ENHANCING FUTURE AUTOMOTIVE SAFETY WITH PLASTICS

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ABSTRACT

A revolution in automotive technology is underway globally. Automobiles of the 21st century will feature radically improved safety and sustainability attributes. Safety R&D is embracing active and passive systems, and advanced vehicle propulsion R&D is tackling cleaner, more reliable energy sources. The innovations currently under development across multiple transportation venues including aerospace have the potential to alter automotive vehicle designs and supporting infrastructures around the globe by 2025.

These revolutionary changes suggest a critical need to rethink vehicle architecture and materials requirements. Versatile, durable, and lightweight plastics, plastic composites and plastic-metal hybrid materials that increase the efficiency, crashworthiness, and functionality of today's vehicles hold immense potential to radically enable and optimize advanced vehicle technologies for the future. An important step was taken in this direction in 2002 when the Plastics Division of the American Chemistry Council (ACCPD) then known as the American Plastics Council, published *Plastics in Automotive Markets—Vision and Technology Roadmap*[1] to help define this potential.

Recognizing this need and building on Plastics in Automotive Markets, ACCPD sponsored a Technology Integration Workshop in November 2005 to begin exploring the full potential of polymer-based materials to enhance next-generation systems (passive and active) for superior automotive safety. The National Highway Traffic Safety Administration (NHTSA) Office of Vehicle Safety Research contributed its expertise to the process. R&D priorities were explored in four automotive areas (Interiors, Body/Exterior, Powertrain & Chassis, Lightweighting).

The Technology Integration Workshop Report provides a baseline for a more expansive safety road mapping effort examining Plastic and Composite Intensive Vehicles (PCIVs) that will reflect the consensus of leading technology developers, polymer and composite researchers, automotive safety engineers, designers, manufacturers, and government. This collaborative approach will also help industry, academia, and the government labs identify opportunities for new partnerships to pursue specific technologies or opportunities and will aid NHTSA in coordinating R&D and leveraging resources.

This paper explores the role of the Plastics Industry in facilitating development of Future Vehicle Architectures with enhanced active and passive systems for improved automotive safety worldwide.

INTRODUCTION

Plastics In Automotive Markets Today

Plastics encompass a wide variety of functional polymeric compounds that exhibit a vast range of desirable properties. They are durable, strong and lightweight. They can be made transparent, translucent or opaque; soft, flexible or hard in almost any shape, size or color. They can be heat-, chemical- and corrosion-resistant. They are excellent thermal and electrical insulators and also can be made electrically and thermally conductive. Because of plastics' versatility, they are extremely cost-effective in a wide variety of commercial applications including a broad range of uses in the transportation market.

The use of both thermosets and thermoplastics in passenger vehicles has grown from about 30 kilograms per vehicle in 1970 to about 150 kilograms today. A midsize automobile manufactured in North America is about 10-12 percent plastics by weight. The material volume is much higher. Because plastics are versatile and lightweight, they make up approximately 50 percent of the material volume of new cars.

The Need for Fuel Efficiency and Reduction in Green House Gases

Leading experts say that the easiest and least expensive way to reduce the energy consumption and emissions of a vehicle is to reduce the weight of the vehicle. To achieve lightweight architectures, without compromising on rigidity, automakers have been researching the replacement of steel with plastics, composites, foams, aluminum and magnesium. The recycling and recovery of end-of-life vehicles, which involves recovery targets of 85%, are driving the auto industry to adopt lightweight materials technology to meet these recovery targets[2].

Weight reduction also offers a potentially cost-effective means to reduce fuel consumption and greenhouse gases from the transportation sector. It has been estimated that for every 10% reduction in the weight of the total vehicle, fuel economy improves by 5-7%. Thus for every kilogram of vehicle weight reduction, there is the potential to reduce carbon dioxide emissions by 20 kg.

Automakers Are Increasing Utilization of Lightweight Materials

Global emphasis is being placed on greenhouse gas reduction and fuel efficiency improvement in the transportation sector. Many vehicle manufacturers and suppliers are investing significantly in lightweight materials research and development and commercialization. Most companies are working toward the goal of increasing the use of lightweight materials to achieve more market penetration by manufacturing components and vehicle structures and designing new vehicle architectures that maximize the utilization of lightweight materials.

The American Chemistry Council (ACC) data indicate that currently:

- the average vehicle uses about 150 kg of plastics and plastic composites, versus 1163 kg (2559 lbs) of iron and steel[3],
    - the automotive industry uses engineered polymer composites and plastics in a wide range of applications, as the second most common class of automotive materials after ferrous metals and alloys (cast iron, steel, nickel) which represent 68% by weight; other non-ferrous metals used include copper, zinc, aluminum, magnesium, titanium, and their alloys.
    - the plastics contents of commercial vehicles comprises about 50% of all interior components, including safety subsystems, door and seat assemblies;
    - industry trends project a substantial increase in use of automotive plastics over the next two decades for reducing vehicle net weight, and for improving environmental impacts and fuel efficiency in response to consumer pressures, and to exploit the rapid advances in materials science and technology.

ACC Technology Integration Workshop

The Technology Integration Workshop held in November 2005 and resultant Report[4] examining the role of plastics in future automotive safety represents a collaborative effort of 45 experts representing 29 organizations including plastics producers, auto manufacturers (OEMs), Tier suppliers, universities, and government resources. These experts provided a “snapshot in time” of the priorities for enhancing future automotive safety with plastics by specifying 130 industry challenges and more than 190 activities for overcoming them. This information was synthesized into the ACC Technology Integration Report. The Workshop was a collaborative effort involving the ACCPD and the National Highway Traffic Safety Administration of the U.S. Department of Transportation.

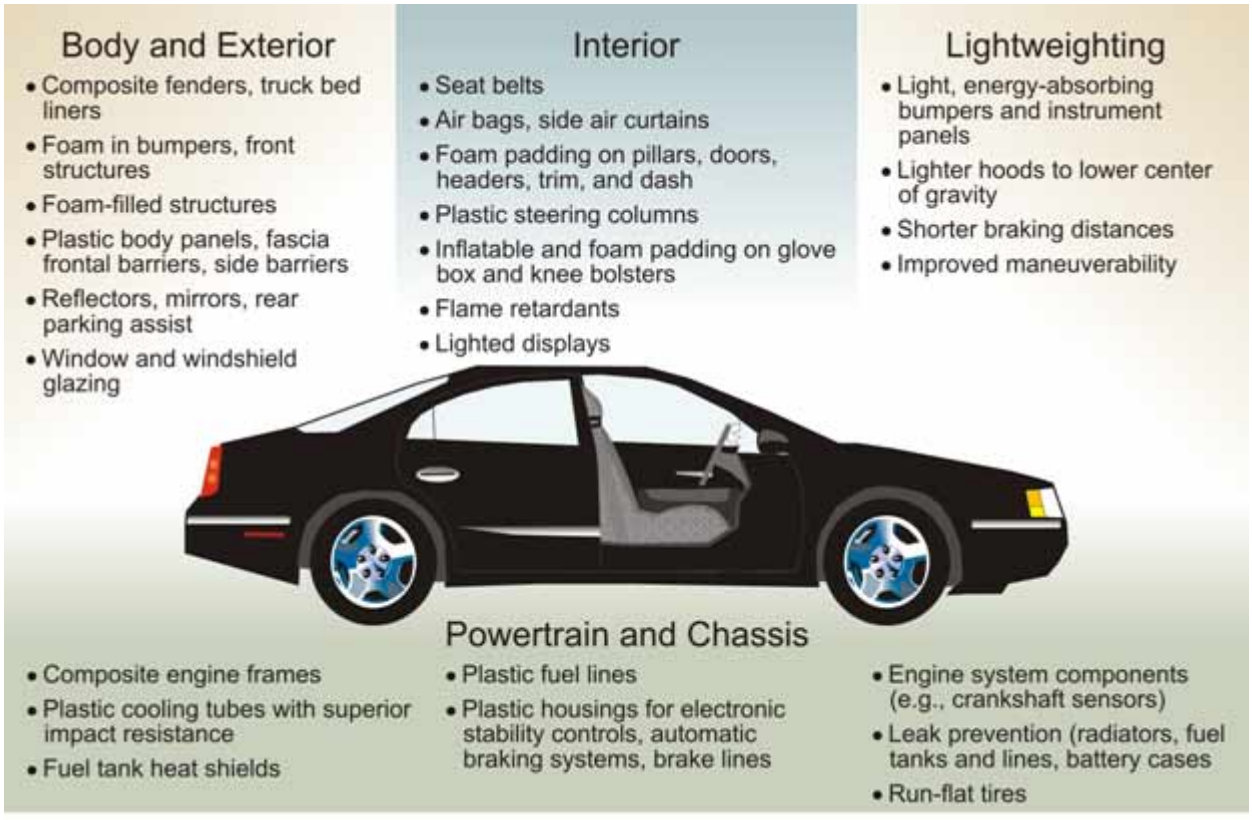
Automotive Safety Today

Drivers are safer than they have ever been, in part because of safer cars, higher safety belt use and stronger safety laws.[5] However, according to statistics, worldwide, the number of people killed in road traffic crashes each year is estimated to be almost 1.2 million.[6] That's 3000 people killed on the world's roads every day. The number injured in road traffic accidents is estimated to be as high as 50 million – the combined population of five of the world's large cities. According to World Health Organization data, deaths from road traffic injuries account for around 25% of all deaths from injury.[7] It is expected that, without efforts and new initiatives to tackle the causes of road traffic injuries and deaths, they will rise by some 65% between 200 and 2020[8]

In the United States more than 43,000 people die annually on roadways – the equivalent of an airplane crashing every day with nearly 120 people aboard – and fatality numbers have remained largely stagnant for the past two decades. In Japan there were 6,871 traffic accident deaths in 2005, the first time since 1956 that the number has fallen below 7,000. The number of casualties may be falling, but the number of accidents in Japan is higher than ever. According to the European Union, in 2000, road accidents killed over 40,000 people in the European Union and injured more than 1.7 million. The age group most affected is the 14-25 year olds, for whom road accidents are the primary cause of death. One person in three will be injured in an auto accident at some point in their lives. The directly measurable cost of road accidents is of the order of EUR 45 billion. Indirect costs (including physical and psychological damage suffered by victims and their families) are three to four times higher. The annual figure is estimated at EUR 160 Billion, equivalent to 2% of the European Union's Gross National Product.

As long as the number of highway deaths and crashes remains high, automotive producers will continue to seek innovative solutions that make people safer in their cars and trucks. The plastics industry has been an active partner in this process of innovation (see Figure 1) and remains committed to action. Globally, the World Health Organization and the United Nations are increasing their focus on automotive safety as a growing concern, particularly in developing nations with rapidly expanding economies, such as China and India where automobile use is growing rapidly. The ACC Technology Integration Report reflects the plastic industry's strong commitment to enhanced automotive safety and is aligned with both domestic and global needs.

Figure 1.
Overview of Use of Plastics to Enhance Safety in Today's Vehicles



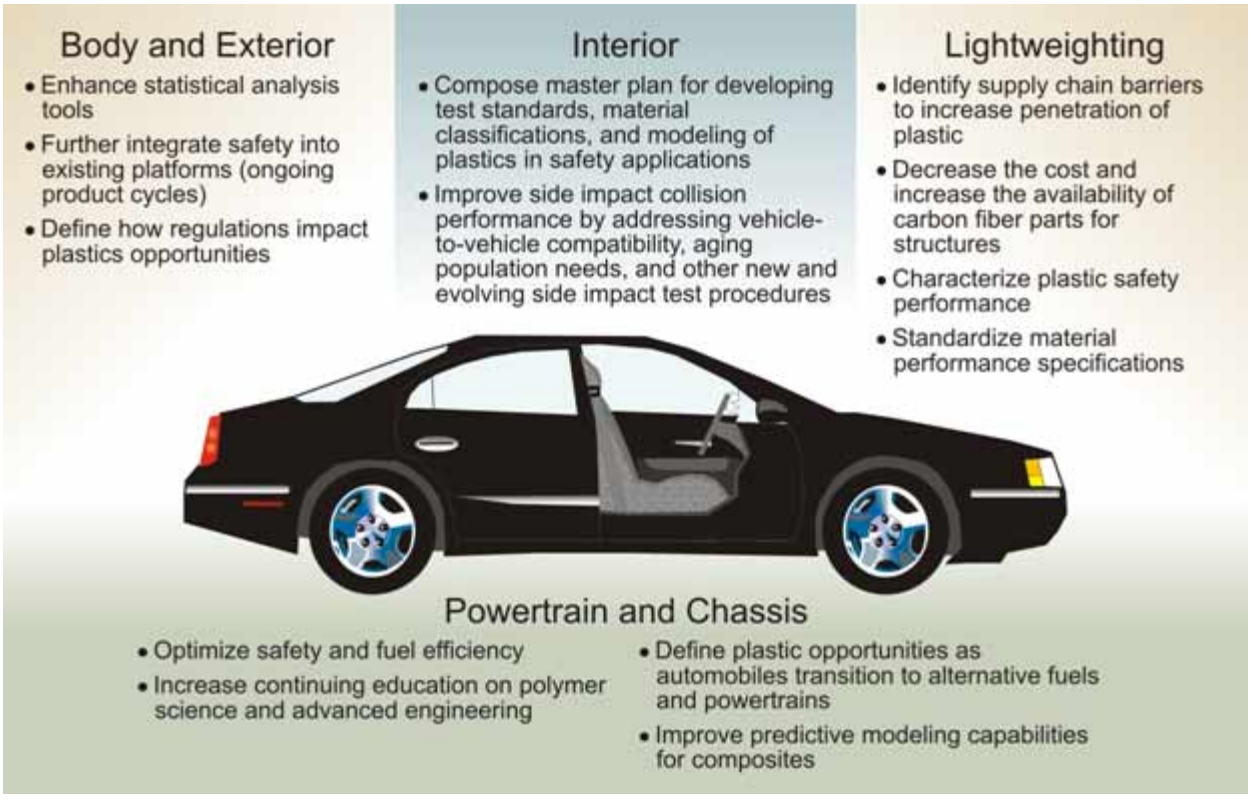
Technology Activities and Priorities in Four Key Areas

To meet the significant challenges associated with enhancing automotive safety, automotive and plastics producers, along with their suppliers, have identified a preliminary research agenda and set of priorities. The Technology Integration Workshop Report presents R&D priorities in four automotive areas that together capture the broad range of plastics applications in vehicles (see Figure 2). These four areas are Interiors, Bodies and Exteriors, Powertrain and Chassis Components, and Lightweighting:

- Interior – Priorities for improving safety in the passenger compartment include making safety advances affordable through innovative design and more efficient manufacturing capabilities, designing for increased vehicle compatibility, accommodating an aging driver population, including more safety features in reduced package space, and enhancing safety belt designs.
- Body & Exterior – From bumpers to body panels, laminated safety glass to rear parking assists, research activities must include energy management technologies that resist vehicle intrusion, impede roof crush, and reduce body and exterior weight without compromising safety performance.
- Powertrain & Chassis – Research in this area focuses on components that generate and deliver power and include the frame and its working parts. R&D priorities include pursuing significant advancements in engineering and research capabilities for designing with plastics, exploring new ways to optimize safety and fuel efficiency, expanding predictive modeling capabilities for composite materials, and developing the new safety components that will be required for future alternative vehicles and powertrain options.

Figure 2.

Summary of Highest-Priority Research and Development Needed to Enhance Future Automotive Safety with Plastics



- Lightweighting – The transition to lightweight materials from conventional ones requires research activities that will increase the overall value of plastics in automobiles; develop new, high-

performance components that lower the center of gravity of a vehicle; improve crash avoidance and performance systems; and enhance pedestrian safety.

Common Themes and Top Priorities

At the Technology Integration Workshop, six important themes were repeatedly cited as central to the challenge of enhancing future automotive safety using plastics.

1. Improve Characterization and Predictive Modeling of Plastics – Continuous improvement in predictive modeling of the crash performance of plastic components is vital to strengthening the position of plastics as a preferred automotive material. Automotive designers also require extensive materials characterization data for new plastics as they become available. Obtaining reliable, validated constitutive data may require a coordinated, industry-wide effort.

2. Develop Material Classifications, Test Standards, and Performance Specifications – To encourage design engineers and original equipment manufacturers (OEMs) to choose plastics over competing materials, designers must be confident in the materials' ability to achieve required performance in the application. Because plastics are less familiar than metals to most design engineers, the plastics industry must benchmark performance and create material classifications to characterize their products. Afterward, OEM material performance specifications and test methods must be updated and expanded to reflect the unique properties and capabilities of these new materials.

3. Enhance Crash Performance with Improved Energy Management – Managing the impact energy created during a crash and protecting occupants from absorbing too much of this energy is a fundamental part of vehicle safety. Advanced plastic components and systems in the interior, body and exterior, and powertrain systems are sought to allow automakers to manage crash energy in creative, more effective ways.

4. Uncover Plastic Opportunities under Evolving Active and Passive Safety Standards and Lightweighting Regulations – Understanding technology needs for meeting evolving safety standards and lightweighting regulations addressing both crash worthiness and crash avoidance is a necessary foundation for planning future plastics research. The industry must better define plastics performance requirements of new safety standards and use with new integrated components, alternative fuel vehicles, powertrain options, and transportation infrastructure. Once these issues are determined, new opportunities for optimizing safety and lightweighting with plastics should be identified.

5. Accommodate Changing Demographics to Older Population – As the population of older drivers increases, improved counter measures and crash performance systems will be needed to keep these passengers safe. Many older drivers have lower biomechanical tolerances and require special safety features to avoid injury. With targeted research, highly versatile plastics may enable important advances in safety features that are needed to protect the 65-and-older population.

6. Make Automotive Safety with Plastics Affordable – Optimizing material selection for automotive safety components will require that plastics become more affordable, both as a material and as they enable efficiency gains throughout the vehicle manufacturing and assembly process. At the same time, the perception among automotive customers must be changed to appreciate the value of safety features enabled by plastics to increase their willingness to select those features.

CONCLUSIONS

By pursuing an initial collaborative technology agenda focused on R&D priorities most needed to enhance safety, the plastics industry and its key stakeholders have taken an important first step toward enhancing automotive safety with plastics. The Technology Integration Report provides a baseline for more expansive safety road mapping efforts that will reflect the consensus of leading technology developers, polymer and composite researchers, automotive safety engineers, designers, manufacturers, and

government. This collaborative roadmapping approach is now underway in the United States and will also help industry, academia, and government labs identify opportunities for new partnerships to pursue specific technologies or opportunities. The roadmap will provide an integrating R&D agenda to align R&D efforts across public and private sectors and will aid NHTSA in coordinating R&D and leveraging resources. The aggregate impact will be increased efficiency and speed in developing successful automotive safety solutions—both active and passive.

In the Technology Integration Report, the plastics and automotive industries have articulated their wish to journey toward a future in which innovative materials will radically improve vehicle safety for passengers and pedestrians. Subsequent road mapping efforts will produce a clear set of directions defining an efficient and cost-effective route toward that future. To propel the plastics and automotive industries along this chosen route, collaborative partnerships among industry, universities, and government will generate the requisite power and momentum. The journey will entail rigorous challenges, yet the destination is worthwhile and careful planning and road mapping will ensure its success.

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