SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) Recommended Practice for Optimizing Automobile Damageability and Repairability

RATIONALE

SAE J1555 has been updated to reflect more current vehicle costs of ownership and insurance cost elements. To focus user attention on the guidelines which typically can have the largest impact on reducing collision damage frequencies and repair costs, Sections 5 through 15, and the guidelines within each section, have been prioritized in approximately decreasing orders of importance. Photographic examples of how the guidelines apply in real-world applications have been added to some of the guidelines. References to the Audatex damageability claims database, and figures utilizing data from this resource, have been deleted, since the database is no longer available.

FOREWORD

The cost of vehicle ownership has developed into a major interest for vehicle manufacturers. During the 1970s, fuel economy was a primary concern in the vehicle buyer's purchasing decision and in vehicle design. Through the 1990s, the steadily rising cost of vehicle insurance in the U.S. surpassed fuel costs, to become the second highest element of the cost of ownership. Since at least 2006 in the U.S., insurance costs have been the third largest contributor to total cost of vehicle ownership (Figure 1). Insurance costs are also significant factors in the United Kingdom and Germany (Figures 2 and 3).

In addition to medical and litigation costs, two major elements of these rising customer insurance costs are collision repair and comprehensive costs, of which theft is the major contributor (Figure 4).

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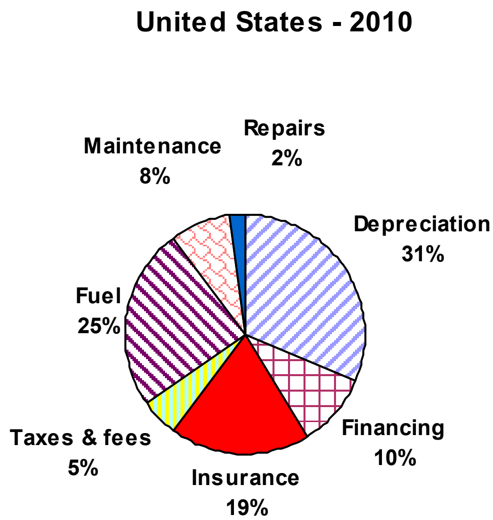

FIGURE 1 - U.S. AVERAGE COST OF VEHICLE OWNERSHIP

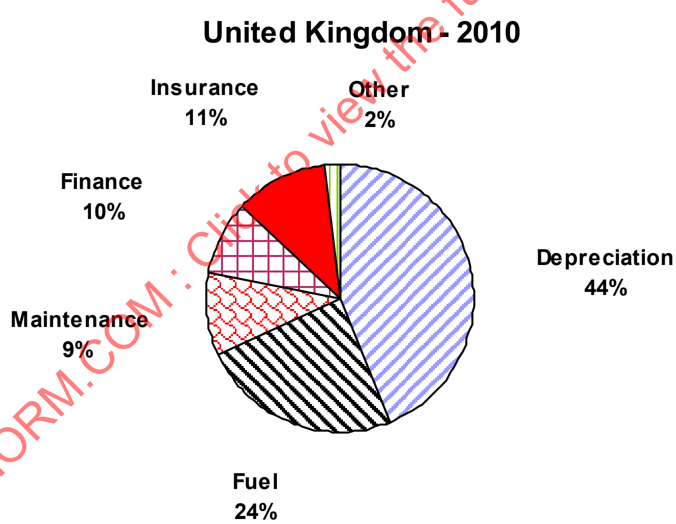

FIGURE 2 - U.K. AVERAGE COST OF VEHICLE OWNERSHIP

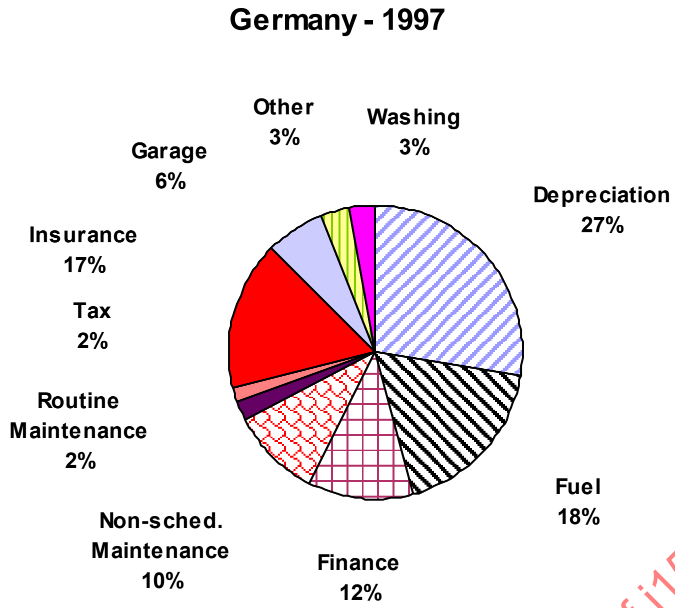

FIGURE 3 - GERMAN AVERAGE COST OF VEHICLE OWNERSHIP

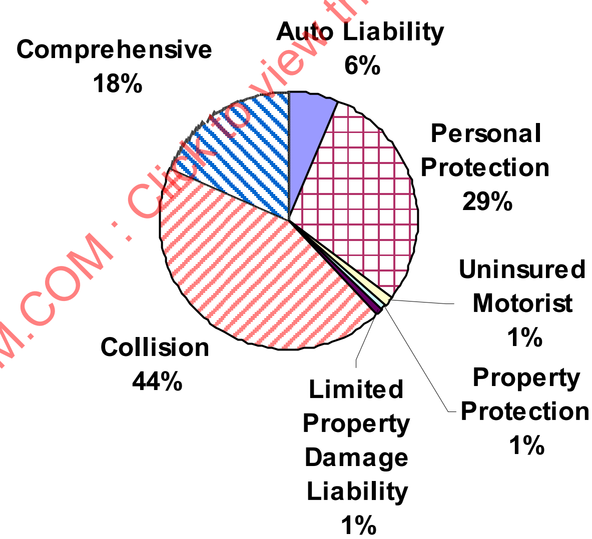

FIGURE 4 - TYPICAL U.S. AUTO INSURANCE COST ELEMENTS - 2010

Automobile manufacturers, insurance companies, and the collision-repair industry continue to work together to contain repair costs. Advanced vehicle platforms should be reviewed by insurance industry repair experts as early in the programs as possible, to insure that recommended actions can be considered for implementation.

Extensive data bases, such as those compiled by the Highway Loss Data Institute (HLDI), provide vehicle damage statistics. Theft data statistics are available from National Insurance Crime Bureau (NICB) and HLDI. These statistics can be used to identify design-related vehicle features which have a significant effect on collision-repair costs and to quantify the effects of design alternatives.

This SAE Recommended Practice will assist in the evaluation of future technological changes in vehicle design and manufacturing improvements, which may affect damageability, serviceability, diagnostics and repairability. Such features as adhesive bonding of similar or dissimilar materials, repairability of composites, advanced high strength steels, modular construction, tailored blanks, laser welding, aluminum space frames, etc., are becoming more important in future automotive designs. As an integral part of the design process, vehicle manufacturers should consider the effects of these new technologies and processes on damageability, repairability, and serviceability, and resulting repair costs, and develop the most efficient and practical field repair procedures. Design for damageability, repairability, serviceability and diagnostics should facilitate practical, low cost, high quality collision repairs, but it must be balanced against all other vehicle factors (styling, packaging, manufacturing, safety, cost, fuel economy, etc.) to produce the best overall vehicle for customers.

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1. SCOPE

This SAE Recommended Practice applies to all portions of the vehicle, but design efforts should focus on components and systems with the highest contribution to the overall average repair cost (see 3.7). The costs to be minimized include not only insurance premiums, but also out-of-pocket costs incurred by the owner.

Damageability, repairability, serviceability and diagnostics are inter-related. Some repairability, serviceability and diagnostics operations may be required for collision or comprehensive loss-related causes only, some operations for non-collision-related causes only (warranty, scheduled maintenance, non-scheduled maintenance, etc.), and some for both causes. The scope of this document deals with only those operations that involve collision and comprehensive insurance loss repairs.

1.1 Purpose

The purpose of this document is to assist automobile manufacturers in optimizing their products' damageability, repairability, serviceability, and theft deterrence. This document should be considered concurrently with other parameters such as function, safety, cost, weight, manufacturability, recyclability, quality, styling, performance, marketability, etc. The main objective is to contain or reduce overall collision-repair costs without compromising occupant safety, crashworthiness, and other design parameters.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J817-1 Engineering Design Serviceability Guidelines—Construction and Industrial Machinery—Serviceability Definitions—Off-Road Work Machines

SAE J817-2 Engineering Design Serviceability Guidelines—Construction and Industrial Machinery—Maintainability Index—Off-Road Work Machines

SAE J1142 Towability Design Criteria and Equipment Use—Passenger Cars, Vans, and Light-Duty Trucks

SAE J1143 Towed Vehicle/Tow Equipment Attachment Test Procedure—Passenger Cars, Vans, and Light-Duty Trucks

SAE J1144 Towed Vehicle Drivetrain Test Procedure—Passenger Cars, Vans, and Light-Duty Trucks

SAE J1344 Marking of Plastic Parts

SAE J1828 Uniform Reference and Dimensional Guidelines for Collision Repair

SAE J2069 Recovery Attachment Points for Passenger Cars, Vans, and Light Trucks

SAE J2184 Vehicle Lift Points for Service Garage Lifting

SAE J2235 Paint and Trim Code Location

SAE J2376 New-Vehicle Collision Repair Information

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1556 Stationary Safety Glazing Replacement

SAE J1573 OEM Plastic Parts Repair

2.2.2 "Vehicle Design Features for Optimum Low Speed Impact Performance," available at www.rcar.org/papers. Guidelines published in this document are similar to those included in SAE J1555.

2.2.3 The procedure for conducting a low speed 15 km/h offset insurance crash test to determine the damageability and repairability features of motor vehicles. Available from www.rcar.org/papers.

2.2.4 "The British Insurance Industry's Criteria for Vehicle Security—Security System Evaluation, Passenger Cars," "New Vehicle Security Assessment, Passenger Cars, LCV and HGV" Criteria for After 'Theft Recovery Systems'", available from the Motor Insurance Repair Research Centre (THATCHAM), Colthrop Lane, Thatcham, Berkshire, England RG19 4 NR.

2.2.5 Canadian National Standard on Theft Deterrence Systems, CAN/UCC S-338.

2.2.6 Data Sources

Both the insurance and collision-repair industries can provide valuable insight into the most important damageability factors. Vast data bases are available in some countries, which provide detailed data on both collision and comprehensive losses. This data is the basis for the Design for Damageability/Insurability-(DFI) process.

2.2.6.1 Highway Loss Data Institute (HLDI)

U.S. collision and theft data are available by individual make and model, including relative claim frequency, relative average loss payment per claim, and relative average loss payment per insured vehicle year. Special reports on specific collision and theft topics are also available.

2.2.6.2 Insurance Services Office (ISO, U.S.)

Both collision and comprehensive (theft and glass) data are available, including overall claim frequency, average repair cost, and loss per year (claim frequency x average repair cost).

2.2.6.3 Individual Insurers

Insurance ratings, low-speed crash test data, security rating assessments, etc.

2.2.6.4 Repair Industry Associations

U.S.: Automotive Service Association (ASA), Equipment and Tool Institute (ETI), Inter-Industry Conference on Auto Collision Repair (I-CAR), etc.

2.2.6.5 Insurance Institute for Highway Safety (IIHS) (U.S.)

Test results from 5 and 10 km/h bumper impact tests.

2.2.6.6 Vehicle Information Centre of Canada (VICC)

Similar collision and theft claims data to that provided by HLDI. VICC also publishes ratings of individual vehicle models, based on expected actual loss costs. These ratings are used by Canadian insurers to set premiums.

2.2.6.7 NRMA (formerly National Roads and Motorist Association, Australia)

Test results from low speed offset crash tests and evaluation of vehicle anti-theft security.

3. DEFINITIONS

3.1 AVERAGE LOSS PAYMENT PER CLAIM (AVERAGE VEHICLE REPAIR COST)

The total of all loss payments (collision or comprehensive) made for claims for a group of vehicles, divided by the number of claims paid (as defined by HLDI).

3.2 AVERAGE LOSS PAYMENT PER INSURED VEHICLE YEAR

(Many insurers often refer to it as pure premium.) The product of claim frequency and average loss payment per claim (as defined by HLDI).

3.3 COLLISION INVOLVEMENT FREQUENCY

The number of claims for a group of vehicles, divided by the number of insured vehicle years (as defined by HLDI).

3.4 COMPONENT INVOLVEMENT FREQUENCY

The frequency that a component part or subassembly is involved in a collision, expressed as a percent of collisions (as defined by ADP).

3.5 CRASH PARTS

Parts most frequently involved in collisions, including bumpers, lamps, fenders, doors, decklids, etc.

3.6 DAMAGEABILITY ENGINEERING

A continuous process (from vehicle concept through production and beyond) having the primary objective of reducing the customer cost of ownership by minimizing collision and comprehensive loss costs, which are paid for either by an insurance company or the vehicle owner. Damageability focuses primarily on real-world collision events and is an integral part of the vehicle design process. It is a subset of Designing for Insurability, which also encompasses comprehensive-type events such as theft, hail damage, glass breakage, etc.

3.7 DAMAGEABILITY

A measure of the degree to which a vehicle can be damaged in a defined event.

3.8 EXPECTED COST/COST CONTRIBUTION

The amount which a specific component contributes to the overall average repair cost. It is the product of involvement Frequency and the Average Cost, where the Average Cost is the sum of Net Part Cost, Labor Cost, and Paint Cost (as defined by ADP). Expected cost generally applies to the prediction of future models; Cost Contribution applies to the actual performance of vehicles in production.

3.9 REPAIRABILITY

A measure of the ease with which a damaged part, assembly, or system can be repaired or restored to pre-loss condition (Reference SAE J817).

3.10 SERVICEABILITY

A measure of the ease with which a damaged or broken part, assembly, or system can be accessed and replaced.

3.11 DIAGNOSTICS/DIAGNOSABILITY

A measure of the ease of isolating the cause and extent of a suspected malfunction. It is a function of such things as system design complexity and the requirements for the installation and use of test equipment (Reference SAE J817-1).

3.12 THEFT DETERRENCE

The degree to which a vehicle or portion thereof can resist unauthorized tampering during an attempted theft of the entire vehicle or portion thereof. The RCAR car security Design Guide and Evaluation System is one means of measuring theft deterrence. Also refer to the Canadian National Standard on Theft Deterrence Systems, CAN/UCC S-338.

4. GENERAL DESIGN CONSIDERATIONS

4.1 How Insurance Rates are Determined

Fundamental to an understanding of how to design for insurability globally is the need to appreciate how insurance rates are established in the principal markets, as the strategies required must be tailored to meet the needs of the respective markets. It is also important to understand that insurance rate-setting processes are continuing to evolve, as a growing number of insurance companies and insurance organizations are declaring an interest in developing rating systems that take into account new vehicle-damageability, repairability, serviceability and theft-deterrence characteristics. Following is a summary of how rates are determined in some of these markets:

4.1.1 Make-Model Rating System (United States)

Rates are based on the Manufacturers Suggested Retail Price of the vehicles, and the historical collision and theft loss histories of the vehicle or its predecessors. The relationship between the loss ratio of a vehicle (claims paid out/premiums taken in) and the loss ratio of all vehicles covered by an insurance company determines whether discounts or surcharges are applied to the base insurance rating groups, which will respectively decrease or increase insurance premiums. Rates are updated annually.

4.1.2 Low-Speed Crash and Theft Assessments (United Kingdom, Germany, Australia, Canada, Spain)

4.1.2.1 In the U.K., Six Factors Influence Insurance Ratings

NOTE: The UK insurance group rating formula is under review with a new one scheduled for implementation in 2007. This means the factors below will be subject to change.

The cost of replacement parts to reinstate the vehicle to its pre-crash test condition and times associated with the reinstatement of the vehicle following a 15 km/h, 40% offset right front and left rear crash test; vehicle performance (0 to 96 km/h) and top speed; new car price; availability and price of replacement body shells; and New Vehicle Security Assessment (NVSA) of the electronic and mechanical security systems. The results of the 15 km/h crash tests can contribute as much as 70% of the total points within the rating scheme. Once the damageability/repairability or initial grouping has been determined by the crash test, this is then adjusted to reflect the results of the NVSA. The movement is generally confined to one group up or down, as applicable. Once the final grouping has been determined, it rarely changes.

4.1.2.2 In Germany, Three Factors Influence Insurance Ratings

The extent of damage from left front and rear 15 km/h, 40% offset crash tests, plus estimated costs from a simulated side collision, the cost of repairing the vehicle from these three impacts and the expected accident frequency of the vehicle. A security assessment is not part of the initial rate setting process, but historical collision and theft claims history influences the annual updates to insurance rates.

4.1.2.3 In Australia, Six Factors Influence Insurance Ratings

Vehicle value, the cost of spare parts for the vehicles, repair costs from a right front 15 km/h, 40% offset impact, amount of time required to repair the vehicle, the degree to which the vehicle is prone to theft, using an NRMA/RCAR 100-point rating system, similar to that used in the U.K., and the type of driver utilizing the vehicle.

4.1.2.4 In Canada, a Statistical Model (CLEAR) is used to Estimate the Initial Rating, Using Regression Analysis of a Number of Key Vehicle Parameters (wheelbase, body style, weight to horsepower ratio, price, etc.) that affect claim performance.

Frequency and severity (average size) of claims are evaluated separately for Collision/Property Damage, Comprehensive and Accident Benefits coverage, and separately for cars and trucks. The New Vehicle Assessment Program (NVAP) utilizes an assessment of 15 km/h, 40% offset front and rear crash test results, (procedures recommended by RCAR), and a security evaluation (presence of passive anti-theft system and alarm), to adjust the results of the initial CLEAR statistical modeling. Each year after vehicle introduction, rates are adjusted to reflect actual claims performance.

4.1.2.5 In Spain, four factors affect vehicle classification (Insurance Ratings): Front impact repair cost under conditions fixed by RCAR, rear impact repair cost under the same conditions, replacement part price and official spare part replacement times from vehicle manufacturers.

4.1.3 Other countries may use vehicle weight, horsepower or other factors to determine insurance rates.

4.1.4 Auto manufacturers also need to be sensitive to cost of collision or theft losses in developing countries, where insurance industries may not be well developed, and the primary costs are borne by the vehicle owners.

4.2 Design for Damageability/Insurability Objectives

4.2.1 Minimize collision and non-theft comprehensive damage frequency and repair cost

4.2.2 Minimize total and partial vehicle thefts

4.2.3 Increase ease of collision repair (i.e., modular assemblies, rivets, adhesives, rivet-bonding, weld-bonding, STRSW, etc.)

4.2.4 Increase the potential for quality collision repair

4.2.5 Minimize the frequency and repair cost of minor damage, often paid by the owner

4.2.6 Obtain the lowest possible owner insurance cost at new model introduction

4.2.7 Obtain a marketing advantage based on lowest cost of ownership through "lowest possible insurance costs"

4.3 Design for Damageability/Insurability Process

4.3.1 Compare real-world collision and theft performance of current and competitive models.

4.3.2 Establish targets and objectives for the new model, based upon the field performance evaluation and marketing objectives, and develop plans to achieve the objectives.

4.3.3 Identify issues and opportunities from new design and manufacturing technologies and experiences from past models.

4.3.4 Conduct reviews of new vehicle platform designs with insurance industry experts.

4.3.5 Quantify effects of design alternatives.

4.3.6 Monitor current field performance (insurance and repair industry).

4.3.7 Consider recommendations from the insurance and repair industries on design alternatives.

4.3.8 Evaluate computer simulations and full-scale and component tests, which are conducted during the course of vehicle development, to measure damage extent and repair costs. It is recommended that a well-defined series of tests be developed, that are recognized by the industry as a whole.

4.3.9 Provide new product information to insurance and repair industries, including collision-repair cost analysis, crash parts pricing, low-speed crash and security assessments, and specific repair procedures, as applicable.

4.3.10 Offer continuing collision-repair training programs, with emphasis on vehicle-specific new technologies.

4.3.11 Where applicable, work with insurance research organizations who are members of RCAR, national insurance industry bodies and individual insurers prior to new model introduction, to obtain the most appropriate rating for the new model at launch.

4.3.12 Monitor field performance of new model.

4.3.13 Evaluate collision-repair cost analysis and, as necessary, adjust assumptions, methodology, and process for future analysis.

4.4 Design for Damageability/Insurability Priorities

4.4.1 Collision-repair costs can be minimized by focusing the design effort on areas of the vehicle having the highest expected cost/cost contribution. The HLDI average loss payment has ranged between $2500 and $3000 per claim for the last 5 to 7 years. In addition, non-collision windshield replacement repair costs are the equivalent of 7.7% of all collision-repair costs.

4.4.2 While structural damage has a relatively low expected cost, the ability to restore a vehicle's passive restraint performance to its pre-accident condition may be severely limited, due to the position and overlap of structural members and reinforcements. Partial replacement procedures should be considered in early design reviews.

4.4.3 Design effort (both styling and engineering) in the U.S. should be prioritized based on component expected cost/cost contribution, rather than any one of its individual variables: involvement frequency, part price, or average cost to repair or replace.

4.4.4 Design effort (both styling and engineering) in those countries utilizing 15 km/h crash tests should be prioritized to minimize the potential for damage to components beyond the energy-absorbing elements of bumper systems.

4.4.5 Comprehensive costs can be minimized by focusing on the development of effective theft deterrence systems and glass replacement procedures.

4.4.6 Insurance costs should be minimized to gain a potential marketing advantage for a specific model and market. Loss control (cost and frequency) should be considered at the earliest phases of the design process. This should be considered along with all other vehicle design factors such as function, occupant protection, mass, styling, cost, durability, etc. To best meet these objectives of collision and comprehensive loss control, it is necessary to understand the real-world factors which affect these costs, and how these factors can be affected by vehicle design.

4.5 Factors Affecting Damageability/Insurability

4.5.1 Collision Factors

4.5.1.1 Claim frequency is primarily a DRIVER factor (demographics, lifestyle, etc.), but vehicle design (including bumper systems) can also influence frequency. The experience of the Vehicle Information Centre of Canada (VICC) is that collision frequency varies by 6:1 after removing the “driver” factor. Vehicle design significantly impacts collision frequency (e.g., ABS brakes and lighting systems, etc.).

4.5.1.2 Collision repair cost is primarily a VEHICLE DESIGN factor, influenced by:

4.5.1.2.1 Ease of repair, removal, or replacement (labor time)

4.5.1.2.2 Part price/cost

4.5.1.2.3 Part location and attachment method

4.5.1.2.4 Proximity or clearance to adjacent components (i.e., underhood)

4.5.1.2.5 Damage resistance of components, and how crash energy is dissipated into the vehicle

4.5.1.2.6 Refinish costs

4.5.1.2.7 Repairability limitations as specified by vehicle manufacturers

4.5.2 Comprehensive Factors

4.5.2.1 Theft Losses, consisting of:

4.5.2.1.1 Complete vehicle thefts (unrecovered and recovered stripped/damaged)

4.5.2.1.2 Component theft (styled wheels, wheel covers, removable glass tops, electronic entertainment equipment, including radios, video systems, navigation units, etc., batteries, composite lamps, computer control modules, “air bags,” seats, etc.)

4.5.2.2 Glass Breakage (primarily stone damage to windshields)

4.5.2.3 Other miscellaneous (flood, wind, hail, etc.)

4.5.2.4 Fire

5. ENERGY-ABSORBING ELEMENTS/BUMPER SYSTEMS

The bumper system includes bumper covers or fascias, beams, energy absorbers, brackets, license plate brackets, sight shields, valence panels, rubstrips, and bumper guards.

5.1 The bumper system should be designed to minimize the expected cost/cost contribution of not only the bumper system but also the exterior panels, lamps, body or frame structure, and other adjacent components. In other words, consider the overall damageability of the vehicle when seeking to improve bumper performance. The goal should be optimum energy management and minimum repair costs (Figures 5 and 6).

FIGURE 5 - LARGER BUMPER DEPTHS (OFFSETS) WILL RESULT IN RELATIVELY LOWER REPAIR/REPLACEMENT FREQUENCIES FOR ADJACENT PARTS

FIGURE 6 - SMALLER BUMPER DEPTHS (OFFSETS) WILL RESULT IN RELATIVELY HIGHER REPAIR/REPLACEMENT FREQUENCIES FOR ADJACENT PARTS

5.2 Design improvements (both styling and engineering) to bumpers and increased bumper beam height (100 mm +), along with industry standard bumper heights from the ground would significantly reduce claim costs in low-speed collisions.

5.3 Ends of bumper beams should extend far enough outboard to protect front and rear lamps, and any electromechanical items located behind the beam, during corner collisions (Figure 7).

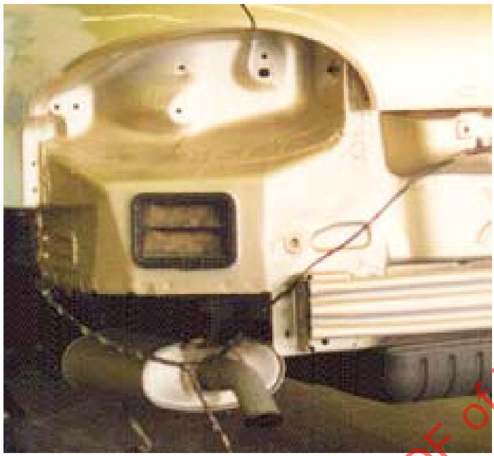

FIGURE 7 - HIGHER POTENTIAL REPAIR/REPLACEMENT FREQUENCIES FOR TAIL LAMP, QUARTER PANEL AND EXHAUST SYSTEM

5.4 When possible, front and rear bumper beams should be isolated from the vehicle structure with shock absorbers, to minimize low-speed impact damage to the rest of the bodyshell (Figure 8).

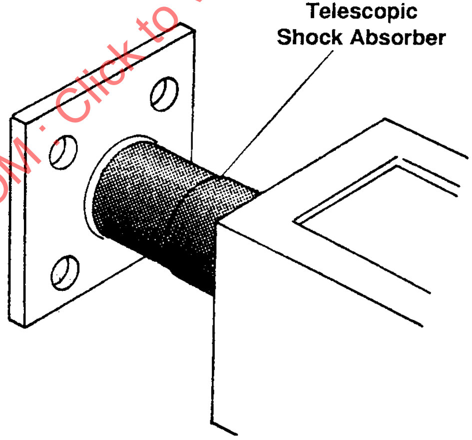

FIGURE 8 - LOWER POTENTIAL BODY STRUCTURE REPAIR/REPLACEMENT FREQUENCIES

5.5 Chrome-plated plastic ornamentation should not be located within the bumper impact zones (Figure 9).

FIGURE 9 - RELATIVELY HIGH REPLACEMENT FREQUENCY

5.6 Bolt-on rail extensions should be used to reduce repair costs.

5.7 To minimize labor time, the entire bumper system should be removable as an assembly, where feasible, with minimal fasteners and without removing other components.

5.8 Multi-piece assemblies are generally preferable to integrated designs (one piece fascia/beam systems), to allow repair or replacement of only the damaged components. Service parts pricing, labor times, and fastener accessibility should be considered to determine which approach offers the lowest expected cost (Figure 10).

FIGURE 10 - RELATIVELY LOWER SERVICE PART COST

5.9 Multi-piece, separately serviceable rub strips are preferred to integral designs.

5.10 Plastic bumper covers, fascias, sight shields and valence panels, designed with features such as molded-in nameplates, textures, or narrow grooves, should be avoided; they are difficult to repair and increase cost.

5.11 Bumper system attachment to the body structure should be with removable fasteners rather than welding. Fasteners connecting bumper covers, fascias or sight shields to body panels should enable displacement of the bumper system during an impact without damaging the body panels.

5.12 The fasteners used to secure the bumper system should remain accessible after moderate damage to the vehicle.

5.13 Painted bumper covers should be preferred over non-painted bumper covers, because of repairability costs.

5.14 Cosmetic damage to the bumper system should be repairable without removing panels from the vehicle.

5.15 Where local market conditions cost-justify it, primed bumper covers and fascias are preferred.

6. LAMPS

6.1 Front and rear lamps should not be packaged in the bumper beams, because they have a greater probability of becoming damaged.

6.2 The more expensive the headlamp assembly, the more protection should be provided by the bumper system (Figures 11 and 12).

FIGURE 11 - RELATIVELY LOWER SERVICE PART COST

FIGURE 12 - RELATIVELY HIGHER SERVICE PART COST

6.3 The more a front or rear lighting assembly wraps around the side of the vehicle, the more protection should be provided by the bumper system.

6.4 Separate taillamps, lenses, and rear decklid appliqués are preferable to cross-car designs, to reduce service part costs. It is possible to design a cross-car theme with individual lamps and lenses.

6.5 Separate headlamps, turn signals, and front side marker lamps may reduce replacement part costs versus integrated designs, but service part pricing, labor times, and fastener accessibility should be considered to determine which approach offers the lowest expected cost (Figure 13).

FIGURE 13 - POTENTIALLY LOWER OVERALL SERVICE PART COSTS

6.6 Hidden headlamps should be avoided (or designed with service in mind), because they result in higher labor and replacement part costs.

6.7 Headlamp mounting brackets should be designed so that they feature a controlled, fusible behavior (parts should be designed to always break initially in a point decided beforehand), and repair kits for them should be supplied as service parts.

6.8 Generally, the front grille and headlamp bezels (doors) should be separate parts to limit damage. However, in some instances, a single component may provide a lower expected cost/cost contribution than the sum of the individual components, generally because of its significantly lower part price.

6.9 The High Intensity Discharge (HID) headlamp ballast/ignitor should be mounted in a position that is protected from damage in minor impacts.

6.10 The HID headlamp ballast/ignitor should be serviceable separately from the headlamp assembly.

6.11 It should be possible to remove and replace the headlights without removing other elements, such as bumpers etc.

6.12 Front, rear and side-repeater lamps should be designed for easy access, both for removing and replacing, as well as for bulb replacement.

6.13 Bulbs should be serviceable without component removal and replacement or the use of special tools.

7. EXTERIOR ORNAMENTATION

7.1 Grille and grille surround should be separate from the hood, or designed to minimize transmission of damage to the hood.

7.2 Damage-resistant, protective bodyside moldings should be located at the widest point on the body surface and be capable of absorbing low speed impacts without transferring energy to the body surface (Figures 14 and 15).

FIGURE 14 - RELATIVELY LOWER DOOR REPAIR FREQUENCIES AND LABOR TIMES

FIGURE 15 - RELATIVELY HIGHER DOOR REPAIR FREQUENCIES AND LABOR TIMES

7.3 Bodyside molding and cladding with molded-in colors should be avoided, unless there is a feasible, cost-effective procedure available to paint damaged parts.

7.4 If hood and decklid ornaments cannot be avoided, they should be designed to minimize damage to mounting surfaces, if vandalized.

7.5 Encourage the design of single part logos, avoiding designs with separate letters.

8. EXTERIOR PANELS AND COMPONENTS

8.1 Fenders should be designed to avoid or minimize the transmission of damage to the windshield and doors.

8.2 Hoods, decklids, and liftgates should be bolted to the body (both sides of the hinge), rather than welded, to allow adjustment with either slots or replacement fasteners.

8.3 Doors should be mounted with bolt-on hinges (both sides of the hinge). Adjustability should be provided in the hinge mounting location and door striker. Where feasible, doors should be designed to be removed and reinstalled without disturbing the original adjustment (i.e., with removable hinge pins, Figure 16).

FIGURE 16 - RELATIVELY LOWER REPLACEMENT LABOR TIME

8.4 Front panels should be bolted to the bodyshell. They preferably should be manufactured from steel sheet, which is easier to repair after minor damage than composites, and easier to recycle if they must be replaced.

8.5 Where feasible, all exterior panels that are crucial to the achievement of uniform panel clearances should be mechanically attached and designed to facilitate field adjustment, with the exception of riveted joints for some parts (e.g., front fenders).

8.6 Exterior panels and components should be removable using common procedures and tools. Resistance spot welding is preferred to GMAW for repairs, where practical, because of lower labor times and ease of repair. If other than common fasteners are used, the vehicle manufacturer should provide information on removal and replacement procedures to the repair industry. Regardless of attachment methods, the equipment and methods used to remove and replace body components must be practical in collision-repair environment.

8.7 The attachment method of the fenders to the bodyshell should be flexible to avoid secondary damage in low-speed collisions.

8.8 The material used to make exterior panels should be repairable using cost-effective methods which are both practical in a collision-repair facility, and consistent with manufacturing design criteria.

8.9 Impact protectors in doors should be bolted, not welded.

8.10 Dent-resistant materials (bake-hardenable steel, plastics, etc.) should be considered to reduce overall repair costs.

8.11 Panel designs should avoid compound curves, sharp radii, and stamped ribs, as such features are difficult and expensive to repair. However, these features may also serve other purposes, such as locating moldings, or creating additional strain into panels, which improves dent resistance (Figure 17).

FIGURE 17 - RELATIVELY HIGHER REPAIR TIME

8.12 Cosmetic damage to visible exterior panels should be repairable without removing panels from the vehicle.

8.13 Access should be provided in the inner fender, closure inner panels, and quarter-panel structures, if feasible, to permit repair of minor damage to the exterior panel skins.

8.14 Door panels preferably should not be designed with integral window frames; use independent frames instead.

8.15 Bonded components should be serviceable at factory seams to allow re-bonding of a new or recycled component. De-bonding procedures should be practical for a collision-repair facility environment and not require expensive, unique tools. Heat-sensitive adhesives should be field-repairable.

9. ENGINE COMPARTMENT PACKAGING

9.1 High-cost components should be located in low-involvement areas (generally rearward toward the cowl or front of dash), and inward (generally toward the longitudinal centerline of the vehicle).

9.2 The battery should be located in a low-involvement area to minimize corrosion damage to sheet metal and other high-cost components. A battery’s potential to spew or leak acid can increase its Cost Contribution well beyond its replacement cost.

9.3 Avoid routing engine compartment wiring across the front of the vehicle. If this cannot be avoided, route along the top of the radiator support, not at the level of the bumper beam. Wiring repair procedures should be available, to eliminate any unnecessary replacement of major (costly) wiring harnesses.

9.4 Routing fluid lines and wires inside enclosed body features should be avoided.

9.5 Clearance between adjacent components should be maximized, where feasible, to minimize frequency of involvement in a collision.

9.6 Components located fore and aft of the radiator core support should be designed and located in a manner which minimizes both impact vulnerability and energy transfer potential. Sharp edges and protruding bolts which may puncture the air conditioning condenser, radiator, battery oil cooler, etc., should be avoided.

9.7 Avoid packaging any rigid components (e.g., cooling fans) in front of the radiator core or air conditioner condenser.

9.8 Mounting systems for high cost components should be designed to flex and allow some energy absorption prior to the component sustaining damage.

9.9 Sacrificial brackets should be used for accessory drive, engine and transmission mounts, and mounting hardware to restrict damage to components and prevent damage to engine or transmission castings.

9.10 Sufficient clearance should be provided around components for removal and installation during collision-repair procedures, without extensive removal of undamaged components.

9.11 Where feasible, electrical components, such as connectors, fuse or relay panels, and protective covers, should have provisions for field replacement which does not necessitate the replacement of major (costly) wiring harnesses. Wire harness pigtails and repair kits, along with procedures, should be utilized to keep repair costs to a minimum.

9.12 The routing of air conditioning lines should allow replacement of the radiator core support side baffles without disconnecting the lines. This avoids the associated cost of recovering, recycling, and recharging of the system. Condenser/radiator modules should allow servicing of one system without opening the other system.

9.13 Utilize “quick plug” joints in the various hoses of the refrigeration system.

9.14 Accessible bulkhead connections for electrical and vacuum systems should be provided to reduce the number of connections involved during powertrain removal.

9.15 Electrical wiring running into the door should be easily disconnected, to facilitate door removal (Figures 18 and 19).

FIGURE 18 - RELATIVELY LOWER LABOR TIME

FIGURE 19 - RELATIVELY HIGHER LABOR TIME

9.16 Battery cables should be shielded to avoid defeat of anti-theft systems (Reference 18.2).

10. BODY STRUCTURE

Collision damage repair differs greatly from vehicle design and manufacturing. In the field today, it is frequently not practical or possible to replace a structural component at the factory joints. Manufacturers should consider the need for collision repairs during the initial design process. Where feasible, materials, structural joint locations, and lapping should be used to allow low-cost and practical field repairs in restoring structural integrity and occupant protection characteristics. The vehicle structure should minimize and isolate damage in a progressive manner.

10.1 Energy management for low-speed collision should consider not only occupant protection, but also collision repair costs.

10.2 Repair of structural damage to a vehicle requires that it be rigidly secured to a straightening fixture during pulling operations. Vehicle manufacturers should work closely with the collision-repair industry and equipment manufacturers to ensure that the vehicle can be clamped and pulled without damaging other parts of the vehicle.

10.2.1 Recommended Design Practice for Unibody Vehicles

10.2.1.1 Downstanding rocker/sill panels should have sufficient length and width in a continuous plane, at the extreme front and rear of the panels, to spread the load and allow for adequate grip area when using typical mounting clamps.

10.2.1.2 Unibody vehicles designed without downstanding rocker/sill flanges should have a practical method (strategy coordinated with service and equipment manufacturers) for securing the vehicle during pulling operations.

10.2.1.3 Adjacent components (brake lines, wiring, suspension components, etc.) should not interfere with clamp installation.

10.2.2 Recommended design practice for body-on-frame passenger cars, light trucks, and utility vehicles:

10.2.2.1 Pickup truck downstanding frame rail flanges should have sufficient length and width in a continuous plane, at the extreme front and rear of the frame rail area directly beneath the cab (beginning with the front cab mount to an area just in front of the pickup box and rear edge of the cab), to spread the load and allow for adequate grip area when using typical mounting clamps.

10.2.2.2 Passenger car downstanding frame rail flanges should have sufficient length and width in a continuous plane at the front and rear torque box areas to spread the load and allow for adequate grip area when using typical mounting clamps.

10.2.2.3 Body-on-frame vehicles designed without downstanding frame rail flanges should have a practical method for securing the vehicle during pulling operations.

10.2.2.4 Adjacent components (brake lines, wiring, suspension components, etc.) should not interfere with clamp installation.

10.3 The most frequently replaced components should be lapped on top or outside of adjacent, less-frequently damaged panels or members.

10.4 The joint locations should allow replacement of frequently damaged components without causing additional damage to adjacent components.

10.5 If lapping and location designs do not facilitate a practical repair, manufacturers should develop repair procedures which restore the crashworthiness, durability, and corrosion protection of the vehicle.

10.6 Access should be provided through the inner structure to allow straightening of minor damage to the outer body panels.Designs should incorporate roof panel to outer bodyside seams for easier blending and refinishing to the break line.

10.7 Do not punch the Vehicle Identification Number onto a part which is likely to be damaged, such as the apron. It is better to locate this on the floor of the interior on the driver's side.

11. BODY HARDWARE

11.1 "Swing-away" outside mirrors will reduce the potential for damage to the doors if the vehicle hits a garage door opening, automatic teller machine, etc. The attachment should fail first (Figure 20).

FIGURE 20 - RELATIVELY LOWER REPAIR/REPLACEMENT FREQUENCY

11.2 Exterior door handles, lock cylinders, etc., should be removable without extensive disassembly of the door, to minimize the time and cost of refinishing the door outer panel.

11.3 Mounting of fixed rear quarter lights (windows) should be by mechanical means, without the use of adhesives when feasible.

11.4 Do not use rivets to fix plastic elements to bodywork.