SAFETY: SIZE VS. WEIGHT DEBATE

ALUMINUM IN TRANSPORTATION
THE ALUMINUM ASSOCIATION, INC.

"Aluminum components can be designed to fold predictably to absorb the majority of energy in a crash."

BACKGROUND

Safety is naturally among the top priorities for consumers and the automotive industry alike. However, safety is a complex issue involving the study of many different types of single vehicle crashes (hitting obstacles, roll-overs, etc.) and multiple vehicle crashes. Historically, automotive safety has been measured by reviewing actual crashes in a statistical manner and assessing which features (weight, wheel base, age or type of vehicle) make a safer vehicle and by conducting vehicle crashes with dummies into barriers or with side impact.

While these measurements are useful, they do not allow for the systematic investigation – across many different crash types – of how much safer a vehicle could be made if its size and weight are altered.

In order to shed light on this issue, the Aluminum Association commissioned Dynamic Research, Inc. (DRI) to analyze the safety differences in a fleet of SUVs that vary by size and weight while also studying the safety of the driver in the other vehicle involved in the crash. This comprehensive approach considers safety in the context of providing protection for all passengers and vehicles on the road.

METHODOLOGIES

A numerical modeling approach was selected for this study. First, 499 crashes were sampled from six calendar years ('97-'02) of the NASS/CDS database. This database contains in-depth investigations of tow-away (i.e. moderate to serious) accidents and represents a stratified sample of real-world accidents. The accidents sampled approximately reflect the U.S. population of crashes. All 499 crashes involved a typical four-door SUV produced in North America. Of the total, 5 percent were rollover accidents, 12 percent were crashes with fixed objects, 50 percent were crashes with a mid-sized four-door passenger car and 33 percent involved crashes with another SUV.

The virtual vehicles, equipped with seat-belted virtual crash dummies, were modeled with an FEM technique originally developed for the National Highway Traffic Safety Administration (NHTSA) and the U.S. Air Force. To ensure the vehicles and dummies behaved in a realistic manner, front- and side-impact crash test data was used and the vehicles were modeled to match the crash forces experienced in the established safety tests. The driver's injuries were analyzed using the injury cost model found in ISO 13232-5. The cumulative injuries were expressed as a Normalized Injury Cost referred to as Equivalent Life Units (ELU). An ELU of one represents the cost of a fatality.

Initially, driver injuries were assessed following 499 crash tests run on a baseline steel SUV and passenger vehicle. Next the SUV was reduced in mass by 20 percent and the stiffness was lowered to match the de-acceleration pulses the dummy experienced in the New Car Assessment Program tests. (An overall 20 percent curb weight reduction is typical of many aluminum intensive vehicles.) The exact same 499 crash tests were modeled and injuries assessed.

Finally, the SUV was returned to its original steel mass but with the lower stiffness used with lighter weight SUV. To absorb the same energy in the barrier tests, it was necessary to make the vehicle about 4.5 inches longer.

With this approach it was possible to directly and independently assess the influence of mass and size on the overall safety of a fleet of vehicles.

STUDY FINDINGS

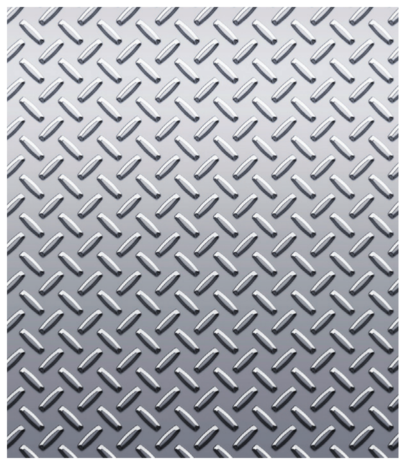
When analyzing the crash and safety data, DRI used ELUs, in which lower numbers indicate the increased safety of passengers.

"Size, not weight, is a better determinant of vehicle safety."

RESULTS AS EQUIVALENT LIFE UNITS

(Brackets in chart indicate number of collisions)

		Baseline	Light SUV	Longer SUV
SUV driver	Rollover (25)	0.36	0.45	0.11
	Hit fixed object (60)	0.41	0.22	0.08
	SUV-Car (250)	0.16	0.29	0.13
	SUV-SUV (164)	2.20	3.83	2.42
	Subtotal (499)	3.13	4.79	2.74
Other driver	SUV-Car	2.52	1.26	1.86
	SUV-SUV	2.35	0.74	1.31
	Subtotal	4.87	2.00	3.17
	Total	8.00	6.79 (-15%)	5.91 (-26%)



For the baseline set of accidents, both drivers suffered injuries with a total ELU of 8.0. However, there was a significant injury incompatibility between the two vehicles.

When the mass of the SUV was reduced, the total ELU was reduced about 15 percent to 6.79, with the safety of the passenger vehicle being significantly improved. There is now less energy in the crash to be absorbed by both vehicles.

Slightly increasing the size of the SUV had a very significant impact, with a total ELU of 5.91 – a reduction of 26 percent. As is well known, a softer deceleration pulse leads to reduced injuries.

CONCLUSION

This study supports the fact that reducing the weight and varying the size of a vehicle provides measurable benefits in terms of reducing harmful energy transfer, injuries and making vehicles safer. Aluminum is a readily available material that can help automakers produce bigger cars and trucks that consumers demand, without adding weight and without compromising fuel economy or safety.

If weight is taken out of an SUV and size remains the same, there is less energy to absorb, while the vehicle structure remains in place to absorb the resulting energy. Furthermore, a lighter SUV is much less damaging to another vehicle in a crash, particularly a traditional passenger car.

However, if the crush zone is increased, even by a few inches, it can have a very significant and positive safety benefit to all in every crash situation.

Aluminum is beneficial for both scenarios. It can be used to reduce the vehicle mass and to slightly lengthen the vehicle without incurring a significant weight increase.

While design studies of this type can oversimplify the complex world of designing and manufacturing vehicles, clearly a lighter, slightly larger vehicle is a safer vehicle for all concerned. In addition, the lighter weight vehicles consume less fuel and emit less harmful emissions. In short, everybody wins.

Many have long believed that size and weight were synonymous where safety was concerned. This study (and others, including a similar study by Honda) confirms that size, not weight, is a better determinant of vehicle safety – a fact that NHTSA has recognized in its new size-based CAFE standards for light trucks.

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