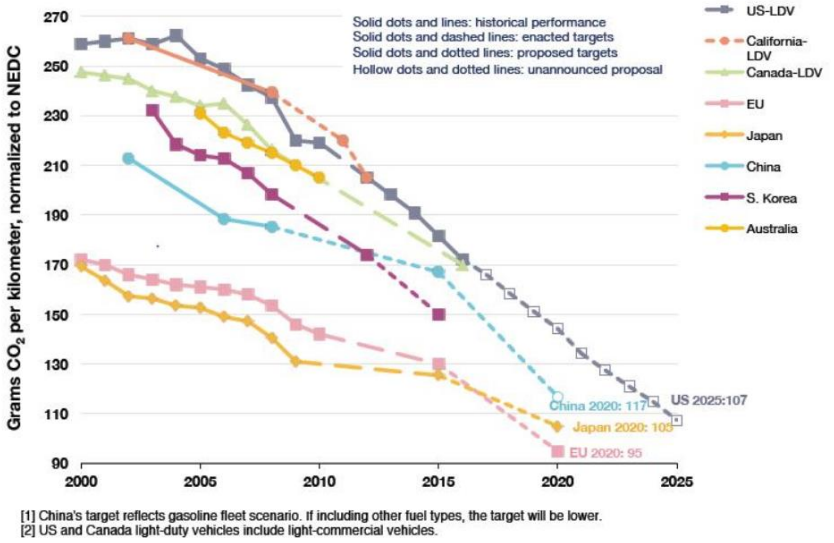
Lightweighting: Now More Important than Ever
A look at weight reduction, yesterday, today and tomorrow

Let's start with what we already know: for years, lightweighting has been a major factor for automotive manufacturers and suppliers. However, as an automotive design engineer – especially if you are primarily engaged in designing the automotive interior – there's never been a more important time to focus on lightweighting than right now.

Lightweighting, or mass reduction, has become mandatory as the nations representing the world's 20 leading industrialized and emerging economies (and 90 percent of new vehicle sales) have adopted policies to reduce fuel consumption, air pollution and carbon emissions. This chart from the International Council on Clean Transportation shows that OEMs worldwide are currently working to hit CO2 emissions targets set for MY 2025. These standards spring from initiatives such as "Made in China 2025." U.S. automakers have agreed to Corporate Average Fuel Efficiency (CAFE) targets, jointly administered by the EPA, NHTSA and California regulators, to increase fleetwide average fuel economy standards to 54.5 miles per gallon on cars and light-duty trucks.



International Council on Clean Transportation

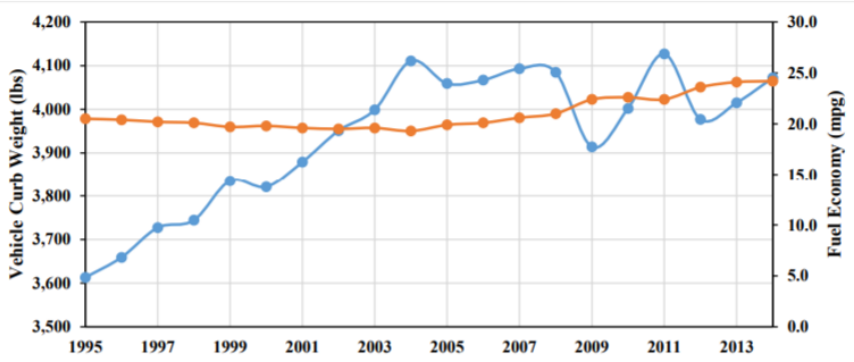
Historical fleet CO_2 emissions performance — current and future planned standards
Note: NEDC — New European Driving Cycle test standard, LDV — light-duty vehicle

We are already seeing emissions standards forecasts for 2030 and beyond. For example, the European Commission recently unveiled proposals for manufacturers to cut emissions of new passenger cars and light commercial vehicles by 30% in 2030 vs. 2021. But emissions are just part of the challenge facing OEM designers and tier suppliers.

Where We've Been

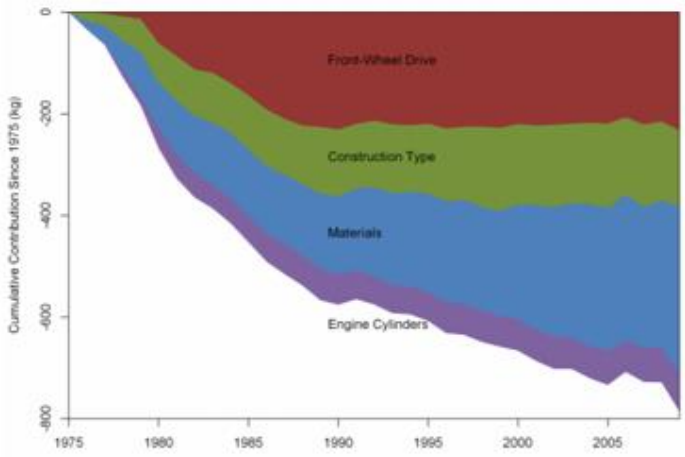
Over the past 30 years, we've seen vehicles improve dramatically in safety, comfort and handling. In the U.S., they've also become heavier.

This chart from a study conducted by the Energy Systems Division Argonne National Laboratory in 2016 shows the relationship between curb weight and fuel efficiency since 1995.



Source: Qiang Dai, Jarod C. Kelly, and Amgad Elgowainy, Vehicle Materials: Material Composition of U.S. Light-duty Vehicles, September 2016

The US Environmental Protection Agency (EPA) published figures showing an average new light-duty vehicle curb weight of 4,072 lbs. in 2014 – up from 3,221 pounds in 1987. As of MY 2016, the average is 4,035 pounds, unchanged from MY 2015, although average new car weight fell by 23 pounds and average new truck weight similarly decreased by 24 pounds.



Source: MacKenzie et al. (2012) 'Determinants of U.S. passenger car weight', Int. J. Vehicle Design, Vol. 1, No. 1

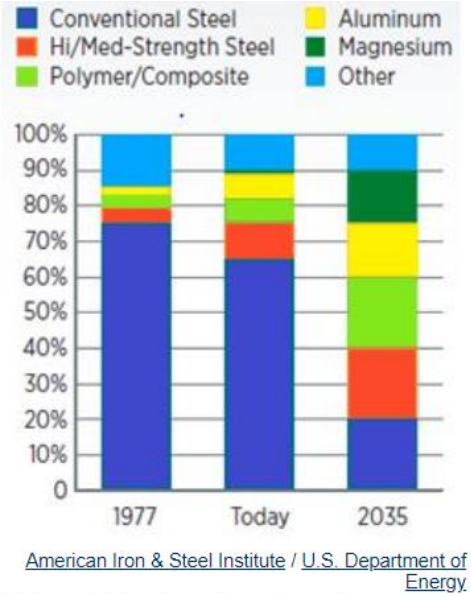
New features are a big reason for added curb weight. Based on EPA data from 1975 – 2010, a study by Mackenzie, et al from the Massachusetts Institute of Technology estimated that new features added 240 lbs. (109 kg) to the average 1975 passenger car. In 2010, the estimated contribution grows to 223 kg (62 kg safety, 25 kg emissions, 136 kg comfort/convenience; a total of 491 lbs).

However, the same study shows that vehicles are not as heavy now as they might have been. The chart above shows theimpact on weight reduction of various innovations to vehicles from 1975 – 2010. The use of lighter-weight materials represents a significant portion of the overall reduction.

Where We Are

Today, a combination of megatrends including electrification, autonomous driving, ride sharing and ever-tightening fuel restrictions create a scenario where two powerful market forces will remain constant: the demand for added features related to comfort, safety and convenience, and the demand for lighter weight. A study from the Center for Automotive Research (CAR) indicates the U.S. fleet will achieve a five percent curb weight *reduction* by 2025, through greater use of aluminum - predominantly in the closures and body-structure.

A vast amount of research like that conducted by the American Iron & Steel Institute points to the increased use of plastics and composites in car body panels. Designers are already working with generation-3 (high strength) steels and hot formed steel processing, as well as aluminum and magnesium. The near future likely will include such automotive interior materials as long-fiber thermoplastics, polymer, metal and ceramic matrix composites, and additional composites such as carbon fiber-reinforced plastics (CFRP) and glass-reinforced composites, plus 3M glass bubble technology that reduces part density.



American Iron & Steel Institute / U.S. Department of Energy

Lightweighting for the Interior

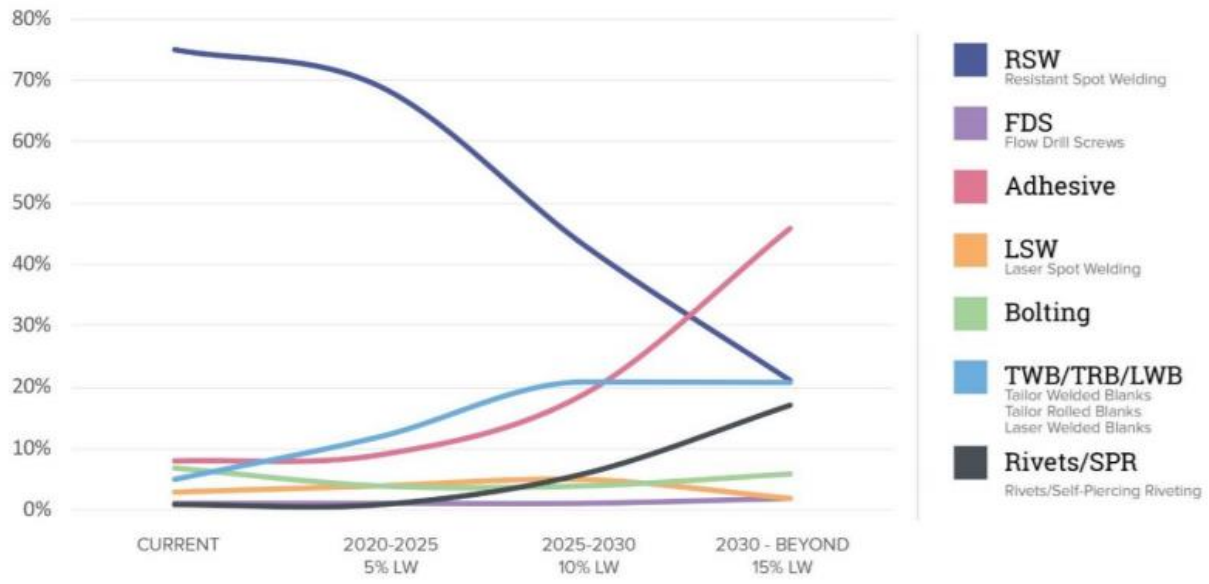
Another area that is coming into focus as a source for lightweighting is the interior.

As CAR research points out, the interior of the vehicle has often been considered dead weight. Yet many of the new features which will potentially add weight to the vehicle will be placed in the interior: ergonomic, temperature-adjustable seating, viewing displays, durable consoles and flooring components, enhanced instrument panels and improved noise, vibration and harshness (NVH) insulation to name a few. Worldwide, there's also an increased demand for customization – not just individualized interiors - but the more broad use of materials customized for each area of the vehicle during production.

New and Dissimilar Materials

Similar to related innovations such as front-wheel drive, body-frame-integrated vehicle architectures, electrified power trains and alternative body materials, lightweighting for the interior presents significant challenges. The latest lightweight materials may not have similar melting points, and may not be conducive to traditional joining at all; spot welding may no longer be an option as new composite materials are developed and specified for the latest interior environments. Tapes and adhesives will likely become a favored alternative for bonding and joining, especially advanced adhesives designed for low-surface-energy substrates.

The "newness" of these interior materials are just part of the challenge – to achieve the customized combinations of safety, comfort and long-term functionality, they may also be dissimilar to each other. Already, the use of alternative metals such as aluminum and magnesium creates additional concerns about galvanic corrosion, especially if the dissimilar metals are bolted or riveted together. Manufacturers are responding with structural adhesives that act as isolators.



Note: LW= Lightweighting
Source: CAR Research, Lucintel

Noise Management

As demand for added features began to take hold in the late 1980s and early 1990s, so did the focus on the quality of sound in the cabin. Designers targeted cavities where vibration could transfer from outside in, and began filling them with relatively heavy, non-flexible materials. Today, they use blown microfiber (BMF) material, which is designed to absorb sound without adding weight to the design.

In 1975, the average US vehicle weighed an average of about 3,800 lbs. (1,750 kg). By 1980, the average had dropped precipitously to little over 2,800 lbs. It's been on the rise ever since. Lightweighting efforts have been helpful in keeping curb weight relatively flat in recent years. But the demand for new, technologically advanced features is here to stay, and with it increased demand for lighter, stronger materials.

As you work to incorporate lighter materials them into your designs for automotive interiors, 3M continues developing solutions for lightweighting as well as joining, bonding and joining noise management and interior VOC. For more information, visit www.3M.com/autointeriors.

Sources:

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