually per tractor-trailer combination. Cost penalties for other types of fleets are similar and range from about \$600 to \$800.
- One of the primary motivators for fleets to purchase automatic tire maintenance systems is that operators will not have to spend as much time checking tires for proper inflation. An average 18-wheel tractor-trailer could easily take 30 minutes to check the pressure of each tire and add air to two or three of the tires. Most fleet maintenance departments ask operators to check tire pressures weekly. However, if operators only check tires twice a month, the total annual labor would be approximately 12 hours (0.5 hours/inspection × 24 inspections). At \$25/hour, the cost would total \$300 annually in tire inspection costs. This is likely a conservative estimate of tire pressure maintenance costs.
- The cost associated with routine tire pressure maintenance, combined with the increased costs due to poor inflation, arguably represents the total costs that could be addressed (that is, reduced) by tire pressure monitoring and automatic inflation systems.
- There are numerous tire pressure monitoring and automatic inflation systems available from vendors that are specifically tailored to commercial vehicles. If such systems could be installed for approximately \$1,000 per tractor-trailer combination, and if they were effective in mitigating incidences of improper tire inflation, such systems would indeed be highly cost-effective. Return-on-investment periods even for an average fleet would be between 1 and 2 years.
- Sensitivity analyses show that even for fleets with relatively "good" tire maintenance practices (fleets which would demonstrate a 25% reduction in total cost of improper inflation compared to "average"), the cost-effectiveness of tire monitoring and automatic inflation systems is still within return periods of less than 3 years.
- Tire pressure monitoring and automatic inflation systems become even more cost-effective, if safety-related benefits are explicitly considered. However, direct costs associated with a fleet's safety record (such as injury claims, insurance premiums, workers' compensation claims, as well as "goodwill" with customers and suppliers) are difficult to estimate, and even more difficult

## Researcher

This study was performed by Booz-Allen-Hamilton Inc., McLean, VA, and Fleet Tire Consulting, Rochester Hills, MI, by Robert M. Kreeb, Brian T. Nicosia, and Peggy J. Fisher. Contract No. DTFH61-99-C-00025.

## Availability

The study final report, FMCSA-PSV-04-002, is available from the United States Department of Transportation and the National Technical Information Service, [www.ntis.gov](http://www.ntis.gov).

## Key Words

Commercial motor vehicles, tires, tire inflation, tire pressure, tire sensors.

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to determine what portion could be attributed to poor tire pressure maintenance. Therefore, while improved tire pressure maintenance will have an important and direct impact on reducing commercial motor vehicle-related property damage, injuries, and fatalities, the economic benefits of such safety improvements have not been quantified.

- Tire pressure monitoring and automatic inflation systems have not achieved significant market penetration rates. Hindrances to increased usage appear to focus on fleet operators' concerns over system reliability and required maintenance costs, as well as the initial costs of the systems.

## Summary

The analyses presented in the report strongly suggest that the savings potential from tire pressure monitoring and automatic inflation systems could support the purchase prices of systems and products currently in the marketplace. The challenge for the supplier community is to prove reliability and reduce or eliminate added maintenance for the systems themselves.



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