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The Aluminum Association

SIZE, MASS AND SAFETY

CLEARLY IDENTIFYING THE RELATIONSHIP BETWEEN VEHICLE SIZE, MASS AND SOCIETAL SAFETY

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SIZE, MASS AND SAFETY

A summary of important works developed over the past 20 years to clearly identify the relationship between vehicle size, mass and societal safety.

Vehicle mass reduction is a fundamental strategy to improve fuel economy and reduce CO2 emissions. Regulators and original equipment manufacturers (OEMs) share a common objective of advancing vehicle efficiency technologies while maintaining or improving overall societal vehicle safety. A number of studies have been conducted over the past 20 years in an effort to estimate the impact of vehicle size and mass on vehicle safety. These studies rely on complex statistical analysis of historical vehicle safety data.

Estimating a change in societal safety of the entire United States fleet using available data sources requires use of complex statistical models and ambitious assumptions. Over the years, researchers have discovered modeling vehicle field safety performance is a difficult task. Estimates are based on statistical analyses of historical data. Analyses of historical data necessarily lag behind the latest developments in vehicles because it takes years for sufficient crash data to accumulate. To achieve statistically valid results, researchers typically need five to 10 years of field data on five to 10 years of production vehicles. Therefore, the analysis is based on vehicle designs and safety technology that is more than 15 years behind current designs. These studies are the best indicators available, but have uncertain value for predicting effects of mass and size on safety of future vehicles.

Early studies (1997-2005) utilized field data for vehicles built between 1980 -1990. Researchers used differed statistical models and different vehicle safety databases for their work. Results of those studies indicated some directional trends but also yielded a great deal of variability and, at times, contradictory conclusions. Factors that appear to confound safety conclusions include: vehicle design, safety belt use, anti-lock braking system (ABS), Electronic Stability Control (ESC), driver frailty, driver behavior, road types, population density and others. Most studies found safety performance is not well correlated to vehicle attributes of size or mass except for small vehicles. Recent studies have attempted to improve clarity of findings. Statistical modeling techniques have become progressively more sophisticated and vehicle field data has become more representative of contemporary vehicle safety engineering and safety equipment.

This paper is intended as a summary of important work over the past 20 years to clearly identify the relationship between vehicle size, mass and societal safety. The "Early Research" is provided as a bibliography of leading studies on the question of vehicle size and mass on safety performance written to support Corporate Average Fuel Economy (CAFE) 2007-2012 regulations. Key points of "Early Studies" are not summarized in this report. These studies have been superseded by more recent studies conducted in support of CAFE 2012 and CAFE 2021-25. Recent studies on vehicle size, mass and safety have utilized advanced statistical analysis models and more contemporary vehicle safety data bases.

Key findings of leading papers in this group of studies are provided. In most cases, the findings presented are direct quotes from individual study conclusions. Findings and conclusion among the recent studies have greater consistency than was seen in earlier studies.

MAIN FINDINGS

Mass reduction in only lighter-than-average cars was associated with a statistically-significant increase in fatality risk; for the other vehicle types, mass reduction was associated with increases or decreases in fatality risk that were not statistically significant.

DOT HS 811 665, NHTSA 2012, Kahane, C.J.

mass reduction in lighter cars is associated with an increase in societal fatalities, mass reduction in the heavier LTVs is associated with a decrease in societal fatalities, and mass reduction in the intermediate classes has little effect.

LBNL, 2012, Wenzel, T.

Most studies found safety performance is not well correlated to vehicle attributes of size or mass

There was little correlation between mass and fatality risk by vehicle model, even after accounting for all other vehicle attributes, driver characteristics, and crash circumstances.
any reasonable combination of mass reductions while holding footprint constant concentrated in the heavier LTVs and limited in the lighter cars – would likely be approximately safety-neutral; it would not significantly increase fatalities and might well decrease them

NHTSA, 2016, Puckett, S.M., Kindelberger, J.C.

mass reduction in lighter cars is associated with an increase in societal fatalities, mass reduction in the heavier LTVs is associated with a decrease in societal fatalities, and mass reduction in the intermediate classes has little effect.

NHTSA, 2016, Puckett, S.M., Kindelberger, J.C.

RECENT RESEARCH - CAFE 2012, CAFE 2021-25

Independent Review: Statistical Analyses of Relationship between Vehicle Curb Weight, Track Width, Wheelbase and Fatality Rates," UMTRI, 2011, Green et. Al.

Updated Analysis of the Effects of Passenger Vehicle Size and Weight on Safety, Phase I. Report No. DRI-TR-11-01. (Docket No. NHTSA-2010-0152-0030) 2011, Dynamic Research, Inc., Van Auken, R.M., Zellner, J. W.

mass reduction was associated with increases in crash frequency, and decreases in risk per crash

mass reduction was associated with more beneficial changes in fatality risk

reducing mass and footprint together (downsizing) on smaller vehicles was harmful

Relationships Between Fatality Risk, Mass, and Footprint in Model year 2000-2007 Passenger Cars and LTVs, Report No. DOT HS 811 665, NHTSA 2012, Kahane, C.J.

Mass reduction in only lighter-than-average cars was associated with a statistically-significant increase in fatality risk; for the other vehicle types, mass reduction was associated with increases or decreases in fatality risk that were not statistically significant.

Assessment of NHTSA's Report "Relationships Between Fatality Risk, Mass, and Footprint in Model Year 2000-2007 Passenger Cars and LTVs., LBNL, 2012, Wenzel, T.

other vehicle attributes, driver characteristics, and crash circumstances were associated with much larger changes in risk than mass reduction

There was little correlation between mass and fatality risk by vehicle model, even after accounting for all other vehicle attributes, driver characteristics, and crash circumstances.

mass reduction was associated with increases in crash frequency, and decreases in risk per crash

mass reduction, while holding footprint constant, was estimated to result in a statistically significant increase in societal fatality risk in lighter cars, but a statistically significant decrease in societal fatality risk in heavier LTVs by decreasing the fatality risk of occupants in lighter vehicles which collide with the heavier LTV

Relationships between Fatality Risk, Mass, and Footprint in Model Year 2003-2010 Passenger Cars and LTVs (Docket No. NHTSA-2016-0068), NHTSA, 2016, Puckett, S.M., Kindelberger, J.C.

mass reduction in lighter cars is associated with an increase in societal fatalities, mass reduction in the heavier LTVs is associated with a decrease in societal fatalities, and mass reduction in the intermediate classes has little effect.

any reasonable combination of mass reductions while holding footprint constant in MYs 2017-2025 vehicles – concentrated in the heavier LTVs and limited in the lighter cars – would likely be approximately safety-neutral; it would not significantly increase fatalities and might well decrease them

estimated effect of mass reduction is a societal fatality increase for cars

< 3,197 pounds, and in all models except one, a societal fatality reduction for LTVs = 4,947 pounds

estimates are based on statistical analyses of historical data, which puts some limitations on their value for predicting the effects of future mass reductions. Analyses of historical data necessarily lag behind the latest developments in vehicles and in driving patterns because it takes years for sufficient crash data to accumulate

Assessment of NHTSA's Report "Relationships Between Fatality Risk, Mass, and Footprint in Model Year 2003-2010 Passenger Cars and LTVs, (LBNL-1005177), 2016, Office of Energy Efficiency and Renewable Energy, US Department of Energy, T. Wenzel

The LBNL report confirms NHTSA's 2016 findings

there is a wide range in fatality risk by vehicle model for models that have comparable mass or footprint

EARLY RESEARCH (1997-2005)

Initial studies evaluated historical vehicle safety data as indicator of future vehicle safety performance. That research examined safety data for vehicles engineered in the 1980s and built in the 1990s. These studies were based on less sophisticated statistical models and vehicle data for vehicles designed and built over 20 years ago. Results of these studies are somewhat inconclusive and, at times, contradictory with other studies. These reports are listed for reference without summary of findings.

Results of these studies are somewhat inconclusive and, at times, contradictory with other studies.

Relationships between Vehicle Size and Fatality Risk in Model Year 1985-93 Passenger Cars and Light Trucks [5] DOT HS 808 570, January 1997, C. Kahane

Review of the Results in the 1997 Kahane, 2002 DRI, 2003 DRI, and 2003 Kahane Reports on the Effects of Passenger Car and Light Truck Weight and Size on Fatality Risk [16] DRI-TR-04-02 March 2004 R.M. Van Auken and J.W. Zellner

Causal Influence of Car Mass and Size on Driver Fatality Risk, American Journal of Public Health 91: 1076-8, 2001, Evans, Leonard

Assessment of the Effects of Vehicle Weight on Fatality Risk in Model Year 1985-98 Passenger Cars and 1985-97 Light Trucks [14] DRI-TR-02-02 February 2002 R.M. Van Auken and J.W. Zellner

A Further Assessment of the Effects of Vehicle Weight and Size Parameters on Fatality Risk in Model Year 1985-98 Passenger Cars and 1985-97 Light Trucks [15] DRI-TR-03-01, 2003, R.M. Van Auken and J.W. Zellner

Estimation of the Effects of Vehicle Size and Mass on Crash-Injury Outcome Through Parameterized Probability Manifolds, SAE Technical Paper Series 2003-01-0905, Nusholtz G., .Rabbiolo, G., ShiY.

Influences of Vehicle Size and Mass and Selected Driver Factors on Odds of Driver Fatality, Padmanaban, J., AAAM, 2003 USCAR.

Vehicle Weight, Fatality Risk and Crash Compatibility of Model Year 1991-99 Passenger Cars and Light Trucks, 2003, NHTSA Technical Report. DOT HS 809 662, Kahane, C. J.

Further Assessment of the Effects of Vehicle Weight and Size Parameters on Fatality Risk in Model Year 1985-98 Passenger Cars and 1986-97 Light Trucks. Report No. DRI-TR-03-01 (2003).. Torrance, CA: Dynamic Research, Inc. Van Auken, R. M., and Zellner, J. W.

Review of the Results in the 1997 Kahane, 2002 DRI, 2003 DRI, and 2003 Kahane Reports on the Effects of Passenger Car and Light Truck Weight and Size on Fatality Risk, DRI-TR-04-02 (2004), Van Auken, R.M., and Zellner, J.W..

Motor Vehicle Fuel Efficiency and Traffic Fatalities, Energy Journal, Vol. 25, No. 4 (2004), pp. 1-22. Noland, Robert B

Technical Report on Vehicle Weight, Fatality Risk and Crash Compatibility of Model Year 1991 -99 Passenger Cars and Light Trucks, 68 FR 661 531Docket No. NHTSA-2003-163 18, (2004), Kahane, C.J..

Supplemental Results on the Independent Effects of Curb Weight, Wheelbase, and Track on Fatality Risk in 1985-1998 Model Year Passenger Cars and 1985-1997 Model Year LTVs [17] DRI-TR-05-01, 2005, R.M. Van Auken and J.W. Zellner

different independent effects of vehicle weight and size on fatality risk are observable in the 1995 to 1999 calendar year data for 1985 to 1988 model year passenger cars and 1985 to 1997 model year light trucks. The results indicate that vehicle weight reduction tends to decrease fatalities, but vehicle wheelbase and track reduction tends to increase fatalities.

Effect of Fuel Economy on Automobile Safety: A Reexamination," Transportation Research Record No. 1941, 2005, Ahmad. S. and D.L. Greene

Assessment of the Effects of Vehicle Weight and Size on Fatality Risk in 1985 to 1998 Model Year Passenger Cars and 1985 to 1997 Model Year Light Trucks and Vans), Society of Automotive Engineers Paper No. 2005-01-1354, 2005, Van Auken, R. M., and Zellner, J. W.

Increasing the Fuel Economy and Safety of New Light Duty Vehicles, White Paper for the William and Flora Hewlett Foundation, 2006, Wenzel, T., Ross, M.

Comments on Safety Impacts of EPA-NHTSA Proposed Rule to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, September 2009, DRI-TM-09-86., Van Auken, R.M., and Zellner, J.W

Comments on the Joint Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards Docket No. NHTSA–2009–0059 and Docket No. EPA-HQ-OAR-2009-0472, Wenzel, T.

Relationships Between Fatality Risk, Mass, and Footprint in Model Year 1991-1999 and Other Passenger Cars and LTVs., NHTSA 2010, Kahane, C.J.

mass reductions in historical data might not be consistent with future mass reductions.

future vehicle design is likely to take advantage of safety-conscious technologies that could reduce risk associated with lighter vehicles in the historical analyses

Analysis of Relationship between Vehicle Weight/Size and Safety and Implications for Federal Fuel Economy Regulation, Office of Energy Efficiency and Renewable Energy, Department of Energy, LBNL-3143E, 2010, Wenzel, T.

Risk for cars of the same mass varied greatly, and overall curb weight alone was found to be a modest predictor of risk.

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