United States Government Accountability Office

GAO

Report to Congressional Committees

April 2005

VEHICLE SAFETY

Opportunities Exist to Enhance NHTSA's New Car Assessment Program

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Accountability ★ Integrity ★ Reliability

GAO-05-370

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Highlights

Highlights of GAO-05-370, a report to congressional committees

April 2005

VEHICLE SAFETY

Opportunities Exist to Enhance NHTSA's New Car Assessment Program

Why GAO Did This Study

In 2003, 42,643 people were killed and more than 2.8 million people were injured in motor vehicle crashes. Efforts to reduce fatalities on the nation's roadways include the National Highway Transportation Safety Administration's (NHTSA) New Car Assessment Program. Under this program, NHTSA conducts vehicle crash and rollover tests to encourage manufacturers to make safety improvements to new vehicles and provide the public with information on the relative safety of vehicles. GAO examined (1) how NHTSA's New Car Assessment Program crash tests vehicles, rates their safety, and reports the results to the public; (2) how NHTSA's program compares to other programs that crash test vehicles and report results to the public; and (3) the impact of the program and opportunities to enhance its effectiveness.

What GAO Recommends

GAO recommends that NHTSA examine the direction of the New Car Assessment Program to ensure that it maintains its relevance in improving vehicle safety, including identifying tests that best address the fatalities occurring on the nation's roads. GAO also recommends that NHTSA enhance the presentation and timeliness of the information provided to the public. NHTSA generally agreed with GAO's findings.

www.gao.gov/cgi-bin/getrpt?GAO-05-370.

To view the full product, including the scope and methodology, click on the link above. For more information, contact JayEtta Hecker at (202) 512-2834 or heckerj@gao.gov.

What GAO Found

NHTSA conducts three types of tests in the New Car Assessment Program—full frontal and angled side crash tests and a rollover test. Each year, NHTSA tests new vehicles that are expected to have high sales volume, have been redesigned with structural changes, or have improved safety equipment. Based on test results, vehicles receive ratings from one to five stars, with five stars being the best, to indicate the vehicles' relative crashworthiness and which are less likely to roll over. NHTSA makes ratings available to the public on the Internet and through a brochure. Other publications, such as *Consumer Reports*, use NHTSA's test results in their safety assessments.

Examples of NHTSA's New Car Assessment Program Tests

Source: National Highway Traffic Safety Administration.

GAO identified four other programs—the Insurance Institute for Highway Safety's program and the New Car Assessment Programs in Australia, Europe, and Japan—that crash test vehicles and report the results to the public. They share the goals of encouraging manufacturers to improve vehicle safety and providing safety information to consumers. These programs conduct different types of frontal and side crash tests, and some perform other tests, such as pedestrian tests, that are not conducted under the U.S. program. Only the U.S. program conducts a rollover test. The other programs measure test results differently and include more potential injuries to occupants in ratings. They also reported their test results differently, with all summarizing at least some of the scores or combining them into an overall crashworthiness rating to make comparisons easier.

NHTSA's New Car Assessment Program has been successful in encouraging manufacturers to make safer vehicles and providing information to consumers. However, the program is at a crossroads where it will need to change to maintain its relevance. The usefulness of the current tests has been eroded by the growing number of larger pickups, minivans, and sport utility vehicles in the vehicle fleet since the program began. In addition, NCAP scores have increased to the point where there is little difference in vehicle ratings. As a result, the program provides little incentive for manufacturers to further improve safety, and consumers can see few differences among new vehicles. Opportunities to enhance the program include developing approaches to better measure the interaction of large and small vehicles and occupant protection in rollovers, rating technologies that help prevent crashes, and using different injury measures to rate the crash results. NHTSA also has opportunities to enhance the presentation and timeliness of the information provided to consumers.

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Abbreviations

AAAM	Association for the Advancement of Automotive Medicine
ADAC	General German Automobile Association *(Allegmeiner Deutscher Automobil-Club e V)*
AIS	Abbreviated Injury Scale
c.g.	center of gravity
CFR	Code of Federal Regulations
DOT	Department of Transportation
ESC	Electronic Stability Control
Euro NCAP	European New Car Assessment Programme
HIC	Head Injury Criterion
kg	kilogram
km/h	kilometers per hour
mm	millimeter
mph	miles per hour
NASVA	National Agency for Automotive Safety and Victims' Aid
NBC	National Broadcasting Company
NCAP	New Car Assessment Program
NHTSA	National Highway Traffic Safety Administration
SID	side-impact dummy
SUV	sport utility vehicle
SSF	Static Stability Factor
TREAD Act	Transportation, Recall Enhancement, Accountability, and Documentation Act
TSRE AB	Traffic Safety Research and Engineering AB
TTI	Thoracic Trauma Index

United States Government Accountability Office
Washington, D.C. 20548

April 29, 2005

The Honorable Christopher Bond
Chairman
The Honorable Patty Murray
Ranking Member
Subcommittee on Transportation, Treasury, the Judiciary,
Housing and Urban Development, and Related Agencies
Committee on Appropriations
United States Senate

The Honorable Joe Knollenberg
Chairman
The Honorable John W. Olver
Ranking Member
Subcommittee on Transportation, Treasury, and Housing
and Urban Development, the Judiciary, District of Columbia,
and Independent Agencies
Committee on Appropriations
House of Representatives

Motor vehicle travel is the primary means of transportation in the United States. Yet for all its advantages, deaths and injuries resulting from motor vehicle crashes are the leading cause of death for all persons from 3 through 33 years old. In 2003, 42,643 people were killed and more than 2.8 million people were injured in motor vehicle crashes. Frontal crashes caused the largest portion of occupant deaths (about 41 percent), followed by rollovers and side impact crashes (30 percent and 22 percent, respectively). In addition to the loss of life, motor vehicle crashes have a high economic cost, which the National Highway Traffic Safety Administration (NHTSA) estimated at over $230 billion in 2000, the most recent year for which cost estimates were available.[1]

Efforts to reduce fatality rates in motor vehicle crashes have resulted in some improvement. The fatality rate per 100 million miles of travel in 2003 was at a historic low of 1.48, down from 1.75 per 100 million miles of travel

[1]Economic costs include productivity losses, property damage, medical costs, rehabilitation costs, travel delay, legal and court costs, emergency services, insurance administration costs, and the costs to employers. For more information, see U.S. Department of Transportataion National Highway Traffic Safety Administration, *The Economic Impact of Motor Vehicle Crashes, 2000* (Washington, D.C.: May 2002).

in 1993. The Department of Transportation (DOT) attributes this change to several factors, including increased safety belt use, reduction of alcohol-related deaths, and vehicle safety programs, including Federal Motor Vehicle Safety Standards and the New Car Assessment Program (NCAP), both run by NHTSA. Under NCAP, which began in 1978, NHTSA conducts frontal and side crash tests and rollover tests of new cars, light trucks, vans, and sport utility vehicles (SUV) and reports the results to the public. The specific goals of the program are to encourage market forces that prompt vehicle manufacturers to make safety improvements to new vehicles and provide the public with objective information on the relative safety performance of vehicles.

Federal Motor Vehicle Safety Standards are regulations that establish minimum performance levels that manufacturers must self-certify to in order to sell vehicles in the United States. Under the safety standards, NHTSA requires vehicles to pass a number of performance tests to ensure that the minimum safety level is met. The NCAP frontal and side crash tests are based on two of the crash tests carried out under the safety standards. However, the NCAP tests are conducted at 5 miles per hour faster so that the differentiation between vehicles becomes more apparent. When considering changes to NCAP, NHTSA generally follows the rulemaking process, which includes seeking informal comments on proposed changes before they become effective.

The Senate Appropriations Committee Report accompanying the Department of Transportation appropriations bill for fiscal year 2004 (S. 1589) directed us to conduct a study of the New Car Assessment Program. This report examines (1) how NHTSA's New Car Assessment Program tests vehicles, rates their safety, and reports the results to the public; (2) how NCAP compares to other programs that test vehicles and report results to the public; and (3) the impact NCAP has had and the opportunities that exist to enhance its effectiveness.

To understand NHTSA's basis for testing and rating vehicles, we reviewed laws, regulations, and program documentation. We also conducted interviews with NHTSA officials, crash test contractors, vehicle manufacturers, trade associations, public interest groups, and independent researchers. We observed various vehicle crash tests and documented how the results were converted into star ratings. To document how NHTSA reports the results to the public, we consulted NHTSA officials, the Internet, and other vehicle safety information sources, such as *Consumer Reports*. To compare NHTSA's program with other crash test and rating programs, domestic and foreign, we interviewed officials of the Insurance Institute for Highway Safety and the New Car Assessment Programs of Australia, Europe, and Japan.[2] We also interviewed vehicle safety experts and officials of foreign government entities, foreign vehicle manufacturers, and foreign consumer magazines such as *Which?*. To identify the impact of NCAP and opportunities for improvement, we analyzed changes in NCAP scores over time and obtained views from experts in the auto and insurance industries, public interest groups, and academia. We determined that NCAP data were sufficiently reliable for the purposes of this report. In addition, we analyzed how other organizations tested vehicles, rated the crash tests, and reported their results to the public to identify practices from other programs that may have potential application to the U.S. program. We conducted our work from March 2004 through April 2005 in accordance with generally accepted government auditing standards.

Results in Brief

Under NCAP, NHTSA conducts three types of tests on vehicles—a full frontal crash test, a side crash test, and a rollover test, as shown in figure 1.[3]

Figure 1: Three Types of Tests—Frontal, Side, and Rollover—Conducted by NCAP

Source: National Highway Traffic Safety Administration.

[2]The Insurance Institute for Highway Safety is a nonprofit research and communications organization in the United States funded by the auto insurance industry.

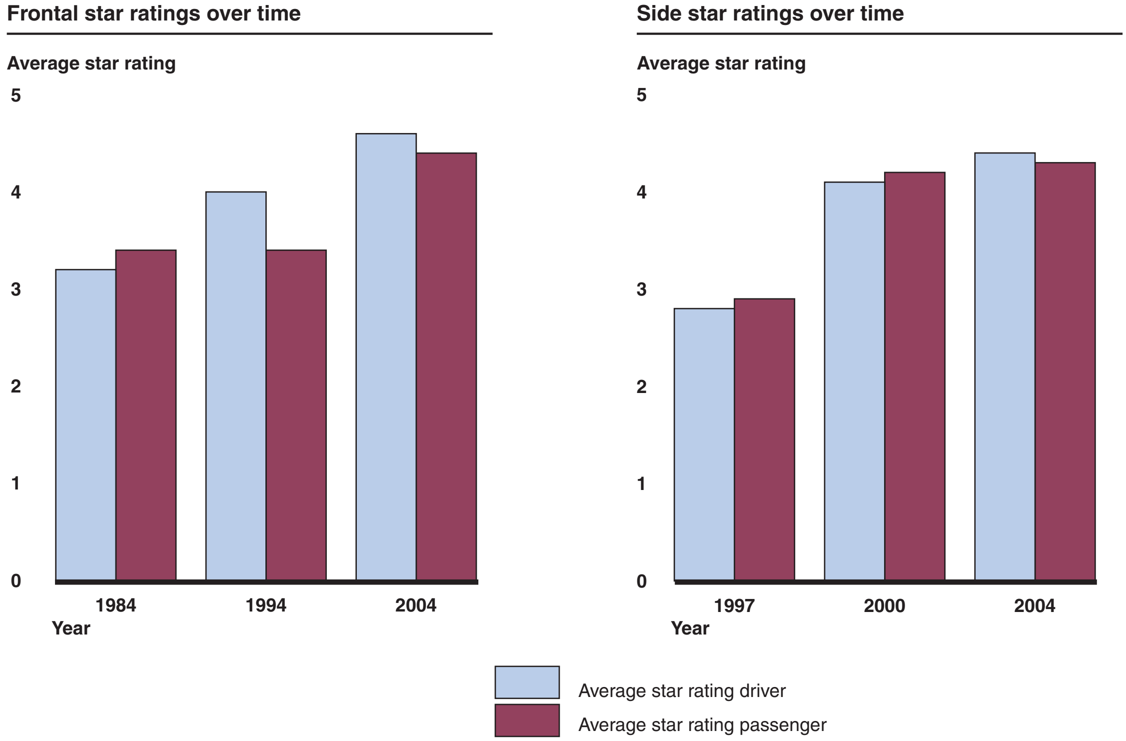
[3]The rollover test is nondestructive.

Each year, NHTSA tests a number of new vehicles that are predicted to have high sales volume, have been redesigned with structural changes, or have improved safety equipment. This practice is designed to ensure that NHTSA rates vehicles that consumers are buying. NHTSA develops five separate ratings based on the three tests and assigns one to five stars to indicate which vehicles are more crashworthy in frontal and side crashes and which vehicles are less likely to roll over. NCAP ratings, designed to help consumers decide which vehicle to purchase, are available to the public on the Internet and through the NHTSA *Buying a Safer Car* brochure. NCAP crash results are also incorporated in different vehicle safety ratings developed by others, such as *Consumer Reports* and *The Car Book*, both of which get more extensive distribution than direct NHTSA reporting.

We identified four other programs that crash test vehicles and report the results to the public—the Insurance Institute for Highway Safety's program and NCAP programs in Australia, Europe, and Japan. Like the U.S. NCAP, all these programs shared similar goals—providing relative safety information to consumers and encouraging manufacturers to improve vehicle safety. The three foreign NCAPs conduct different types of frontal and side crash tests and conduct pedestrian and child restraint systems tests that are not conducted under the U.S. program. The Insurance Institute also conducts different frontal and side crash tests than NHTSA's NCAP. Only the U.S. program conducts a rollover test. Each vehicle testing program also measures test results differently than the United States For example, in addition to the data provided by the crash test dummies in the vehicles, inspectors in other programs examine vehicles after crash tests to determine if there was intrusion into the passenger compartment or other abnormalities and adjust the test score accordingly. These other programs also report their testing results to the public in a different manner. While the U.S. NCAP reports results for each crash dummy by their seating locations in the crash test, all of the other programs summarize at least some of the scores or combined them into an overall crashworthiness rating in an effort to make it easier for the public to understand the results.

NCAP has contributed to making vehicles safer, but the program is at a crossroads where it will need to change in order to maintain its relevance. As shown in figure 2, vehicle safety as measured by NHTSA star ratings has improved since the program began.

Figure 2: Improvement of Average Star Ratings for Frontal and Side NCAP Tests



Source: GAO analysis of historical NCAP data provided by NHTSA.

Note: Data include only the vehicles that were crash tested for each model year.

The usefulness of the current tests has been eroded by changes in the vehicle fleet that have occurred since the program began. Today there are many more large pickups, minivans, and SUVs than existed 27 years ago, and this has created new safety hazards from the incompatibility between large and small vehicles and rollover crashes, which are not fully addressed by current NCAP tests. In addition, because most vehicles now receive four- or five-star ratings, NCAP tests provide little incentive for automakers to continue to improve vehicle safety and little differentiation among vehicle ratings for consumers. Lastly, NHTSA is upgrading its frontal and side crash tests in the Federal Motor Vehicle Safety Standards, which will make current NCAP tests less meaningful. For example, NHTSA is increasing the speed of the frontal safety standards to the same speed as the NCAP test, eliminating the difference between the frontal NCAP and safety standard tests. Opportunities to enhance the program include developing approaches to better measure the effects of crashes between large and small vehicles and occupant protection in rollovers, rating technologies that help prevent crashes from occurring, and using different measures to rate the crash results. NHTSA also has opportunities to enhance the timeliness of the tests and the presentation of the information provided to consumers.

We are making recommendations to the Secretary of Transportation to ensure that NCAP maintains its relevance in improving vehicle safety and to enhance the presentation and timeliness of the information provided to the public. We received oral comments from NHTSA on a draft of this report. In general, NHTSA agreed with the report's findings. We are also making a version of this report available at www.gao.gov, which includes video clips of crash tests that are conducted by NHTSA and others.

Background

Motor vehicle crashes are complex events resulting from several factors, including driver behavior, the driving environment, and the vehicle.[4] Vehicle design can affect safety through crashworthiness—that is, by providing occupants protection during a crash—and through crash avoidance—that is, by helping the driver to avoid a crash or recover from a driving error. Vehicle characteristics such as size, weight, and the type of restraint system affect crashworthiness because they play a large role in determining the likelihood and extent of occupant injury from a crash. Vehicle characteristics such as vehicle stability and braking performance are examples of crash avoidance features in that they aid the driver in preventing a crash from occurring.

The New Car Assessment Program (NCAP) was established in response to a requirement in the Motor Vehicle Information and Cost Savings Act of 1972 to provide consumers with a measure of the relative crashworthiness

[4]Driver behavior involves the actions taken by or the condition of the driver of the motor vehicle, including speeding and violating traffic laws, as well as the effects of alcohol or drugs, inattention, decision errors, and age. The driving environment associated with crashes includes roadway design, roadside hazards, and road conditions. Vehicle factors that contribute to crashes include vehicle-related failures or design of the vehicle. For additional information on the causes of motor vehicle crashes, see GAO, *Highway Safety: Research Continues on a Variety of Factors That Contribute to Motor Vehicle Crashes*, GAO-03-436 (Washington, D.C. : Mar. 31, 2003).

of passenger vehicles.[5] NCAP's goals are to improve occupant safety by providing market incentives for vehicle manufacturers to voluntarily design vehicles with improved crashworthiness and provide independent safety information to aid consumers in making comparative vehicle purchase decisions. NHTSA has pursued these goals by conducting frontal and side crash tests and a rollover test, assigning star ratings, and reporting the results to the public.[6] In fiscal year 2004, NCAP conducted 85 crash tests and 36 rollover tests, with a budget of $7.7 million.[7]

NHTSA also administers the Federal Motor Vehicle Safety Standards.[8] All motor vehicles sold in the United States for use on the nation's highways must meet minimum safety requirements as required by the standards. The standards prescribe a minimum performance level for crashworthiness that vehicles must meet in a number of different crash tests. Auto manufacturers self-certify that their vehicles meet these minimum standards. To test compliance with some of these standards, NHTSA conducts 30 miles per hour (mph) frontal impact tests and 33.5 mph side impact tests for belted occupants.[9]

The Federal Motor Vehicle Safety Standards tests serve as a foundation for NCAP testing. The test protocols for NCAP's frontal and side crash tests are the same as the safety standards, except that the NCAP tests are conducted at 5 mph faster. NHTSA's policy, although not required by law, has been to make changes to the safety standards before considering changes to NCAP.

[5]Crashworthiness is defined in 49 USC § 32301 as "the protection a passenger motor vehicle gives its passengers against personal injury or death from a motor vehicle accident." Section 49 USC § 32302, subsection (a), requires the Secretary of Transportation to "maintain a program for developing . . . information on passenger motor vehicles['] . . . crashworthiness." Subsection (b) requires the Secretary to "provide to the public information developed under subsection (a) . . . in a simple and understandable form."

[6]NHTSA also rates the ease of use for child safety seats under NCAP, which is not included in the scope of this report.

[7]An additional 16 vehicles were also rated for rollover based on a calculation of their top-heaviness.

[8]The Federal Motor Vehicle Safety Standards (CFR Title 49: chapter V, part 571) were created under section 103 of the National Traffic and Motor Vehicle Safety Act of 1966. The standards cover a broad range of safety concerns, from windshield wipers and brakes to crashworthiness.

[9]Federal Motor Vehicle Safety Standards No. 208 and No. 214, for the frontal and side tests, respectively.

When considering changes to NCAP, NHTSA generally follows the informal rulemaking process, which includes seeking comments on proposed changes.

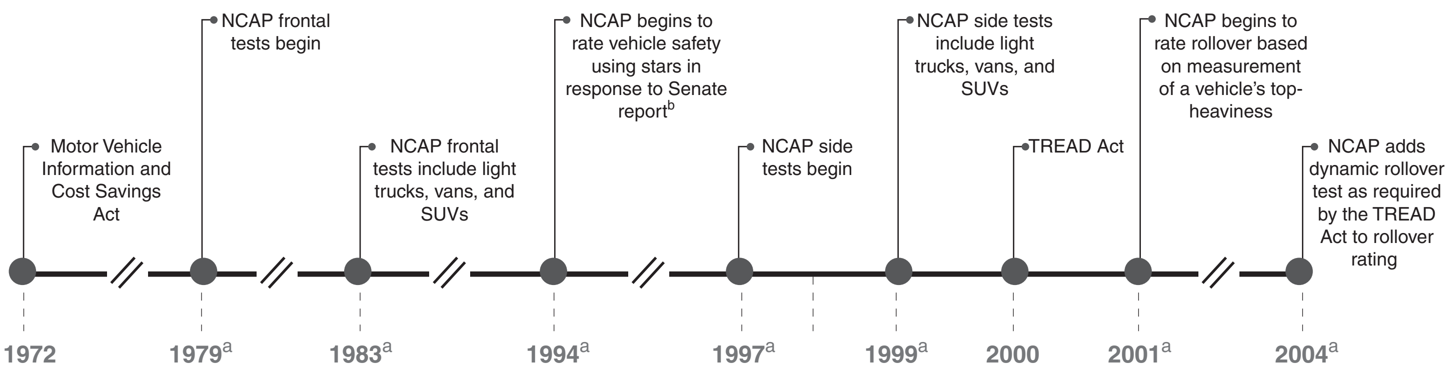
NCAP provides consumers with information regarding the crashworthiness of new cars beyond the applicable Federal Motor Vehicle Safety Standards with which all vehicles sold in the United States must comply. There are no minimum performance levels for the NCAP tests. NHTSA tests as many vehicles as possible under NCAP to provide consumers with sufficient independent information to make vehicle comparisons. In contrast, NHTSA relies on auto manufacturers to self-certify compliance with the Federal Motor Vehicle Safety Standards and only conducts a limited number of tests to ensure manufacturer compliance.[10]

NHTSA conducted the first NCAP crash tests in 1978 on model year 1979 vehicles, measuring only the crashworthiness of passenger cars in frontal crashes. Since then, there have been a number of vehicle tests added to NCAP, as shown in figure 3. For model year 1983, NHTSA expanded NCAP to include light trucks, vans, and SUVs. In 1996, NHTSA first began the side-impact NCAP test for model year 1997 vehicles. NHTSA expanded the side-impact NCAP test to include light trucks, vans, and SUVs for model year 1999. NHTSA began to rate vehicles for their rollover risk beginning with the 2001 model year. NHTSA initially rated the risk of vehicle rollover by measuring the top-heaviness of a vehicle and comparing this measurement to the top-heaviness of vehicles involved in single-vehicle crashes, as reflected in crash data. As required by the November 2000 Transportation, Recall Enhancement, Accountability and Documentation (TREAD) Act, NHTSA began dynamic rollover testing on model year 2004 vehicles to supplement the measurement of a vehicle's top-heaviness in determining a vehicle's rollover risk.[11]

[10]Vehicle manufacturers face severe civil penalties, potentially expensive vehicle safety recalls, and potential legal liability if NHTSA's testing indicates that a vehicle does not comply with Federal Motor Vehicle Safety Standards.

[11]The dynamic rollover test is a specific driving maneuver. The Static Stability Factor is a laboratory measurement.

Figure 3: Time Line of NCAP



Source: GAO.

[a]Indicates vehicle model year.

[b]NHTSA has not always used the star rating system to communicate a vehicle's crashworthiness as measured by NCAP. Previously, NHTSA published the numerical injury scores indicating the likelihood of head, chest, and upper leg injuries to the vehicle occupants. NHTSA devised the star rating system after the Senate and Conference Appropriations Reports for fiscal year 1992 requested that NHTSA improve methods of informing consumers of the comparative safety of passenger vehicles as measured by NCAP.

NCAP Crash Tests Vehicles, Rates Their Safety, and Reports the Results to the Public

NHTSA conducts three types of tests in NCAP: a full frontal crash test, an angled side crash test, and a rollover test.[12] NCAP ratings, designed to aid consumers in deciding which vehicle to purchase, are available to the public on the Internet and through NHTSA's *Buying a Safer Car* brochure. NCAP crash results are also used in developing vehicle safety ratings by other organizations, such as *Consumer Reports* and *The Car Book*.

NCAP Conducts Three Tests—Full Frontal, Side, and Rollover

Every year NHTSA tests new vehicles that are predicted to have high sales volume, have been redesigned with structural changes, or have improved safety equipment. NHTSA purchases vehicles—the base model with standard equipment—for frontal and side crash tests directly from dealerships across the country, just as the consumer would. The vehicles are provided to five contractors that conduct the crash tests. NCAP crash-

[12]According to NHTSA officials, they are conducting pilot studies to determine the feasibility of conducting more tests under NCAP, including a child seat crashworthiness sled test, rating vehicles on how well they protect children, braking, and lighting.

test ratings only apply to belted occupants, as the crash test dummies used in NCAP tests are secured with the vehicle's safety belts. According to NHTSA officials, NCAP crash-test ratings are available on about 85 percent of the new vehicles sold because ratings for some models that have had no significant safety or structural changes are carried over from year to year. For the rollover tests, which are nondestructive, NHTSA leases new vehicles, which are tested at one contractor location. Rollover risk ratings are available for about 75 percent of new vehicles sold, according to NHTSA officials.

Full Frontal Crash Test

The full frontal crash test is the equivalent of two identical vehicles, both traveling at 35 mph, crashing into each other head-on.[13] The test vehicle is attached to a cable and towed along a track at 35 mph so that the entire front end of the vehicle engages a fixed rigid barrier, as shown in figure 4. This type of crash test produces high level occupant deceleration, making this test demanding of the vehicle's restraint system.

Figure 4: Full Frontal Crash Test Conducted under NCAP

Source: National Highway Traffic Safety Administration.

Click the following link to watch a video of a full frontal crash test conducted by NHTSA NCAP at 35 mph:
http://www.gao.gov/media/video/d05370v1.mpg

Because the full frontal crash test is equivalent to two identical vehicles moving toward each other at 35 mph, the crash test results can only be compared to other vehicles in the same class and with a weight that is plus

[13]See appendix VIII for a diagram of the full frontal crash test configuration.

or minus 250 pounds of the test vehicle. The test protocols for the full frontal NCAP test are the same as the full frontal belted test in the Federal Motor Vehicle Safety Standards, with the exception of the test speed—the NCAP test is conducted at 35 mph, 5 mph faster than the standard test.[14]

Angled Side Crash Test

The angled side crash test simulates an intersection collision in which one moving vehicle strikes another moving vehicle.[15] The test vehicle is positioned such that the driver's side forms a 63 degree angle with the test track. On the other end of the test track is a chassis with a barrier also turned at a 63 degree angle.[16] The barrier is made of a deformable material to replicate the front of another vehicle and is attached to a cable that tows it down a track into the test vehicle at 38.5 mph. Both the barrier face and the driver's side of the vehicle are parallel, so that the entire face of the barrier impacts the side of the vehicle, as shown in figure 5.

[14]The higher speed creates more crash energy or power and inflicts potentially more damage on the vehicle and its occupants. The increased speed also allows differences in crashworthiness to be more readily observed. The difference in speed is only 5 mph faster, but the total kinetic energy released in a 35 mph crash is 36 percent greater than that released in a 30 mph crash.

[15]See appendix VIII for a diagram of the angled side crash test configuration.

[16]NHTSA performs the angled side test because accident data suggests that intersection or perpendicular impacts occur with two moving vehicles. To simulate a moving car to moving car crash, the angled or "crabbed" side test is used. The test simulates the striking vehicle traveling at approximately 34 mph and the test vehicle traveling at roughly half that speed—approximately 17 mph—due to the 63/27 degree configuration.

Figure 5: Angled Side Crash Test Conducted under NCAP

Source: National Highway Traffic Safety Administration.

Click the following link to watch a video of an angled side crash test conducted by NHTSA NCAP at 38.5 mph: http://www.gao.gov/media/video/d05370v2.mpg

Because all vehicles are hit with the same force by the same moving barrier, test results can be compared across weight classes. The barrier used in this test weighs approximately 3,015 pounds, and the top of the deformable face is approximately 32 inches from the ground. The side NCAP test is similar to the Federal Motor Vehicle Safety Standards test, with the exception that the side NCAP test is conducted at 38.5 mph, or 5 mph faster than the safety standard test.[17]

Rollover Test

The dynamic rollover test simulates a driver making a high-speed collision avoidance maneuver—steering sharply in one direction, then sharply in the other direction—within about 1 second. NHTSA has focused its rollover test primarily on pickups and SUVs because cars are not susceptible to tipping up in this test. The rollover test is actually a series of four runs, two left/right tests and two right/left tests, at two different steering wheel angles and different speeds. Before the test, the vehicle is loaded to represent five passengers and a full tank of gas. During the test, the steering wheel is turned sharply in one direction at a high speed and then turned sharply in the opposite direction at a greater steering angle.[18] The first run of each test is conducted at 35 mph. Subsequent runs are conducted at about 40 mph, 45 mph, 47.5 mph and 50 mph, until the vehicle fails or “tips up” as defined by test procedures or attains a speed of 50 mph on the last

[17]The safety standard, No. 214, applies to both sides of the vehicle and specifies performance requirements for vehicle occupant protection in side crashes. NCAP side tests only apply to the driver’s side of the vehicle.

[18]Appendix III provides additional discussion of the basis for NHTSA’s rollover rating.

run of each test without tipping up. Tipping up is defined as both wheels on one side of the vehicle lifting off the ground more than 2 inches simultaneously, which most commonly occurs during the second turn, as exhibited in figure 6. Outriggers are attached to the vehicle to prevent it from tipping all the way over and injuring the test driver.

Figure 6: Rollover Test Conducted under NCAP

Source: National Highway Traffic Safety Administration.

Click the following link to watch a video of a dynamic rollover test conducted by NHTSA NCAP at 48 mph: http://www.gao.gov/media/video/d05370v3.mpg

NHTSA Rates Vehicles by Assigning Up to Five Stars to Communicate the Results of Its Tests

NHTSA separately rates the frontal, side, and rollover tests. It assigns one (worst) to five (best) stars to communicate the results of the three tests to aid consumers in their vehicle purchase decisions. Each star in the frontal and side ratings corresponds to a diminishing probability of a potentially life-threatening injury, whereas each star in the rollover rating corresponds to a reduced likelihood of vehicle rollover. The rollover rating does not represent the chance of a potentially life-threatening injury should a rollover crash occur.

Frontal and Side Crashworthiness Ratings

Frontal and side star ratings represent the chances of a person wearing a safety belt incurring an injury serious enough to require immediate hospitalization or to be life threatening in the event of a crash. Frontal star ratings indicate the combined chance of a serious head and chest injury[19] to the driver and right front seat passenger, as shown in figure 7.

[19]The head and chest measurements are known as the Head Injury Criterion (HIC) and chest deceleration value, measured in Gs.

Figure 7: Frontal Star Rating and the Corresponding Chance of Serious Injury to the Head and Chest

Frontal star rating	Chance of serious injury
★★★★★	10 percent or less
★★★★	11 percent to 20 percent
★★★	21 percent to 35 percent
★★	36 percent to 45 percent
★	46 percent or greater

Source: National Highway Traffic Safety Administration.

Side star ratings indicate the chance of a serious chest injury to the driver and the rear seat driver's side passenger, as shown in figure 8.[20] NHTSA reports two separate star ratings for the frontal and side crash test, according to the occupant position.

Figure 8: Side Star Rating and the Corresponding Chance of Serious Injury to the Chest

Side star rating	Chance of serious injury
★★★★★	5 percent or less
★★★★	6 percent to 10 percent
★★★	11 percent to 20 percent
★★	21 percent to 25 percent
★	26 percent or greater

Source: National Highway Traffic Safety Administration.

In the side and frontal test, NHTSA uses crash test dummies that represent an average-sized adult male. Each dummy is secured with the vehicle's

[20]The forces on the dummy's lower spine and the greater of the accelerations of the lower and upper ribs are used in the side NCAP star ratings. These accelerations are averaged to produce a measurement known as the Thoracic Trauma Index.

safety belts prior to the crash test.[21] The dummies are affixed with instruments that measure the force of impact experienced in different parts of the body during the crash. While only forces to the head and chest are used to calculate the frontal star ratings, impacts to each dummy's neck, pelvis, legs, and feet are also measured.[22] For the frontal rating, NHTSA calculates the chance of serious injury to the head and chest by linking measured forces on the dummies' heads and chests during the crash test to information about human injury.[23] For the side rating, NHTSA calculates the chance of serious injury to the chest by linking measured forces on the dummies' ribs and lower spine during the crash test and information about human injury. Forces to the head and pelvis are also measured but are not included in side star ratings.

Rollover Rating

NHTSA's rollover star ratings represent the propensity of a vehicle to roll over but do not address the probability of a severe injury in a rollover crash. Knowing a vehicle's propensity to roll is important because rollovers are the most deadly crashes. While totaling just over 2 percent of police reported crashes, rollovers account for almost one-third of all passenger vehicle occupant fatalities. The crash avoidance rollover rating is based primarily on the measure of a vehicle's top-heaviness, as shown in figure 9, and, to a lesser extent, the results of the dynamic test.[24]

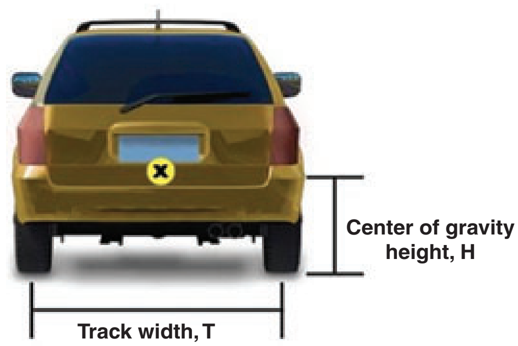
[21]The crash test dummies used in the frontal and side NCAP test represent the 50th percentile male or the average male in terms of height and weight. The dummy used is approximately 5 feet 9 inches tall and weighs approximately 170 pounds.

[22]If these force measurements are sufficiently high to cause serious or life-threatening injury, they are reported separately as a safety concern but are not included in the star rating calculation. NHTSA does not report tibia and feet measurements as safety concerns because there are no agency-approved metrics for these body regions. In side impact tests, forces to the head are also measured, though they are not included in the star rating. They are also reported separately as a safety concern if considered high.

[23]See appendix II for more information about how dummy measures and information about human injury are combined to develop a probability of injury.

[24]NHTSA began rating a vehicle's risk of rollover in 2001. Rollover ratings between 2001 and 2003 were based on the measure of a vehicle's top-heaviness because NHTSA had determined that this was a good indicator of rollover likelihood. In 2004, NHTSA began to conduct a dynamic rollover test as mandated by the TREAD Act.

Figure 9: Calculation of a Vehicle's Top-Heaviness



$$SSF^{a} = \frac{T}{2H}$$

Source: National Highway Traffic Safety Administration.

[a]The Static Stability Factor (SSF) is a vehicle's track width divided by two times its center of gravity height.

NHTSA uses the measure of a vehicle's top-heaviness to predict the likelihood of a vehicle rolling over under the circumstances that occur most often—when a vehicle leaves the roadway and the vehicle's wheels hit a curb, soft shoulder, or other roadway object, causing it to roll over. These "tripped" rollovers account for about 95 percent of all rollover crashes. NHTSA's dynamic rollover test does not correspond to these types of rollovers because it does not involve the vehicle hitting a tripping mechanism, such as a curb or soft shoulder. As such, NHTSA's dynamic rollover test does not affect the star rating significantly, resulting in no more than a half-star difference in a vehicle's rollover rating. NHTSA primarily selects top-heavy vehicles, such as light trucks, small vans, and SUVs for the rollover test.[25] NHTSA assigns one to five stars to reflect the chance of rollover, as shown in figure 10.[26]

[25]A vehicle's Static Stability Factor ranges (SSF) from approximately 1.00 to 1.50, with SUVs lying in the lower half and passenger cars lying in the upper half of that range. The lower the SSF, the more likely a rollover will occur. For rollover ratings, vehicles are rated using a statistical risk model that incorporates both the vehicle's SSF and its tip or no-tip result in the dynamic test. NHTSA does not always subject passenger cars to the dynamic test. For some passenger cars, NHTSA imputes or assigns a "no tip-up" if other passenger cars that are more top-heavy did not tip up during the dynamic test. NHTSA periodically puts vehicles with imputed test results through the dynamic test to verify the no tip-up assignation.

[26]See appendix III for a more detailed description of the development of the NCAP rollover rating.

Figure 10: Rollover Star Rating and the Corresponding Risk of Rollover

Rollover star rating	Chance of serious injury
★★★★★	Less than 10 percent
★★★★	Between 10 percent to 20 percent
★★★	Between 20 percent to 30 percent
★★	Between 30 percent to 40 percent
★	Greater than 40 percent

Source: National Highway Traffic Safety Administration.

NHTSA Reports the Results to the Public Through the Internet and the *Buying a Safer Car* Brochure

NHTSA distributes NCAP safety ratings and information about a vehicle's safety features through its Web site, press releases, and the *Buying a Safer Car* brochure. NHTSA primarily relies on the Web site to educate consumers about vehicle safety; in 2004 there were about 4.3 million visits to the NCAP Web site. The Web site was last redesigned in August 2004 and provides information about crash test ratings from model year 1990 to the present.[27] To view a vehicle's ratings, users can search using parameters such as vehicle class, year, make, and model. Once a vehicle class and year are selected, the list of vehicles comes up with the star rating information, as shown in figure 11.

Figure 11: Ratings for a 2004 Passenger Vehicle as It Appears on NHTSA's Web Site

Frontal star rating based on risk of head and chest injury		Side star rating based on risk of chest injury		Rollover rating	
Driver	Passenger	Front seat	Rear seat	2 wheel drive	4 wheel drive
★★★★	★★★★	★★★★	★★★★	★★★★	

Source: National Highway Traffic Safety Administration.

[27]NCAP rating information for vehicles prior to model year 1990 is archived and not available on the Web site. NCAP information for these vehicles has been converted into star ratings and is available to consumers upon request.

Users can get more detailed information about the vehicle's star rating by selecting a specific vehicle, as shown in figure 12.

Figure 12: Details of Frontal, Side, and Rollover Star Ratings for a Passenger Vehicle as They Appear on NHTSA's Web Site

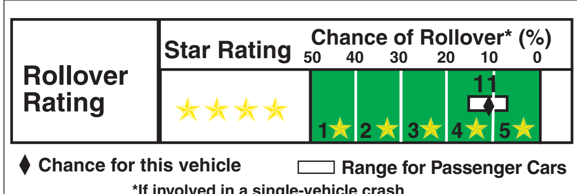
Frontal Crash

	Driver	Passenger
	★★★★★	★★★★★
Head Injury Criterion	268	214
Chest Deceleration (g's)	42	43
Femur Load l/r[1] (lbs) [1]not used in calculating frontal star rating	187/214	805/350

Side Crash

	Front seat	Rear seat
	★★★★★	★★★★
Head Injury Criterion[2] (HIC)	288	532
Thoracic Trauma Index (TTI)	52	67
Pelvis deceleration[2] (g's) [2]not used in calculating side star rating	64	57

Rollover



Chance of rollover	11%
Static stability factor	1.37
Dynamic test result	No-tip*
Drive	Front wheel drive
Tire size	P215/50R17

*imputed test result

Source: National Highway Traffic Safety Administration.

In addition to the Web site, NCAP's star ratings and a list of vehicles' safety features are available in the *Buying a Safer Car* brochure. The American

Automobile Association primarily distributes the brochure, and it is also available at NHTSA's regional offices, state highway safety offices, and libraries. For vehicle model year 2004, NHTSA published 25,000 copies of the *Buying a Safer Car* brochure. For vehicle model year 2005, NHTSA published a first printing of the brochure in December 2004. In addition, it plans to print a second brochure in spring 2005. While the 2004 edition does not have all the test results for model year 2005, it has a large number of carryover vehicles from model year 2004 plus some early 2005 tests.

Other sources of vehicle safety information that use data from NCAP crash tests include *Consumer Reports* and *The Car Book*. *Consumer Reports* takes into consideration a vehicle's performance in NHTSA NCAP tests and tests conducted by the Insurance Institute for Highway Safety (Insurance Institute) to determine an overall crash-protection rating. Instead of printing stars, *Consumer Reports* uses a circle rating scheme. *Consumer Reports* publishes this crash-protection rating, as well as individual NHTSA and Insurance Institute front and side crash test results, in its monthly magazine, in all of its newsstand-only new-car publications, and on its Web site. *Consumer Reports* magazine has about 4 million subscribers, but representatives told us they inform in excess of 13.5 million people monthly as a result of pass-along readership. The Web site has an additional 1.8 million subscribers.[28]

Published annually, *The Car Book* provides consumers with a broad range of information about new vehicles, listed alphabetically by model. Information such as fuel economy, repair costs, and front and side crash tests are included in the book. *The Car Book* takes the NCAP raw test results and converts them into a numerical rating scheme, 10 being best and 1 being worst. In addition to the information by vehicle model, *The Car Book* also presents detailed safety information based on the safety features of each car and the government's rollover ratings. Since first being published privately for the 1983 vehicle model year, *The Car Book* has sold over 1.5 million copies.[29]

[28]Visits to the *Consumer Reports* Web site include those seeking rating information on an array of consumer products, not just vehicle safety.

[29]*The Car Book* was originally a government publication. It is now produced commercially.

U.S. NCAP Differs from Other Crash Programs in Testing, Rating, Reporting, and Government Involvement

We identified four other programs that crash test vehicles and report the results to the public—the Insurance Institute for Highway Safety (Insurance Institute) program in the United States and NCAP programs in Australia, Europe, and Japan.[30] All of the programs shared the U.S. NCAP goals of providing manufacturers with an incentive to produce safer vehicles and providing consumers with comparative safety information on the vehicles they plan to purchase. We found differences in the types of tests conducted, how the crash tests were evaluated, and how the test results were shared with the public. In addition, we found that each program had varied levels of government and industry involvement.

Vehicle Testing Programs Conduct Different Tests

Each of the organizations we examined conducts a variety of frontal, side, and other tests designed to measure various elements of vehicle safety. Figure 13 shows the tests performed across the U.S. NCAP and other four programs. (See appendixes II through VIII for additional discussion on each program and the tests conducted.)

[30]The Insurance Institute for Highway Safety is a nonprofit research and communications organization in the United States funded by the auto insurance industry.

Figure 13: Vehicle Safety Tests Conducted by Five Testing Programs

Test	U.S. NCAP	Insurance Institute	Australia NCAP	Euro NCAP	Japan NCAP
Frontal crash tests					
Full frontal crash	●	○	○	○	●
Offset frontal crash	○	●	●	●	●
Side crash tests					
Angled side impact crash	●	○	○	○	○
Perpendicular side impact crash	○	●[a]	●	●	●
Pole test	○	○	●	●	○
Other vehicle safety tests					
Rollover test	●	○	○	○	○
Pedestrian test	○	○	●	●	●
Child restraint test	○	○	○	●	●

● Test performed
○ Test not performed

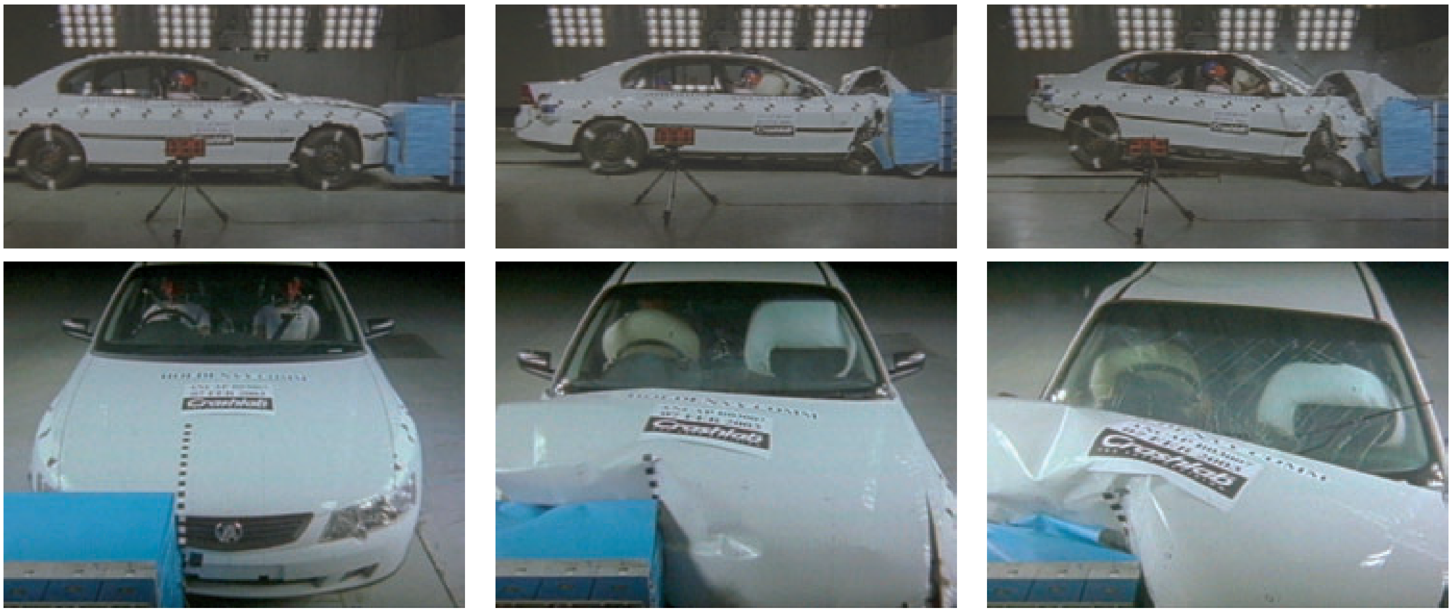
Source: GAO analysis of crash test programs.

[a]The Insurance Institute conducts a perpendicular side-impact crash test with a SUV-like barrier.

Frontal Crash Tests

The five programs we examined use two crash tests to represent frontal crashes—full frontal and offset crash tests. The U.S. and Japan NCAPs conduct full frontal tests, which involve crashing the test vehicle's entire front end into a solid barrier. The offset frontal test involves crashing the test vehicle traveling at 40 mph (64 kilometers per hour—km/h) into a deformable barrier with about 40 percent of the vehicle's overall width on the driver's side actually impacting the barrier, as shown in figure 14. All programs, except the U.S. NCAP, conduct the offset frontal test.

Figure 14: Offset Frontal Crash Test



Source: Australian NCAP, Australian Automobile Club.

Note: This test is conducted on the driver side of the vehicle, whether it is right-hand drive or left-hand drive. In the photo shown, the driver is on the right side of the vehicle.

Click the following link to watch a video of an offset frontal crash test conducted by Australia NCAP at 40 mph:
http://www.gao.gov/media/video/d05370v4.mpg

The full frontal and offset frontal tests measure different characteristics of vehicle crashworthiness. The full frontal test focuses on measuring the ability of the vehicles' restraint systems to protect the occupants. The offset frontal test assesses a vehicle's structural integrity and its ability to manage the crash energy generated from a crash entirely on one side of the vehicle. Officials from the programs using the offset test told us they believe it is more representative of real world crashes because most frontal crashes involve vehicles hitting only a portion of their front ends.

Side Crash Tests

Three types of side-impact tests are conducted among the programs we examined—the angled side test, the perpendicular side test, and the pole side test. Only the U.S. NCAP performs the angled side test.[31] All of the other testing programs conduct a perpendicular side tests. This test involves crashing a moving deformable barrier traveling at about 31 mph

(50 km/h) into a stationary vehicle at a 90 degree angle centered on the driver's seating position. Figure 15 illustrates how the perpendicular test is performed.

Figure 15: Perpendicular Side Impact Crash Test

Source: Euro NCAP.

Note: This test is conducted on the driver side of the vehicle, whether it is right-hand drive or left-hand drive. In the photo shown, the driver is on the right side of the vehicle.

Click the following link to watch a video of a perpendicular side impact crash test conducted by Euro NCAP at 31 mph:
http://www.gao.gov/media/video/d05370v5.mpg

Other differences between the side tests were the height, shape, and weight of the barriers and the crash dummies used. For example, the U.S. NCAP and the three foreign programs performed their side tests using a moving deformable barrier with a front end simulating a passenger car, while the Insurance Institute's barrier simulates the front end of a typical pickup

[31]As discussed earlier, the angled side test involves crashing a 3,015-pound moving deformable barrier traveling at 38.5 mph into a standing test vehicle.

truck or SUV. In addition, the Insurance Institute barrier weighs about 3,300 pounds (1,500 kilograms—kg) compared to 3,015 pounds (1,367 kg) for the U.S. barrier and 2,095 pounds (950 kg) for the Australian, European, and Japanese barriers. Also, the Australia, Europe, Japan, and U.S. side tests used 50th percentile adult male dummies and the Insurance Institute used 5th percentile adult female dummies.[32]

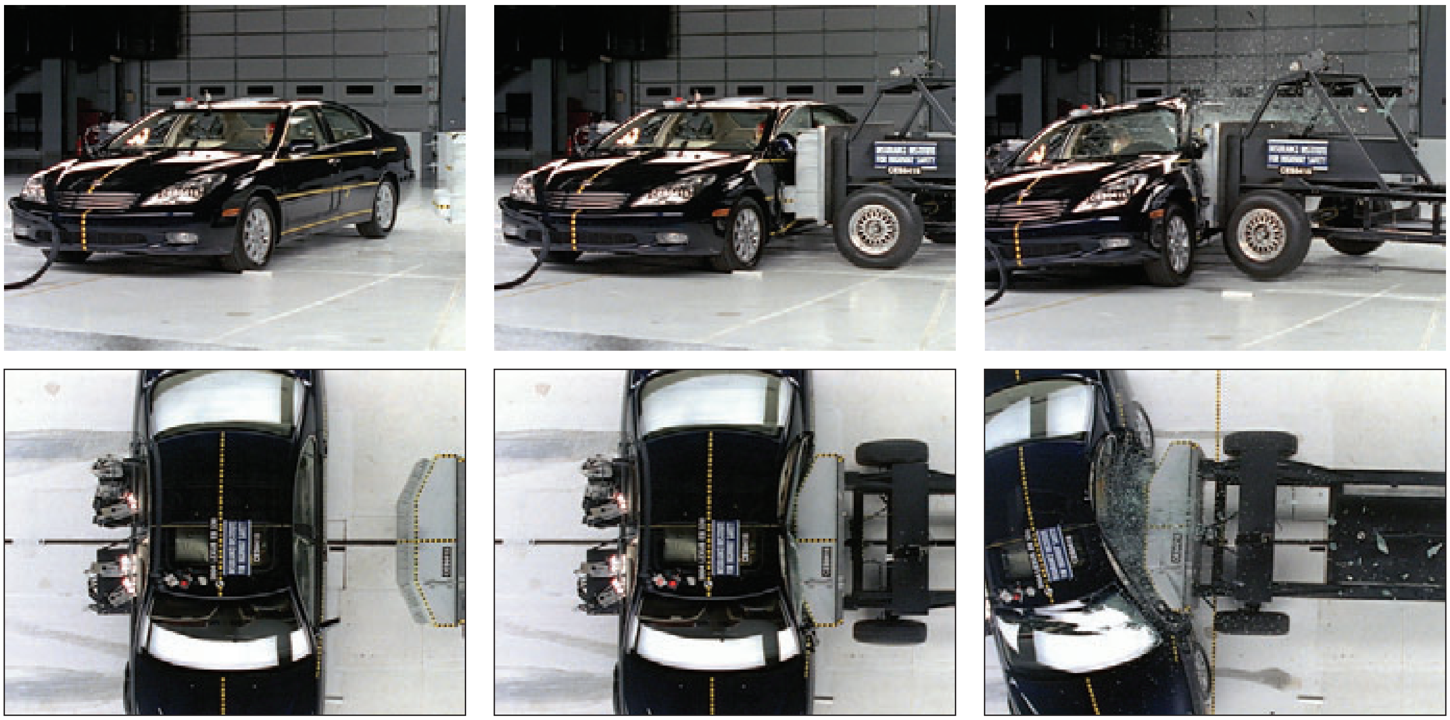
Insurance Institute officials told us they found that in serious real-world side-impact collisions, occupants' heads are often struck by intruding vehicles, especially in the side collisions involving pickup trucks or SUVs with high front hoods. As a result, in 2003 when they began their side impact test, they developed the barrier to simulate these types of vehicles, while using dummies that represented smaller occupants. They said that the test challenges the automobile industry to provide additional occupant protection specifically for the head region. Figure 16 shows the difference in the size and height of the barriers, while figure 17 shows the crash test.

Figure 16: Comparison of Barriers Used in the NCAPs' Side Test (left) and the Insurance Institute Side Test (right)

Source: Insurance Institute for Highway Safety.

[32]The 50th percentile adult male dummy represents an average-sized male, and the 5th percentile adult female dummy represents a small female or 12-year-old child.

Figure 17: Side-Impact Crash Test with SUV-like Barrier



Source: Insurance Institute for Highway Safety.

Click the following link to watch a video of a side-impact crash test with an SUV-like barrier conducted by the Insurance Institute for Highway Safety at 31 mph: http://www.gao.gov/media/video/d05370v6.mpg

The Australia NCAP and European NCAP (Euro NCAP) also include optional pole side tests. The pole side test involves a side impact to a vehicle placed on a platform and propelled at about 29 km/h (about 18 mph) into a stationary cylindrical pole. The pole test is an optional extra test, available at the manufacturer's cost. This option is only available if a vehicle has head-protecting side air bags and receives the highest score in the side-impact test. If the vehicle performs well in the pole test, the vehicle can receive a higher overall score. Officials in Europe said this test is important, for example, because in Germany over half of the serious to fatal highway injuries occur when a vehicle crashes into a pole or a tree. The test is designed to encourage auto manufacturers to equip vehicles with head protection devices. Officials in Australia stated they are considering replacing the perpendicular side test with a pole side test to better test the increasing number of SUVs on their roadways. They said that SUVs are higher off the ground and heavier than most passenger cars. As a result, SUVs would always score higher under the current side-impact test because the barrier often impacts below the hip point on the dummy and would register little injury data. The pole test will impact all vehicles, including SUVs, the same way regardless of height and weight. NHTSA officials told us that while they have no plans at this time to include this test in NCAP, they plan to investigate revisions to the side NCAP once the pole test requirements for the Federal Motor Vehicle Safety Standards are resolved and finalized.[33] Figure 18 illustrates how the pole test is performed.

Figure 18: Side Pole Crash Test

Source: Euro NCAP.

Note: This test is conducted on the driver side of the vehicle, whether it is right-hand drive or left-hand drive. In the photo shown, the driver is on the left side of the vehicle.

Click the following link to watch a video of a side pole crash test conducted by Euro NCAP at about 18mph: http://www.gao.gov/media/video/d05370v7.mpg

[33]NHTSA has proposed a regulatory revision to its Federal Motor Vehicle Safety Standard 214, in which vehicles would have to meet additional performance criteria of a pole side test involving a vehicle traveling at 20 mph into a rigid pole at a 75 degree angle.

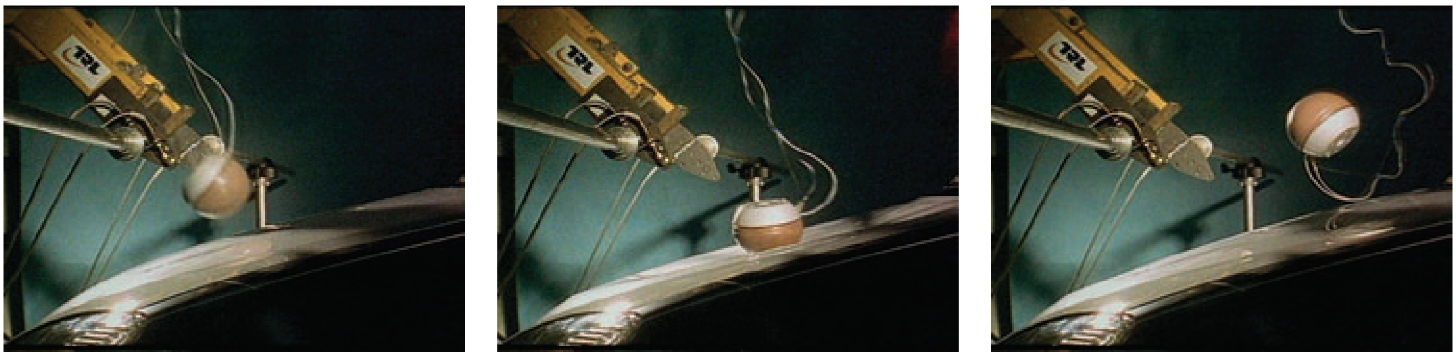
Other Safety Tests

In addition to the frontal and side crash tests, other safety tests are conducted in the various programs. These include vehicle rollover, pedestrian protection, and child restraint tests. The U.S. NCAP is the only program to conduct a vehicle rollover test.[34] Officials of the other NCAPs told us they do not conduct this test because rollover has not been a major problem in their countries due to their smaller-sized vehicle fleet. However, Australian NCAP officials told us they have noted a growth in the size of their vehicle fleets, and they will be evaluating the usefulness of adding a rollover test to their programs.

The NCAPs in Australia, Europe, and Japan also conduct pedestrian tests, which are used to assess the risk to pedestrians if struck by the front of a car. The pedestrian test involves projecting adult and child-sized dummy parts (such as heads) at specified areas of the front of a vehicle to replicate a car-to-pedestrian collision. Officials in these programs said they included this test because pedestrian fatalities in some of their countries were quite high. For example, in 2003 pedestrians accounted for nearly 30 percent of the annual traffic fatalities in Japan, 20 percent in Europe (nearly 30 percent in the United Kingdom alone), and 14 percent in Australia. In contrast, in the United States, approximately 5,000 pedestrians were killed in motor vehicle crashes in 2003, accounting for 13 percent of the annual traffic fatalities. Figure 19 illustrates how the pedestrian protection test is performed.

[34]As discussed earlier, NHTSA's rollover test evaluates vehicles' rollover resistance using a Static Stability Factor calculation and a dynamic test simulating a high-speed collision avoidance maneuver.

Figure 19: Head Form into Hood for the Pedestrian Test



Source: Euro NCAP.

Click the following link to watch a video of a pedestrian test, where a head form is propelled into a vehicle hood, conducted by Euro NCAP: http://www.gao.gov/media/video/d05370v8.mpg

The NCAPs in Europe and Japan also conduct child restraint tests to evaluate child protection, although these tests are not directly related to crashworthiness. In Europe, two different child-size dummies are placed in child seats of the auto manufacturer's choice during the frontal and side crash tests, as shown in figure 20. In Japan, two child-size dummies are placed in child seats installed in the rear passenger seats of a test vehicle that has been stripped down to its body frame. The test vehicle is placed on a sled and subjected to a shock identical to the test speed used in the full frontal crash test. Japan NCAP also separately assesses the ease of correctly using child seats. NHTSA officials told us that the U.S. NCAP is conducting a pilot test to determine whether or not the addition of child safety seats into the frontal NCAP would provide meaningful consumer information. NHTSA also provides ratings on child safety seat ease of use.

Figure 20: Child Restraint Test

Source: Euro NCAP.

Vehicle Testing Programs Rate Safety Differently

Each vehicle testing organization used crash dummy readings as a principal part of its rating process.[35] However, we found some differences in other aspects of the organizations' rating processes. For example, all programs except NHTSA supplement the dummy measures with inspector observations or measurements of the post-crash vehicles. In addition, in Europe and Australia, rating scores can be modified depending on the existence or absence of certain safety features. Further, each program except the Insurance Institute uses stars to convey the test results, and some programs combine individual ratings into summary ratings in an effort to make it easier for the public to understand crash test results.

Organizations Use Different Body Region Measurements and Types of Dummies to Develop Ratings

The four organizations we reviewed used more dummy measures in calculating a vehicle's safety rating than U.S. NCAP. The U.S. NCAP uses head and chest crash dummy readings in frontal crashes and chest and lower spine readings for side crashes, then converts them to a probability

[35]Appendixes IV through VII provide details on each country's approach to vehicle ratings.

for serious injury, which in turn is converted into a star rating.[36] NHTSA officials said they use these measures because they are the most important indicators of serious or fatal injury in frontal and side crashes.[37] In addition to the U.S. NCAP measures, the Insurance Institute uses measurements of the neck, left leg and foot, and right leg and foot for its frontal crash analysis and measurements of the head, neck, pelvis, and left leg for its side crash analysis. Australia and Euro NCAP use the neck, knee, femur, pelvis, and leg and foot for frontal tests and head, abdomen, and pelvis for side tests. Japan uses neck, femur, and tibia measurements for its frontal crash analysis and head, abdomen, and pelvis measurements for its side crash analysis. The other organizations use some of these additional measures to capture what in some cases may not necessarily be life-threatening injuries, such as those to the victim's legs. As discussed earlier, the U.S. NCAP measures the impact of crashes on many of the same body regions but does not use them to calculate safety ratings.

In addition to differences in the body areas being measured, some programs use different dummies in their side-impact tests. For the frontal tests, the U.S. NCAP and other organizations use dummies that represent an average-size adult male who is 5 feet 9 inches tall and weighs about 170 pounds. While this size dummy is used by most programs for the side-impact tests, there are differences in the dummy types and the instrumentation it contains.[38] In addition, in its side-impact tests, the Insurance Institute uses a smaller female dummy (about 5 feet tall and weighing about 110 pounds). Insurance Institute officials said they chose this dummy because there is evidence that females are more at risk in side collisions. It hopes this test will encourage manufacturers to install side curtain air bags that are designed to extend low enough to protect smaller passengers. Although NHTSA's proposed changes to the Federal Motor Vehicle Safety Standards would add a side-impact pole test using the average-size male and the smaller female dummies, NHTSA officials said that at this time they have no plans to alter the sizes or types of crash

[36]For the side crashes, dummy readings of the chest and lower spine are used to compute the Thoracic Trauma Index, which is used to determine the star rating.

[37]In the proposed change to the Federal Motor Vehicle Safety Standards side impact test, the new pole test would evaluate protection to front seat occupants against head, thoracic, and pelvic injuries. This would be the first time that head injury criteria would need to be met under the side standards.

[38]For the side impact tests, the U.S. NCAP uses the SID-H3 dummy, Australia and Euro NCAPs use the EuroSID-II dummy, and Japan's NCAP uses the EuroSID-1.

dummies they use but plan to investigate revisions to the side NCAP once the pole test requirements for the safety standards are resolved and finalized.

Using Inspector Observations to Supplement Dummy Results

Another distinction between the U.S. program and other programs is the use of observations to modify test results. All programs except the U.S. NCAP observe or measure changes to various parts of the occupant compartment after the frontal crash test to identify potential safety concerns. For example, the Euro NCAP measures the intrusion of the steering column and lower leg area into the occupant compartment. Euro NCAP officials noted that while an intrusion may not have affected the dummy in the test, the potential for serious injury to vehicle occupants in real-world crashes causes them to lower the safety rating. Japan's NCAP also measures intrusion into the passenger compartment, but rather than relying on observation, Japan has established fixed measures that if exceeded will result in a lower score in a particular area.

The U.S. NCAP does not use observations to modify test scores. According to a NHTSA official, these observations add subjectivity to the rating assessments and are not based on criteria that can be repeated and substantiated. Many of the automobile manufacturers we contacted stated that using observations adds a subjective element to the test that is difficult for them to replicate. Additionally, some pointed out that in some cases different inspectors could reach different conclusions.

Using a Modifier System to Adjust Scores

Another basic difference in scoring vehicles is the use of a modifier system in Europe and Australia. This system adjusts the score generated from the dummy injury data where injuries to occupants can be expected to be worse than indicated by the dummy readings or the vehicle deformation data alone. For example, a frontal test modifier might result in points being deducted if the dummy's head hit the steering wheel in a vehicle without an air bag.

The system in Europe and Australia also adjusts points based on the existence or absence of various safety features on the test vehicles. For example, a test vehicle can get extra points if it has a safety belt reminder system that meets their NCAP specifications. Officials said they use this approach to encourage manufactures to install new safety features sooner than might otherwise occur.

Officials from several organizations and automobile manufacturers operating under the Europe and Australia programs expressed concerns that some of the modifiers might not have a direct impact on occupant safety and could artificially increase scores. They noted, for example, that in some countries safety belt usage exceeds 90 percent and that giving extra points for a feature to encourage safety belt use may not really add to safety. In addition, some automobile manufacturers identified concerns with how items included in the modifier system are developed and measured. They said that in some cases they have received just 6 months notice of changes. They said that such changes can be expensive and that they need to be notified sooner, so they have time to make changes to comply with new measures.

Use of Stars as a Measure of Safety

Except for the Insurance Institute, all programs used stars to convey test results. Officials from the NCAPs noted that star ratings are well understood by the public. For example, NHTSA officials said they used focus groups in 1993 to examine various options to communicate crash test results to the public, and the five-star rating was found preferable. In addition, officials in the other programs told us they followed the U.S. NCAP's use of star ratings. None of the programs has plans to change its rating measures.

There have been some concerns expressed about the use of stars. For example, a 1996 study by the National Academy of Sciences noted that stars are inherently positive symbols and the public may not understand the distinctions between the different levels of stars.[39] In addition, officials of a consumer group noted that most people would associate the star rating with hotels and that staying in a three-star hotel would be quite acceptable to most people. In discussing its use of Good, Acceptable, Marginal, and Poor, the Insurance Institute said it considered these types of qualitative measures as being clearer to the general public.

Developing Summary Ratings

Australia, Europe, and Japan NCAPs provide summary ratings, while the U.S. NCAP provides only individual ratings for each seating position that is included in the test for the frontal and side crash tests. For example, Australia and Euro NCAPs provide overall ratings that combine the frontal and side crash tests. Japan's NCAP combines frontal and side crash tests to provide overall ratings for the driver and passenger of a vehicle. Australian and European officials explained that they believed potential vehicle purchasers can be confused by the large amount of detail available on the

[39] *Shopping for Safety: Providing Consumer Automotive Safety Information*, Special Report 248, Transportation Research Board, National Research Council.

test results and that summarizing results makes the ratings more useful. They noted they make the actual injury readings available for those interested in that level of detail. In addition, while the Insurance Institute does not combine individual ratings, it does identify “Best Pick – Frontal” and “Best Pick – Side” to assist consumers. Similarly, officials with publications like *Consumer Reports* and *The Car Book* told us they have found it helpful to provide consumers with summarized rating information. NHTSA officials noted that overall or summary ratings might hide or mask deficiencies in some areas of the tests. For example, they said that if a vehicle were to get a very high frontal rating and a very low side rating, merging the results could give consumers a misleading impression of the overall safety of that vehicle.

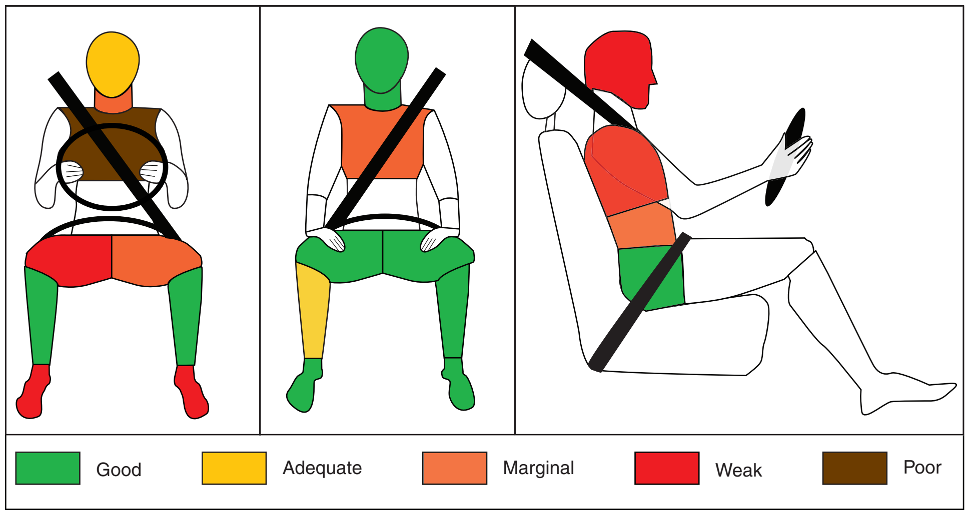
Programs Used a Variety Approaches to Inform Consumers of Safety Results

The crash testing programs we examined used a variety of approaches to share safety results with the public. Across all the programs, the Internet was the most relied-upon source for getting information to consumers, with each organization providing details of its test results. Safety pamphlets were used by all programs to supplement the safety information presented on their Web sites. Some programs also work with the news media to increase awareness of test results.

Internet Used to Convey Results

Each organization made the results of its testing program available to the public on the Internet. In general, the public can access the results of individual tests, including the actual numeric dummy readings. To help the public understand these results, each Web site uses charts, tables, and graphics. For example, in addition to providing star ratings, the Euro NCAP also uses color-coded dummy injury diagrams to display how the specific body regions perform in the frontal, side, pole, and pedestrian tests. The color-coded indicators are: Good (Green), Adequate (Yellow), Marginal (Orange), Weak (Red), and Poor (Brown). The color used is based on the points awarded for that body region, as shown in figure 21.

Figure 21: Dummy Injury Diagrams of Driver and Passenger in Frontal Test and Driver in Side Test



Source: Euro NCAP.

Publications Used to Share Test Results

Each testing organization publishes the results of its testing programs. The U.S. NCAP publishes the *Buying a Safer Car* booklet, which provides new and carryover crash test ratings. The Insurance Institute publishes a *Status Report* newsletter about 10 times a year, which contains new crash test ratings as well as other highway safety information. It can be obtained in hard copy through subscription, as well as downloaded from the Insurance Institute's Web site. Australia publishes a *Crash Test Update* brochure twice a year, which provides new crash test results. According to Euro NCAP officials, Euro NCAP divides its tests into two test phases and releases the results twice a year—in November and June. The results are also published by *What Car?* (a British car magazine), *Which? Car* (a magazine owned and produced by British consumer associations), and the General German Automobile Association (ADAC) magazine. Other consumer magazines in Europe also provide crash test information. Lastly, Japan annually publishes the *Choosing a Safer Car* booklet, which provides new and carryover crash test results. The Japan NCAP also publishes summary brochures of test results.

Working with the News Media to Share Test Results

Like the U.S. NCAP, the Insurance Institute and the Australia and Euro NCAPs worked with the news media to inform consumers about the results of the vehicle safety tests. For example, each program issued press releases to convey the results of safety research and crash tests. In addition, the

Insurance Institute has worked with television broadcasts, such as the prime time news magazine program *Dateline NBC*, to raise the public's awareness of how vehicles perform in the program's crash tests. Insurance Institute officials grant interviews explaining the results of the tests and use broadcast-quality film and lighting to record the crash tests and make them available for television broadcasts. According to Japan NCAP officials, they work with television shows to help produce news segments that highlight changes in test procedures and recent test results. Further, according to Euro NCAP officials, in addition to other activities, Europe promotes consumer education by using crashed vehicles as public displays in prominent places in Europe during press conferences. The events are designed to attract news media and public attention in an attempt to increase public interest in and knowledge about car safety.

Government and Industry Involvement Varies among the Crash Testing Programs

The level of government and industry involvement varies among the crash test programs. For example, the U.S. NCAP, which is operated and funded solely by the U.S. DOT, has traditionally based its U.S. NCAP on the Federal Motor Vehicle Safety Standards as a matter of agency policy and follows an informal rulemaking process where industry and other interested parties can submit comments once NHTSA issues a notice of proposed rulemaking. The Insurance Institute, which is funded by private insurance companies, has no such process and can make an internal decision to modify tests at any time. For example, according to Insurance Institute officials, when they began their side-impact tests, they developed a crash test barrier to represent the risk of severe head injuries in side impacts by SUVs and pickups. The Insurance Institute officials said they did not involve automobile manufacturers in the decision-making process but informed them as well as NHTSA before implementing the change.

The Australian NCAP was developed and is dominated mainly by private motor clubs but includes government transportation departments in six Australian states and territories, the New Zealand government, and consumer groups. The national Australian government sets minimum safety standards for vehicles but is not involved in funding or managing NCAP. Similarly, the Euro NCAP is sponsored by the governments of Great Britain, Sweden, Germany, France, and the Netherlands, as well as a number of motor clubs and consumer organizations. According to Euro NCAP officials, each sponsoring member agrees to perform or sponsor a number of crash tests and participates in making the decisions related to the program. In Australia and Europe, NCAP officials told us that by not being exclusively controlled by government, they have flexibility when modifying their programs. They said that as a result they can make changes quicker because they do not have to follow governmental procedures.

According to NCAP officials, the decision processes for Australia and Europe involve the use of committees and working groups to examine issues and make recommendations for change. The automobile industry and public safety organizations may be involved in providing research or opinions, but the committees are free to make decisions they believe are appropriate. When these committees make recommendations, the full governing body votes to accept or reject the changes. The government partners have a vote in the process but cannot veto the result. In Australia, according to NCAP and government officials, automobile manufacturers were initially reluctant to engage in meaningful dialogue with the officials of the Australia NCAP. However, more recently, Australia NCAP officials have consulted with manufacturers prior to making changes in the program and have received positive responses. On the other hand, the Euro NCAP allows industry representatives to participate in the discussions of the subgroups of its two technical working groups—primary safety and secondary safety.[40] Also, the technical working groups and automobile manufacturers engage in direct dialogue in industry liaison meetings.

According to NCAP officials, Japan's NCAP is funded by the government but administered by an independent, government-appointed committee. The committee includes members who are experts from automobile research institutes, academics, journalists, and representatives of the Japanese automobile industry and the automobile importers association. This government/industry committee manages the program and must approve changes submitted by program officials. The committee reaches its decisions through consensus. Although the government ministry that oversees the program may override the committee's decisions, this has never occurred.

[40]Primary safety includes vehicle safety features designed to help vehicles avoid crashes. Secondary safety includes vehicle safety features designed to help minimize the risk of injury for vehicle occupants involved in crashes.

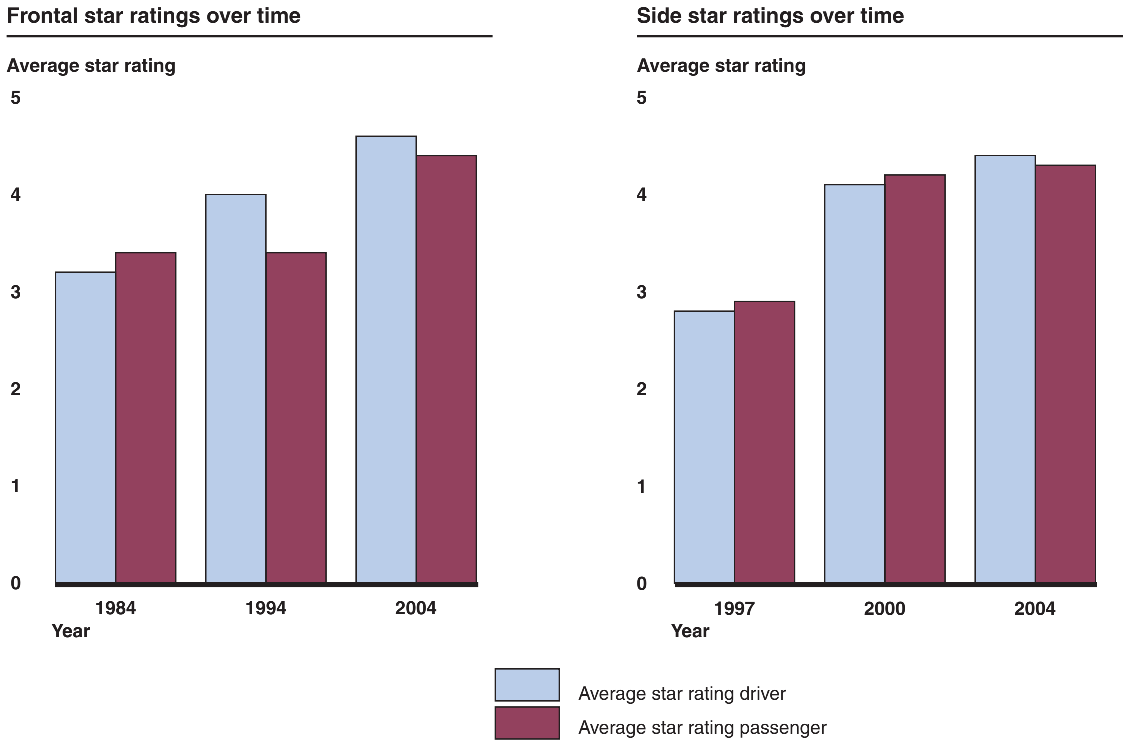
NCAP Has Contributed to Making Vehicles Safer, but Changes are Needed to Maintain Its Relevance

NCAP has been successful in encouraging manufacturers to produce safer vehicles and providing consumers with comparative safety information. However, the program is at a crossroads where it will need to change to maintain its relevance. The usefulness of the current tests has been eroded by changes in the vehicle fleet that have occurred since the program began. Today there are many more large pickups, minivans, and SUVs than existed 27 years ago and new safety hazards have resulted from the incompatibility between large and small vehicles and rollover crashes, which are not fully addressed by current NCAP tests. In addition, because most vehicles now receive four- or five-star ratings, the NCAP tests provide little incentive for automakers to continue to improve vehicle safety and little differentiation among vehicle ratings for consumers. Lastly, NHTSA is upgrading its frontal and side crash tests in the Federal Motor Vehicle Safety Standards, which will make current NCAP tests less meaningful. Opportunities to enhance the program include developing approaches to better measure the effects of crashes between large and small vehicles and occupant protection in rollovers, rating technologies that help prevent crashes from occurring, and using different measures to rate the crash results. NHTSA also has opportunities to enhance the presentation and timeliness of information provided to consumers.

NCAP Has Encouraged Improvement in Vehicle Safety and Provided the Public with Vehicle Safety Information

NCAP testing has contributed to more crashworthy passenger vehicles and NHTSA has informed the public of test results. As shown in figure 22, there has been a substantial increase in the average star rating of vehicles since testing began. In 2004, tested vehicles averaged about 4.6 stars for the driver in frontal crash tests, about 4.4 stars for the passenger in frontal crash tests, about 4.4 stars for the driver in side crash tests, and about 4.3 stars for the rear passenger in side crash tests.

Figure 22: Improvement of Average Star Ratings for Frontal and Side NCAP Tests



Source: GAO analysis of historical NCAP data provided by NHTSA.

Note: Data include only the vehicles that were crash tested for each model year.

The improved ratings indicate that manufacturers have taken NCAP seriously and designed and built vehicles that do well on NCAP tests. Automakers told us that vehicle safety and NCAP test results have become an important marketing tool. As a result, many auto manufacturers advertise five-star ratings in government crash tests in their television, radio, and print ads.

NHTSA has informed the public of the NCAP test results through its Web site and by publishing a safety brochure. In addition, according to NHTSA officials, the NCAP Web site has been redesigned in an effort to make it more user-friendly. More importantly, NCAP crash test results are used by popular publications that influence large segments of the car-buying public. Both *Consumer Reports* and *The Car Book* use NCAP test results as part of their vehicle safety ratings.

Without Change, NCAP's Relevance Will Likely Diminish

While NCAP has been successful in encouraging manufacturers to make safer vehicles, it will need to change to remain relevant. There have been significant changes in the makeup of the nation's vehicle fleet, a growing similarity of crash test ratings, and upgrades in the safety standard tests for frontal and side crashworthiness. Without addressing these changes, NCAP provides little incentive to manufacturers to continue to improve safety and may provide consumers with only limited comparative information on vehicle safety.

Since NHTSA began NCAP testing in 1979, there have been dramatic changes in the vehicle fleet. Vehicles such as pickups, minivans, and SUVs have transformed the fleet once dominated by passenger cars. There are now more than 85 million pickups, minivans, and SUVs on the road, representing about 37 percent of the vehicle fleet. The change in vehicle fleet presents new safety challenges that NCAP's testing does not fully address—vehicle incompatibility and rollover. The issue of incompatibility emerges when a large vehicle such as a pickup, minivan, or SUV crashes into a smaller, lighter vehicle because the larger vehicle can inflict serious damage that is particularly dangerous to the occupants of the smaller vehicle. The current NCAP frontal and side tests do not account for vehicles of different size, weight, and geometry crashing into one another. Significant differences in ratings can result when tests are designed to address these vehicle differences, as evidenced by comparing the Insurance Institute side test results with NCAP results. The Insurance Institute, which uses a higher SUV-like barrier, gave 27 vehicles its lowest rating (Poor) in side-impact tests, primarily because there were no side air bags in the vehicle. NHTSA, which uses a low barrier and, unlike the Insurance Institute, does not include head measures in its star calculations, gave 21 of these same 27 vehicles (77 percent) four- or five-star safety ratings. Also, with the increase in pickups, minivans, and SUVs in the nation's fleet, vehicle rollover has become a more important issue; in 2003, rollovers accounted for over 10,000 fatalities, or more than 30 percent of all passenger vehicle occupant fatalities. However, the NCAP rollover test only measures the likelihood that a vehicle will roll over and does not assess the safety afforded to occupants should a rollover occur.

NCAP frontal and side crash test results have improved to a point where there is little difference among most vehicles' ratings. In 2004, NHTSA provided the public with NCAP rating information for 234 vehicles.[41] Most of these vehicle ratings were four or five stars for drivers and passengers in frontal and side crash tests, as shown in figure 23.

Figure 23: Frequency of Four- and Five-Star Ratings for Frontal and Side Crash Tests in 2004

Source: GAO analysis of 2004 NCAP data available on NHTSA's Web site.

Note: For the driver and front passenger in the frontal test, star ratings were available for 234 vehicles in 2004. For the driver in the side test, star ratings were available for 210 vehicles in 2004. For the rear passenger driver's side, in the side test, star ratings were available for 186 vehicles in 2004.

The vehicles crash tested more recently have done even better. Of the 49 frontal and 18 side crash tests conducted in 2004, over 95 percent received a four- or five-star rating. As a result, NCAP's ability to challenge auto manufacturers to continue improving vehicle safety has eroded. Also, with almost all scores being about the same, consumers do not have

[41]This includes carryover vehicles and corporate twins. Carryover vehicles are those that have been tested under NCAP in previous years and whose design and safety rating has not changed. Corporate twins are two vehicles that are built on the same chassis, share most of their underhood and interior components, and have the same air bag and safety belt interaction but are sold under different brand names.

comparative safety information that differentiates significantly among vehicles.

Lastly, NHTSA is upgrading the frontal and side tests under the Federal Motor Vehicle Safety Standards, which make current NCAP testing less meaningful.[42] For frontal tests, safety standards will require that for vehicles built after September 1, 2007, manufacturers must certify the crashworthiness of their vehicles at 35 mph (instead of the current 30 mph).[43] This change will eliminate the speed difference between the frontal NCAP and the frontal belted safety standard tests. Because of this change, NHTSA has begun to examine alternatives to its current frontal crash test program and hopes to finalize any changes to the NCAP frontal test in 2006. Similarly, NHTSA announced in May 2004 that it is proposing to add a 20 mph side pole crash test to the Federal Motor Vehicle Safety Standards. This test will use a more technically advanced average-size male dummy than is currently used in the NCAP tests and a dummy that represents a small female. According to NHTSA officials, the new test and advanced dummy will enable them to confidently measure compliance with head injury standards and challenge automakers to provide adequate head protection to vehicle occupants in side impact crashes. However, neither this test nor the new dummies are currently part of NCAP. NHTSA officials said they plan to begin examining alternatives to the side crash test at the end of 2005.

Opportunities to Enhance NCAP Testing

NHTSA could explore several opportunities to enhance NCAP and ensure its relevance. These opportunities include (1) addressing changes to the vehicle fleet, particularly as it relates to vehicle incompatibility and rollover; (2) developing approaches for NCAP to encourage improved safety from emerging technology that helps drivers avoid crashes; and (3) examining the various testing procedures and measures that are available and in use by other organizations and determining their applicability to NCAP.

[42]NHTSA made these changes in recognition of the need to upgrade the level of safety in frontal crashes in the regulations and to reflect specific fatality risks in side crashes in the regulations.

[43]The higher test speed will be phased in for increasing percentages of vehicles over 3 years.

Addressing the Increased Fatality Risks Created by Changes in the Vehicle Fleet

Vehicle Incompatibility

When pickups, minivans, and SUVs collide with smaller passenger cars, the mismatch of the vehicles' weight, height, and geometry are considerable, as shown in figure 24. In terms of the weight differences, subcompact cars may weigh as little as 1,500 pounds while the large SUV may exceed 6,000 pounds.

Figure 24: Example of Height Mismatch Between Vehicles of Different Type and Weight

Source: National Highway Traffic Safety Administration.

Because of the higher ground clearance of large pickups and SUVs, their bumpers may skip over the crash structures of passenger cars, raising the likelihood that an occupant of the car will be killed or seriously injured.[44] A

[44]This is called self protection and partner protection. While the occupants of a large vehicle might be protected in a crash, occupants of a smaller vehicle, the partner in a vehicle-to-vehicle crash, would have less protection.

2003 NHTSA study found that in frontal collisions involving a car and a light truck or van, there were almost four times the number of fatalities in the car than in the light truck or van.[45] The success of NCAP and the other testing programs may have indirectly contributed to this problem. According to some experts, to improve crashworthiness scores of large vehicles, vehicle manufacturers have increased the rigidity of the structure that absorbs and manages the substantial forces in the crash tests.[46] As a result, the structure of large vehicles has had to become more substantial and stiffer than that of smaller vehicles because the larger vehicles must absorb more energy in the crash test due to their greater weight.

NHTSA's NCAP frontal tests could potentially be modified to measure and rate vehicle incompatibility. Some experts, NHTSA officials, and vehicle manufacturers told us that there are a number of approaches being investigated that could help to address vehicle incompatibility. For example, some researchers are examining the use of sensors in test walls; crashing a moving deformable barrier into the front of the test vehicles, instead of propelling the test vehicle into a solid wall; or crashing test vehicles into a solid wall at varying speeds, depending on the size of the vehicle, to equate the crash to hitting a standardized vehicle. The hypothesis is that information obtained by measuring how vehicles strike the crash test barrier could be used to estimate the relative damage that a vehicle would cause in collisions with another vehicle and could be used to rate the aggressiveness of vehicles. Using a moving barrier for frontal crash tests would make test results comparable across weight classes, as is the case with the current side-impact rating, because all vehicles would be struck by the same size barrier. Using variable speeds based on vehicle weight would also allow ratings of small and large vehicles to be compared. Each of these alternatives requires further development and testing to assess the overall safety implications, including the potential for reducing fatalities in passenger cars when struck by larger vehicles, the potential for diminished occupant protection for large vehicles in single vehicle crashes,

[45]*Initiatives to Address Vehicle Compatibility*, NHTSA, June 2003.

[46]According to a safety expert, automobile manufacturers have generally opted to increase the strength and stiffness of the front of their vehicles within the original vehicle design rather than adding additional length to the front of vehicles which could be used to reduce the impact on the vehicle struck.

and consideration of potential costs.[47] Ratings based on these tests could provide manufacturers with incentives to address incompatibilities between large and small vehicles and provide consumers with information on the potential safety hazards associated with vehicle incompatibility.

The problem of vehicle incompatibility is even worse in side crashes. When a large vehicle like an SUV crashes into the side of a small vehicle, the larger vehicle may miss the door sill of the vehicle, causing most of the energy to be directed to the door and window areas, as shown in figure 25. In such cases, the injuries can be exacerbated when there is no side head protection, leaving the window as the only barrier between the occupant's head and the impacting vehicle. Head injuries are a major cause of fatalities in side collisions, particularly in crashes where a single vehicle strikes a tree or utility pole and in intersection crashes where smaller, lighter vehicles are hit in the side by larger, heavier vehicles. NHTSA has estimated that in serious side-impact crashes involving one or more fatalities in 2002, nearly 60 percent of those killed suffered brain injuries.

Figure 25: Example of the Damage Caused by an SUV Striking the Side of a Small Vehicle

Source: GAO photo of Insurance Institute test vehicles.

[47]According to NHTSA officials, in such tests, larger vehicles could experience a lower change in velocity than smaller vehicles, potentially leading manufacturers to incorporate softer structures that would not absorb as much energy when these vehicles are in single vehicle crashes.

There are also possibilities for modifying the NCAP side test to help address vehicle incompatibility. For example, NHTSA could examine the barrier that is being used to ensure that it best represents today's vehicles. NHTSA's current side-impact barrier is about the size and weight of a compact car. As a result, when this barrier hits the test vehicle, it will almost always hit the bottom sill of the door, which is designed to manage much of the crash energy.[48] To address the disparity in height between passenger cars and SUVs, the Insurance Institute uses a side-impact test barrier that is larger and higher than NCAP's barrier, as shown in figure 26. According to Insurance Institute officials, they designed this barrier to represent an SUV so their test could more accurately reflect the increased risk for occupants in smaller vehicles. They said that it has encouraged manufacturers to install side curtain air bags. Using this higher barrier has resulted in different scores than NHTSA's NCAP. For example, the Insurance Institute has given 27 vehicles its lowest rating (Poor) in side-impact tests, while NHTSA, which uses a low barrier and does not include head measures in its star calculations, gave 21 of these 27 vehicles (77 percent) four- or five-star safety ratings.

Figure 26: Example of Head Movement during the Insurance Institute Test with the SUV-like Barrier

Source: Insurance Institute for Highway Safety.

Click the following link to watch a video of an interior view of the side impact crash test with an SUV-like barrier conducted by the Insurance Institute for Highway Safety at 31 mph:
http://www.gao.gov/media/video/d05370v9.mpg

[48]NHTSA officials said they are addressing this issue by proposing a change to the Federal Motor Vehicle Safety Standards that would require a 20 mph oblique side pole test.

Officials from a number of automobile makers told us that vehicle compatibility is an important safety issue, and they are working to enhance occupant protection in front and side crashes, outside of NHTSA safety standards or NCAP testing. Several automakers voluntarily entered into an agreement with the Insurance Institute to work collaboratively to have all of their vehicles meet new safety criteria that require large vehicles to match the height of the fronts of small vehicles by September 2009, as shown in figure 27. According to Alliance of Automobile Manufacturers members, better matching of structural components may enhance the ability to absorb crash forces, thereby reducing occupant fatalities by an estimated 16 to 28 percent. The agreement also specified that by September 1, 2007, at least 50 percent of these automakers' vehicles offered in the United States will meet enhanced side-impact protection with features such as side air bags, air curtain bags, and revised side-impact structures. By September 2009 all vehicles of these manufacturers are to meet the new side criteria.

In commenting on a draft of this report, NHTSA officials noted that in order for 50 percent of the vehicles to meet the voluntary side requirements by September 1, 2007, manufacturers can certify by using either the existing Federal Motor Vehicle Safety Standard pole test or the Insurance Institutes side impact test. They noted that in September 2009, the pole test will no longer be an option and that, therefore, it is very possible that large vehicles, such as pickups, minivans, and SUVs, would be able to pass the test without incorporation of enhanced side-impact features such as side air bags or curtains for the following reasons:

- Manufacturers may not need to subject large vehicles to the pole test by September 1, 2007, if 50 percent of its fleet is comprised of smaller passenger cars.

- Larger vehicles will sustain a lower velocity change than smaller vehicles when struck by the Insurance Institute barrier.

- The higher ride height of large vehicles could keep the dummy's head from striking the top of the Insurance Institute barrier.

Figure 27: Example of Improved Matching of Frontal Vehicle Structures

Source: National Highway Traffic Safety Administration.

Occupant Protection in Rollover Crashes

Given the changes in the vehicle fleet, fatalities due to rollover crashes have continued to increase. Rollovers are dangerous incidents and have a higher fatality rate than other kinds of crashes. Just over 2 percent of all police-reported crashes that occurred in 2003 were rollovers, but they accounted for over 10,000 highway fatalities, or more than 30 percent of all passenger vehicle occupant deaths. All types of vehicles can roll over. However, taller, narrower vehicles such as pickups, minivans, and SUVs have higher centers of gravity and thus are more susceptible to roll over if involved in a single-vehicle crash. NHTSA reported that 61 percent of fatalities in SUVs and 45 percent of fatalities in pickups in 2002 were the results of rollover crashes.[49] NCAP's rollover testing does not rate the chance of a potentially life-threatening injury should a rollover crash occur; it only measures the risk of rollover.

[49]By contrast, 22 percent of those who died in passenger cars in 2002 were killed in rollover crashes.

Although NHTSA has not incorporated occupant protection in rollovers into NCAP, officials said they have been examining occupant protection in rollover crashes, focusing on reducing occupant ejection and increasing roof strength through regulation. According to NHTSA officials, the most deadly rollovers occur when unbelted occupants are completely ejected from the vehicle though doors, windows, and sun roofs and when the roof crushes into the occupant compartment, causing serious, if not deadly, head, neck, and spinal cord injuries. NHTSA has proposed changes to the Federal Motor Vehicle Safety Standards that would upgrade the door lock requirements to help prevent vehicle occupant ejection and increase roof strength. They are also considering other ways to prevent ejection, specifically looking at the potential of side curtain air bags to prevent ejection through vehicle windows.

NHTSA's NCAP rollover testing could be modified to better measure and rate the risks of serious injury associated with a rollover crash. NHTSA officials and others said that they have not been able to develop a repeatable crash test in which the vehicle rolls over and dummies would be used to measure injuries. However, in the absence of such a rollover crash test, NCAP could examine various aspects of the vehicle which are known to affect occupant safety in rollover, such as rating the roof strength of vehicles. For example, officials from a consumer group told us that NHTSA could conduct dynamic tests on roof strength and point to a 2002 Society of Automotive Engineers paper that attests that such drop tests for roof strength are repeatable. They also said that there has been other promising research that would measure roof crush in dynamic tests. However, including such tests in NCAP would require further development and funding considerations.

Incorporating Active Safety Technologies into NCAP

NCAP also has an opportunity to begin assessing new technology that could help prevent crashes. Vehicle manufacturers and others have been developing and testing new active safety systems that hold promise for reducing traffic fatalities by helping drivers avoid crashes altogether. These active safety systems include improving vehicle handling and braking in emergency situations, providing warning alerts for potential collisions or straying out of roadway lanes, and providing distance alerts when driving too close to another vehicle. A 2004 NHTSA study estimated that the incorporation of electronic stability control systems[50] could reduce certain

[50]Electronic stability control keeps the vehicle under control by applying brakes to individual wheels when the system detects loss of control or instability.

crashes by about 67 percent.[51] Similarly, the Insurance Institute reported that electronic stability control can reduce the risk of involvement in single vehicle crashes by more than 50 percent.[52] Some experts suggested that NCAP might be used to encourage and speed the adoption of active safety systems into the vehicle fleet.

Some elements of active safety systems are included in some current tests. While the rollover test is not designed to measure the effectiveness of electronic stability control systems, vehicles equipped with this technology would be expected to perform better in the rollover test because the vehicle would be less likely to tip up. In addition, brake tests are conducted as part of Japan's NCAP, with the results provided as a separate safety rating. The Euro NCAP has also established committees to identify potential active safety systems to include in their program, as well as the testing protocols that would be used.

While using NCAP to further test and rate active safety systems could encourage their adoption in the marketplace, there are challenges to overcome. According to NHTSA officials, NHTSA would first need to identify those active safety systems that could be effective in preventing crashes. They said this would be difficult because they would have to determine how well a system helps drivers avoid crashes. Also, determining the testing methodology would be challenging because the effectiveness of some active systems could be affected by factors such as driver behavior and the physical characteristics of the road, such as the dampness of the pavement.

Officials from various automobile manufacturers told us that they are developing many new active safety systems with the objective of helping drivers avoid crashes. They pointed out that while NCAP could be used to encourage them to market such systems, they would have concerns regarding which systems to include in NHTSA's program and how the system would be rated. In addition, they noted that because of competitive forces, active safety advances could be available sooner than NHTSA is capable of deciding to include them and developing an acceptable approach for testing and rating them. Officials from automakers said they

[51] *Preliminary Results Analyzing the Effectiveness of Electronic Stability Control (ESC) Systems*, NHTSA, September 2004.

[52] *Effects of Electronic Stability Control on Automotive Crash Risk*, C.M. Farmer, Insurance Institute for Highway Safety, 2004.

are willing to share their research and work in cooperation with NHTSA to develop tests or measurements that could help NCAP address these issues.

Using Additional Test Measures and Different Size Dummies

NHTSA could provide consumers with more safety information by using additional test measures and different crash dummies. All of the other organizations we contacted used more dummy measures to calculate vehicles' safety ratings than U.S. NCAP used. To determine the star ratings, NHTSA uses head and chest readings from the frontal NCAP test and chest and lower spine readings for side-impact tests. Other organizations use measurements that included such areas as the head, neck, chest, leg, and foot for frontal test ratings and the head, neck, chest, pelvis, and leg for side test ratings.[53]

The concern with using few dummy readings is that the safety rating might not include important safety considerations. While NHTSA uses head and chest readings for frontal ratings and chest and lower spine readings for the side ratings, it measures other items during crash tests and may identify them as "Safety Concerns" on its Web site if they exceed certain values. We identified over 140 Safety Concerns on NHTSA's Web site since vehicle model year 1990—36 of these were for vehicles that received four- or five-star ratings.[54] The Safety Concerns included high femur readings in frontal crashes, which could mean there was a high likelihood of thigh injury; high head acceleration readings in side crashes, which could indicate a high likelihood of serious head trauma; and doors opening during side crash tests, which could increase the likelihood of occupant ejection.[55] Having a Safety Concern noted for vehicles with a four- or five-star rating presents conflicting information that could be confusing to consumers.

[53]The U.S. NCAP uses head and chest crash dummy readings in frontal crashes and chest and lower spine readings for side crashes because according to NHTSA these are the most important indicators of serious or fatal injury. The Insurance Institute uses four body regions for its frontal crash analysis and three for its side crash analysis. Japan uses five body regions for its frontal crash analysis and four for its side crash analysis, while Australia and Europe use four for frontal and two for side. The other organizations use additional measures to capture what can be serious, although not necessarily life-threatening injuries such as those to the victim's legs.

[54]These Safety Concerns were taken from the several thousand vehicle ratings available on NHTSA's Web site, including carryover vehicles and corporate twins.

[55]Data collected during NCAP tests but not used to calculate star ratings are available on the NHTSA Web site. Other data, such as the results of force-of-load testing, are available on the NHTSA research Web site.

As NHTSA makes changes to its testing program, it has the opportunity to reexamine the size and type of dummies it uses in crashes in addition to the body areas of the dummies being measured. At present, NHTSA's dummies equate to an average-size adult male who is about 5 feet 9 inches tall and weighs about 170 pounds. Most of the other organizations use this size dummy in their crash tests, and vehicle manufacturers work to maximize the safety systems for an occupant with these characteristics. However, not all vehicle occupants are the same size, and optimizing the restraint system for the average male would not necessarily be optimum for others who may be smaller, shorter, taller, or heavier.[56] Also, children and the elderly may react differently to crash forces than the average-size male. Recognizing this, the Insurance Institute uses a smaller female dummy (about 5 feet tall and weighing about 110 pounds) in the driver and rear seat of the side-impact test. Insurance Institute officials said they made this change to encourage manufacturers to install side curtain air bags that would extend low enough to protect the heads of smaller passengers. In addition, in its proposed side-impact pole standards test, NHTSA specifies using a 50th percentile male and a 5th percentile female to address the issue of different size drivers and passengers.

The U.S. NCAP officials said that at this time they are waiting on the resolution to the proposed safety standard changes that would add a side pole test before deciding on altering the size or type of crash dummies they use. While generating additional information on which to base safety ratings, altering the size of the dummy in the NCAP tests could provide challenges for automobile manufacturers because they would have to conduct more internal tests. Officials from many vehicle manufacturers said they must already conduct hundreds of crash tests each year to ensure that they meet the variety of tests and dummies used in NHTSA's standards, U.S. NCAP, and tests conducted by the other testing organizations.[57]

[56]Officials from vehicle manufacturers said they are developing new restraint systems that they believe will be able to determine the weight of the occupant and will vary the safety belt restraint and air bag deployment to maximize the protection for different-sized occupants during a crash.

[57]Automakers also encouraged NHTSA to work towards consistency with other countries to lessen the burden on their testing programs. For example, they noted that an advanced side impact dummy called "World SID" has been developed and that it should be considered for use in side crash tests by all side testing programs.

Opportunities to Enhance the Presentation and Timeliness of NCAP Results

NCAP has the opportunity to enhance its program by changing the way it reports test results. Specifically, it could provide summary ratings, present information in a comparative manner, increase public awareness, and make results available earlier in the model year.

Providing Summary Ratings

According to some safety experts, NHTSA could improve its program by developing an overall safety rating rather than reporting four separate ratings for crash tests.[58] *Consumer Reports*, *The Car Book*, the Insurance Institute, and all of the other NCAPs provide more summary information for consumers than NHTSA. Further, a 1996 National Academy of Sciences study that examined NCAP recommended that NHTSA provide an overall rating to provide consumers with an overview of a vehicle's safety. However, the study also recommended that NHTSA make the detailed test results available for those consumers who wish to examine them more fully.[59]

NHTSA and Insurance Institute officials said they did not develop an overall crashworthiness rating because combining ratings are technically difficult and could obscure low ratings in one test area that would be revealed when test results are reported separately. Insurance Institute officials added that consumers can evaluate the different ratings to determine those that are most applicable to their situations. They said a person who is primarily the sole occupant of a vehicle might not be as concerned with the passenger safety rating as someone who routinely carries passengers.

NHTSA officials said that they will continue investigating the feasibility of creating an overall safety rating for vehicles. However, they said that they would like to incorporate additional elements into such a rating. For example, they said that it is important to develop a rating that considers more than just the frontal and side-impact test results, such as the rollover results and vehicle compatibility, which can have a large bearing on the overall safety of vehicles. In their view, without the elements that address rollover and compatibility, consumers might get the wrong impression of

[58]The U.S. NCAP provides four separate star ratings for crash test results. There are separate ratings for drivers and passengers (front seat) in frontal crashes and separate ratings for drivers and rear (driver side) passengers in side-impact crashes.

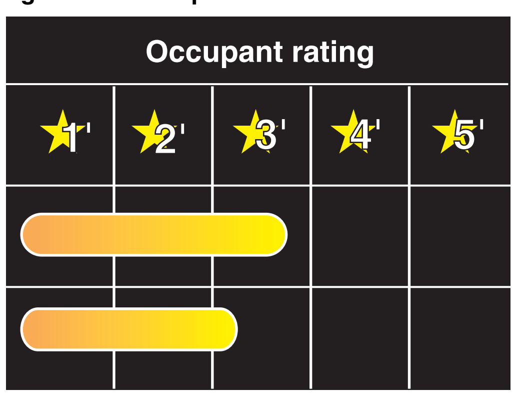
[59]"*Shopping for Safety,*" Special Report 248, National Academy Press (Washington, D.C. : 1996).

the relative safety of vehicles. Officials said they have not yet developed a method to incorporate the rollover rating into an overall rating and have not identified measures to reflect vehicle compatibility, although they have long recognized compatibility as an issue. They could not estimate how long it would take to address the problem of adding the rollover rating to a combined rating but said they would pursue developing a summary safety rating for vehicles after they decide how to measure vehicle compatibility.

Comparative Safety Information Could Benefit the Public

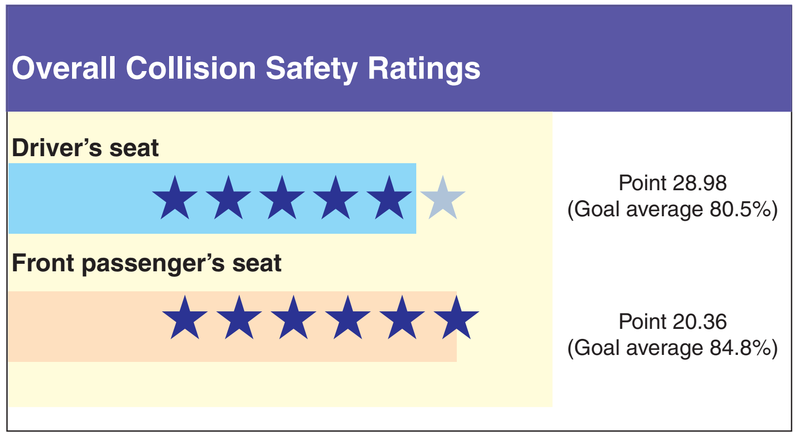
Each testing organization uses a different presentation approach for reporting its test results, with some providing additional information to the public. The U.S. NCAP provides separate star ratings for the four dummy positions in the two crash tests and the rollover test. The only ratings the U.S. NCAP presents in a comparative manner are the rollover ratings, which compare vehicle performance within a class of vehicles, such as pickup trucks. In contrast, Australia's and Japan's NCAPs provide more comparative information by supplementing their star ratings by adding bar charts that show how well the vehicle performed in the tests, as shown in figures 28 and 29. The Australia publication shows that although two vehicles received three stars, one of them performed better than the other. The Japan NCAP rating shows that the vehicle received five stars for overall driver safety but that the passenger score was higher than that of the driver.

Figure 28: Example of Australia's NCAP Safety Rating Information



Source: Australian NCAP, Australian Automobile Association.

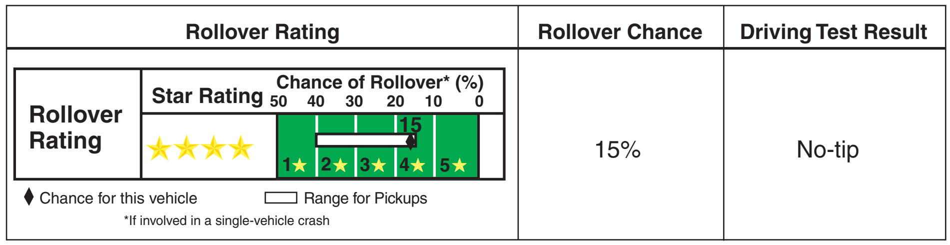
Figure 29: Example of Japan's NCAP Safety Rating Information



Similarly, *Consumer Reports* provides summary safety ratings for accident avoidance and crash protection and uses a bar chart to present its overall safety score. *Consumer Reports* also lists vehicles in ranked order rather than alphabetically, provides comments to highlight particular aspects of each vehicle's performance, and uses qualitative descriptions--Excellent, Very Good, Good, Fair, and Poor--to help inform its readers of safety results. *Consumer Reports* officials said that the overall rating provides an overview of the vehicle's safety, and the two summary categories of accident avoidance and crash protection provide additional information that consumers may want.

NHTSA recently began using a rating system for its rollover assessment that indicates, along with the star rating, the percentage of likelihood that a vehicle may roll over. NHTSA's rollover information provides an extra level of detail of vehicle performance than the information provided for the frontal and side collision tests. The rollover results are ranked according to performance and, as illustrated in figure 30, show how well each vehicle performed within the range of performance of its vehicle class, such as passenger cars, pickups, vans, and SUVs.

Figure 30: Example of NHTSA's Rollover Rating for a Pickup Truck with Bar Chart Showing How the Vehicle Performed within Its Class



Source: National Highway Traffic Safety Administration.

Increasing Public Awareness of Results

NHTSA could look to other programs for innovative ways to garner more interest in crash test results. Like other testing organizations, NHTSA uses the Internet, brochures, and press releases to inform the public of NCAP ratings. However, other organizations use additional approaches to inform the public of their program and test results. For example, the Japan Automobile Federation creates public awareness of the program with a portable sled in which the general public can experience a simulated collision at 5 kilometers per hour and have a protective air bag deploy. The Euro NCAP also stages a public display of crash vehicles. They try to select areas where media and public interest would be high. Recent events were held in Wenceslas Square, Prague; Athens; and London. Figure 31 shows two events, one in London and another in Prague.

Figure 31: Examples of Euro NCAP Public Displays of Crash Vehicles

Source: Euro NCAP.

There have also been proposals to increase public awareness of NCAP results by requiring their inclusion on new car stickers. For example, S. 1072, a bill introduced in the 108th Congress to reauthorize funds for federal aid highways, highway safety programs, and transit programs, included a provision that would require automakers to include NCAP test results on new car stickers. Officials from consumer advocate groups told us that they support such an approach because consumers would have information available at the time of their purchase decisions. Officials from automakers said that there are a number of challenges that would need to be overcome if such an approach were taken, including scheduling tests to ensure that results are available in time for the information to be included on new car stickers.

NCAP Ratings Could Be Available Earlier in the Car Model Year

NHTSA could conduct vehicle tests earlier and release NCAP ratings sooner in the model year, which would make the results more useful for consumers. NCAP ratings are often released late in the model year, after many of the vehicles have already been purchased. In May 2003, long after the beginning of model year 2003, NHTSA released the results of some model year 2002 vehicle tests. NHTSA published its *Buying a Safer Car* brochure for 2004 in February 2004, about 6 months after the vehicles were available for sale and before all of the tests were completed for the 2004 models. To the extent that test results are available sooner, more car buyers could have safety information to help make their purchase decisions. For example, by the time NHTSA released the *Buying a Safer Car* brochure in

February 2004, according to industry sales statistics, about 7.7 million, or over 46 percent, of new cars and trucks had been purchased in the United States.[60] For model year 2005, NHTSA attempted to address the issue of getting timely information to consumers by publishing an early edition of its *Buying a Safer Car* brochure in December 2004. This publication included test results for some 2005 models. In addition, towards of the end 2004, NHTSA began posting the results to its Web site as soon as the quality control process was completed. NHTSA officials plan to publish an updated version in spring 2005, after additional testing has been completed.

There are several factors that affect the timing of the testing and the release of NCAP ratings. First, NHTSA obtains vehicles for NCAP testing directly from the dealerships and leasing companies to ensure that each vehicle is representative of that make and model. Under this approach, testing cannot begin until after vehicles are available for purchase by the public—the model year begins in September for many companies. In addition, NHTSA does not receive its funding until after the fiscal year begins on October 1st of each year. Further, due to the number of vehicles to be included, vehicle testing is spread out over a period of months. As a result, testing can extend from October though April. Until recently, NHTSA did not make ratings available to the public as soon as the results were known but waited until all testing of a vehicle category was finished before issuing a press release announcing the test results. Beginning with model year 2005 tests, NHTSA began posting the test results to its Web site after the quality control process was complete. Press releases continue to be generated after each batch of tests is completed. NHTSA officials said that by releasing the results this way, consumers have comparative information on all vehicles of one type at the same time.

One testing organization has addressed some of the timeliness issues. Euro NCAP obtains some vehicles directly from the manufacturers prior to distribution to dealerships. This enables them to begin testing before the vehicles are available to the public.[61] In addition, the Euro NCAP divides its program into two testing and information releases each year—one in November and one in June—to speed the information to the public.

[60]*Automotive News*. Includes new model year passenger vehicles sales from September 2003 though February 2004.

[61]The Euro NCAP selects the vehicles from the manufacturers randomly by vehicle identification number.

Conclusions

While NHTSA's New Car Assessment Program has contributed to making safer vehicles, it is at a crossroads where it will need to change to remain relevant. The usefulness of the current testing has been eroded by changes in the vehicle fleet that have occurred since the program began. The growing number of large pickups, minivans, and SUVs in the nation's vehicle fleet is creating different safety risks, particularly with regard to the incompatibility of large and small vehicles and vehicle rollover, which NCAP does not fully address. In addition, the very success of the program has brought it to a point where it is not clear that the program's goals can continue to be met. Because almost all vehicles today receive four- and five-star frontal and side-impact safety ratings, NCAP provides little incentive for manufacturers to further improve the safety of their vehicles and does not provide consumers with information that differentiates the safety of one vehicle compared to another. Further, the planned changes to the safety standards for frontal and side crashworthiness may make current NCAP tests less meaningful.

While we believe there are opportunities to enhance NCAP by developing approaches to better measure the interaction of large and small vehicles and occupant protection in rollovers, rating technologies that help prevent crashes from occurring, and using different injury measures to rate the crash results, there are challenges that must be considered and addressed before changes can be implemented. However, without changing its testing, NCAP provides little incentive for manufacturers to improve vehicle safety. In addition, NHTSA will need to enhance the timeliness of testing and presentation of the New Car Assessment Program information. For example, by the time NHTSA finished its testing and published the test results for model year 2004 vehicles, about 7.7 million, or over 46 percent of new vehicles had already been purchased. To enhance the information available to consumers, NHTSA can provide summary ratings, present information in a comparative manner, increase public awareness, and conduct tests earlier in the car model year. Given the substantial numbers of traffic deaths and injuries suffered on the nation's roads each year, efforts to improve vehicle safety seem warranted.

Recommendations for Executive Action

We recommend that the Secretary of Transportation direct the Administrator, National Highway Traffic Safety Administration, to examine the future direction of the New Car Assessment Program to maximize its value in providing an incentive for manufacturers to improve vehicle safety and informing the public about the relative safety of vehicles.

This examination should include

- identifying and evaluating NCAP tests that should help prevent fatalities on the nation's roadways, which should include developing measures for rating vehicle incompatibility in front and side-impact tests and occupant protection in rollover crashes;

- developing approaches to incorporate active safety systems ratings as a part of NCAP; and

- analyzing alternative testing methodologies and dummies to provide a robust and accurate measure of the likelihood of serious injuries to a wide range of vehicle occupants.

In addition, we recommend that steps be taken to provide the public with improved NCAP safety information in a more timely manner. In doing so it may be necessary to examine how other organizations inform the public and develop summary ratings, whether vehicles could be obtained more efficiently for testing, how budgeted funds are managed during the year, and how efficiently NCAP times the crash tests conducted by its contractors.

Agency Comments and Our Evaluation

We provided a copy of the draft report to the Department of Transportation for its review and comment. In commenting on the report, the Senior Associate Administrator for Vehicle Safety commented that NHTSA was pleased that the report concluded that NCAP has been successful in encouraging manufacturers to make safer vehicles and providing vehicle safety information to consumers. While NHTSA generally agreed with the report findings, including recognition that there are opportunities to enhance NCAP, the official emphasized that NCAP was just one of the many interrelated methods, including Federal Motor Vehicle Safety Standards and traffic injury control programs, the agency uses to achieve its mission of saving lives, preventing injuries, and reducing vehicle-related crashes. The official said that NHTSA has been consistently working to address the challenges associated with enhancing this complex technical program while ensuring that the testing and results reported to consumers are accurate and reliable. The official explained that this requires NHTSA to ensure that any changes to NCAP, or for that matter to the Federal Motor Vehicle Safety Standards, are based on sound science and careful analysis of supporting data. The official cited a number of recent efforts that NHTSA said demonstrate the careful and systematic approach the agency uses when considering changes to the program. These include pilot studies with child restraint systems to determine the feasibility of incorporating them into NCAP, seeking public comments for revising frontal NCAP collision testing, and working to ensure that advanced safety technologies are publicized so that consumers can factor them into the vehicle purchase decision-making process.

The NHTSA official also said that the agency recognizes that vehicle rollover and compatibility issues cause a significant portion of the fatal and serious motor vehicle occupant injuries on our nation's highways, and NHTSA has made these areas two of its highest priorities. In June 2003, NHTSA published initiatives for public comment to address both of these areas. The NHTSA official said the agency is continuing its efforts to identify effective vehicle metrics and countermeasures to address these issues, since they are necessary in order for NCAP to provide meaningful consumer information that can be linked to safety improvements in the vehicle.

We recognize that NCAP is one of a number of efforts that NHTSA uses in an attempt to reduce highway crashes, serious injuries, and fatalities. In addition, we support NHTSA's view that changes to the NCAP program should be based on sound science and careful analysis of supporting data. We encourage NHTSA to take timely action to address the issues raised in this report. NCAP has helped make vehicles safer, but there are opportunities to improve the program and ultimately help save more lives. The risks associated with vehicle incompatibility and rollover and the potential benefits to be gained from active safety systems heighten the importance of addressing these issues as promptly as possible. In addition, analyzing alternative testing methodologies and dummies could lead to more robust and accurate measures of the likelihood of serious injury to a wide range of vehicle occupants. Lastly, NHTSA has the opportunity to improve the timeliness and presentation of the NCAP results, which could help consumers make informed decisions when they purchase cars.

NHTSA also provided technical clarifications to our report, which we incorporated as appropriate.

We are sending copies of this report to appropriate congressional committees and the Secretary of Transportation. We will also make copies available to others upon request. In addition, this report will be available at no charge on GAO's Web site at http://www.gao.gov. We are also making available a version of this report that includes video clips of some of the crash tests conducted by NHTSA and others.

If you or your staffs have any questions regarding the contents of this report, please contact me at (202) 512-2834 or heckerj@gao.gov. Individuals making key contributions to this report are listed in appendix IX.

JayEtta Z. Hecker
Director, Physical Infrastructure Issues

Scope and Methodology

To determine how NHTSA's New Car Assessment Program tests vehicles, rates their safety, and reports the results to the public, we reviewed Federal Motor Vehicle Safety Standards (CFR Title 49: Chapter V, Part 571); the Motor Vehicle Information and Cost Savings Act of 1972 (Public Law 92-513); the Transportation, Recall Enhancement, Accountability and Documentation (TREAD) Act; and other documents pertaining to NCAP regulations. We also searched NHTSA's docket and NCAP documentation. In addition, we conducted interviews with NHTSA officials responsible for operating the Federal Motor Vehicle Safety Standards regulatory program and the New Car Assessment Program. We visited and interviewed officials from the Federal Highway Administration and the National Crash Analysis Center. During visits to all five of the contractors that perform regulatory and NCAP crash tests-- including Karco Engineering, LLC, in Adelanto, California; MGA Research Corporation in Burlington, Wisconsin; Medical College of Wisconsin in Milwaukee, Wisconsin; General Dynamics—Advanced Information Systems in Buffalo, New York; and the Transportation Research Center, Inc., in East Liberty, Ohio--we interviewed officials and engineers performing tests and observed various crash tests. We documented the procedures for obtaining the data, how results were recorded, and the conversion into star ratings. We determined that NCAP data were sufficiently reliable for the purpose of this report. In addition, we reviewed literature pertaining to vehicle safety issues and documents published by the Transportation Research Board.

To compare NHTSA's New Car Assessment Program with other programs that test vehicles and report vehicle safety results to the public, we researched literature and interviewed NHTSA officials to identify three foreign New Car Assessment Programs (in Australia, Europe, and Japan) and the Insurance Institute for Highway Safety as a domestic program. We also identified publishers of *Consumer Reports* and *The Car Book* as organizations that used NHTSA's NCAP data to derive their own vehicle safety ratings. We identified a program in Korea but did not include this program in our review because it began operating in 1999 and had not tested a significant number of vehicles.

We obtained information on these programs by reviewing their literature and their Web sites. We also interviewed officials and visited the test facilities of the Insurance Institute and the NCAPs in Australia, Europe, and Japan. We visited the Insurance Institute of Highway Safety's Vehicle Research Center and observed a crash test. We also examined international crash test and rating programs, including the Australia, Euro, and Japan NCAPs. For Australia's NCAP, we visited Australia and conducted interviews with government officials associated with the respective New Car Assessment Program and vehicle safety policy. For Euro NCAP, we visited Belgium, Germany, Sweden, and the United Kingdom, where we conducted interviews with the European Commission, and the government officials associated with the respective New Car Assessment Programs and vehicle safety policies in Germany, Sweden, and the United Kingdom. For Japan's NCAP, we visited Japan and interviewed government officials associated with the respective New Car Assessment Program and vehicle safety policy. While in these countries, we also interviewed auto associations, consumer advocacy groups, and vehicle safety experts. We identified and selected these auto associations, consumer advocacy groups, and vehicle safety experts by reviewing studies and conference papers, talking to program officials and other experts, and reviewing materials on Web sites. We interviewed auto manufacturers in these countries, including BMW, Honda, Mercedes, Nissan, Toyota, and Volvo. We reviewed New Car Assessment Program regulations, testing protocols, and program documentation. See table 1 for a list of domestic and international organizations contacted.

To determine whether opportunities exist for NCAP to enhance its vehicle safety testing and reporting, we obtained views from experts in vehicle safety and the auto and insurance industries. In selecting vehicle safety experts, we examined studies and conference papers, considered referrals from other experts, and consulted the National Academy of Sciences. We interviewed officials of the Association for the Advancement of Automotive Medicine and Applied Research Associates. We visited and interviewed automobile manufacturers in the United States, including General Motors, Ford Motor Company, Daimler-Chrysler, and American Honda Motor Company. We interviewed trade associations including the Alliance of Automobile Manufacturers and the Association of International Automobile Manufacturers. We interviewed consumer advocacy groups, including Consumers Union, Public Citizen, the AAA Foundation for Traffic Safety, Advocates for Highway Safety and Auto Safety, and the National Safety Council. We reviewed relevant research on consumer information regarding vehicle safety from the Transportation Research Board.

Table 1: List of Organizations Contacted

U.S. NCAP
Federal agencies
Department of Transportation
NHTSA
George Washington University's National Crash Analysis Center
Federal Highway Administration
Consumer information organizations
Consumer Reports
The Center for Auto Safety (*The Car Book*)
Crash test organizations
Insurance Institute for Highway Safety
Automobile manufacturers
American Honda Motor Company
Daimler-Chrysler Corporation
Ford Motor Company
General Motors Corporation
Industry associations and experts
AAA Foundation for Traffic Safety
Advocates for Highway and Auto Safety
Alliance of Automobile Manufacturers
American Association of State Highway and Transportation Officials
Applied Research Associates
Association for the Advancement of Automotive Medicine
Association of International Automobile Manufacturers
Consumers Union
Japan Automobile Standards Internationalization Center
National Safety Council
Public Citizen
Transportation Research Board
Vehicle Certification Agency North America
Contractors
General Dynamics—Advanced Information Systems
Karco Engineering, LLC
Medical College of Wisconsin
MGA Research Corporation
Transportation Research Center

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Australia NCAP
Australia Automobile Association (administrator for Australia NCAP)
Australian Consumers' Association (*CHOICE* magazine)
Department of Transport and Regional Services—Vehicle Safety Standards
Crashlab—New South Wales Road and Traffic Authority (Australia NCAP test facility)
Federal Chamber of Automotive Industries
Monash University Accident Research Center
National Roads and Motorists Association Motoring and Services
Royal Automobile Club of Victoria
Victoria Road and Traffic Authority
Euro NCAP
Belgium
European Auto Manufacturers Association
European Commission, Directorate General for Energy and Transport
European Transport Safety Council
Germany
General German Automobile Club (ADAC)
BMW AG
Daimler Chrysler AG, Mercedes-Benz Technology Center
Federal Ministry for Traffic, Building, and Housing
TÜV Automotive Group
United Kingdom
Automotive Safety Centre at the University of Birmingham
Department for Transport
Euro NCAP
International Consumer Research and Testing (*Which?* magazine)
Thatcham (Motor Insurance Repair Research Centre)
Transportation Research Laboratory
Sweden
Swedish Road Administration
Swedish National Road and Transport Research Institute
Volvo
Japan NCAP
Honda Research and Development Corporation
Japan Auto Research Institute (Japan NCAP test facility)
Japan Automobile Federation
Japan Automobile Importers Association
Japan Automobile Manufacturers Association

(Continued From Previous Page)
Japan Ministry of Land Infrastructure and Transport
Mitsubishi Motors Corporation
National Agency for Automotive Safety and Victim's Aid (Japan NCAP)
Nissan Motor Corporation
Toyota Motor Corporation

Source: GAO.

We conducted our work from March 2004 through April 2005 in accordance with generally accepted government auditing standards.

Basis for NHTSA's Crashworthiness Ratings

To rate a vehicle's crashworthiness, NHTSA combines information about (1) the forces that would injure a human during a crash and (2) the effects of those forces on areas of the human body. The forces that would injure a human during a crash are measured by anthropomorphic test devices, commonly referred to as crash test dummies, which serve as proxies for human vehicle occupants. These dummies are fitted with accelerometers and load sensors that measure the forces of impact on particular areas of the body, as shown in figure 32.

Figure 32: A Crash Test Dummy Fitted with Load Sensors and Accelerometers

Because the current dummy technology has yet to replicate a human with the same biological matter or physiology, dummies cannot exhibit injuries following a crash as a human would. Therefore, the effects of the forces on particular areas of the human body, as measured by the dummies, have been developed by researchers who have gathered information by applying varying forces to biological specimens and by using a scale developed by the Association for the Advancement of Automotive Medicine (AAAM).

This scale, the Abbreviated Injury Scale (AIS), ranks injuries, from minor through currently untreatable, for particular areas of the body and assigns a number from 1 through 6 to each rank, as shown in table 2. The AIS is used to provide a simple numerical method for ranking and comparing injuries by severity.

Table 2: Abbreviated Injury Scale (AIS)

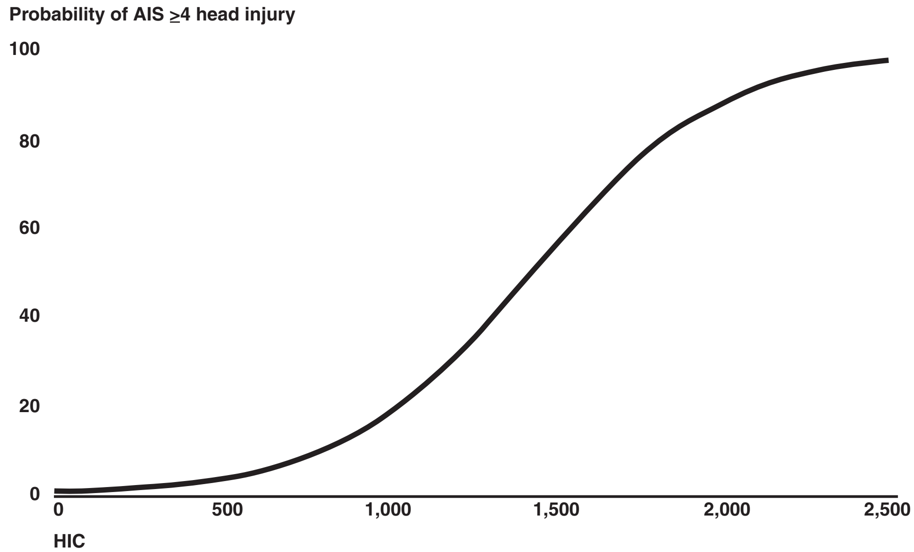
AIS code	Description of injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Currently untreatable

Source:

AIS values in NCAP are injury probability values derived from measurements of dummy response taken from specific characteristics (e.g., size, shape, mass, stiffness, or energy dissipation) that simulate corresponding human responses (e.g., acceleration, velocity, or articulation). These dummy responses are correlated with both experimental biomechanical research as well as with real world crash injury investigation. Researchers have used a statistical procedure to relate the levels of injury to the forces that caused them. This procedure produces theoretical injury curves, which NHTSA uses as the basis for safety ratings.

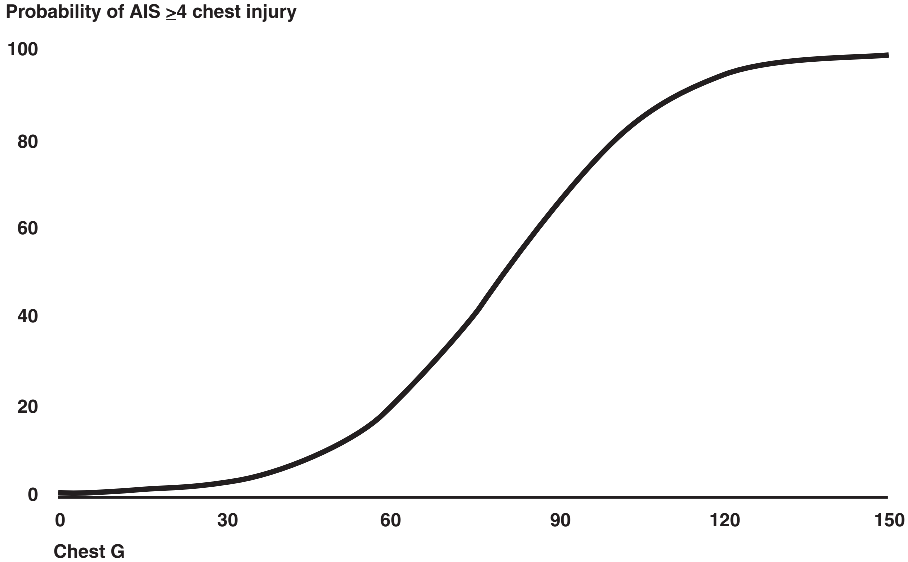
NHTSA develops crashworthiness ratings, expressed in stars, for both frontal and side crashes. To develop the NCAP ratings for frontal crashes, NHTSA measures forces to the head and chest. Specifically, the injury criteria for the frontal star rating are the head, as measured by a composite of acceleration values known as the Head Injury Criterion (HIC), and the chest, as measured by a chest deceleration value known as chest Gs. Each of these two measures has its own injury risk curve that has been fixed at AIS level 4 or greater—that is, a severe, critical, or currently untreatable injury, as shown in figures 33 and 34. Using the mathematical functions that describe each of these injury risk curves, NHTSA transforms the HIC and chest G measures from the frontal NCAP test into probabilities of head and chest injuries of AIS level 4 or greater. The lower the HIC and chest G measures, the less risk of receiving a severe, critical, or currently untreatable injury to the head and chest in a full frontal crash.

Figure 33: Injury Curve for HIC



Source: National Highway Traffic Safety Administration.

Figure 34: Injury Curve for Chest G



Source: National Highway Traffic Safety Administration.

To convert the probability of severe injury for particular HIC and Chest G scores into a star rating for the frontal NCAP test, NHTSA adds the probability of severe injury to the head and chest and then subtracts the product, shown below in figure 35. NHTSA concluded that a combined effect of injury to the head and chest should be used since it is well documented that an individual who suffers multiple injuries has a higher risk of death. NHTSA calculates the probability of severe injury to the head and chest for both the driver and the front passenger dummies in the frontal NCAP test.

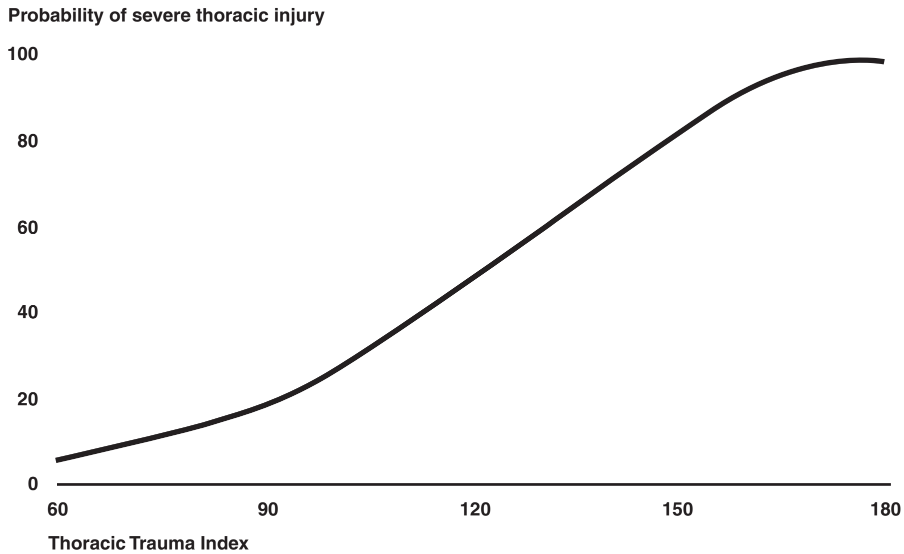
Figure 35: Probability Equation Used to Produce Star Ratings for Frontal Crashes

Prob(Combined) = Prob(HIC) + Prob(Chest) - (Prob(HIC) * Prob(Chest))

Source: National Highway Traffic Safety Administration.

To develop the NCAP ratings for side crashes, NHTSA measures forces to the ribs and lower spine. Specifically, the injury criteria for the side star rating are the greater acceleration of the upper or lower ribs and the acceleration of the lower spine. NHTSA averages these accelerations to generate a measurement known as the Thoracic Trauma Index (TTI). The TTI also has an injury curve that has been fixed at the AIS level of 4 or greater, as shown in figure 36. The lower the TTI measure, the lower the risk of receiving a severe, critical, or currently untreatable injury to the thorax and upper abdomen in a side crash.

Figure 36: Thoracic Trauma Index Curve



Source: National Highway Traffic Safety Administration.

The Thoracic Trauma Index score and its associated probability of receiving an AIS level 4 or greater injury is the sole basis for the side NCAP star rating. NHTSA calculates probability of severe injury to the thorax and upper abdomen for both the front and rear dummies on the driver's side.

Using the probability of injury calculated from the frontal and side NCAP tests, NTHSA assigns a vehicle a rating of one (the worst) to five (the best) stars for each of the dummy occupants in each of the crashworthiness tests. The star ratings for the frontal and side tests correspond to the percentage chance of serious injury for each of these tests.

The numerical boundaries between each star rating are determined by NHTSA. The frontal NCAP star boundaries are roughly twice as large as the side NCAP star boundaries because NHTSA uses a combined probability of injury to generate star ratings for the frontal NCAP test and uses only one probability of injury to generate star ratings for the side NCAP test. In addition, the forces and associated probabilities at the boundary between two and three stars for both the frontal and side NCAP tests are roughly equal to the relevant force thresholds for compliance with two Federal Motor Vehicle Safety Standards—numbers 208 and 214, respectively.

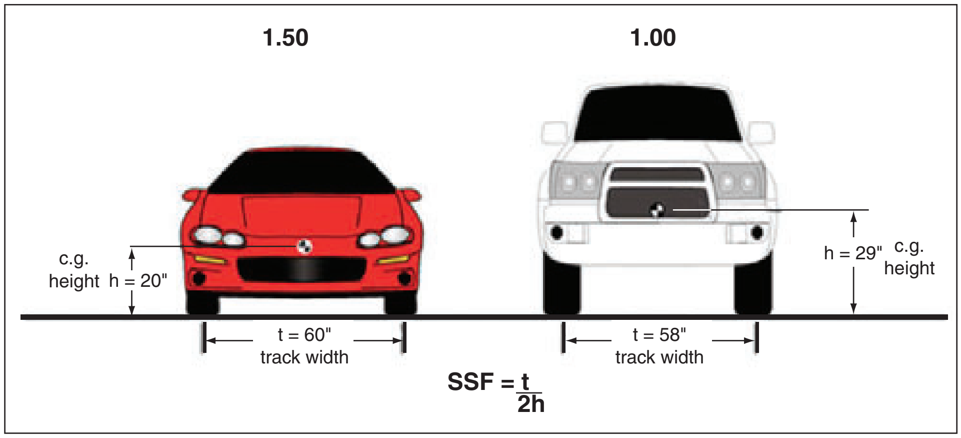
Basis for NHTSA's Rollover Rating

To indicate the likelihood of a vehicle's rolling over in a single-vehicle crash, NHTSA combines the risk of rollover in a single vehicle crash indicated by a measure of the vehicle's top-heaviness, called the Static Stability Factor (SSF), with the results of a dynamic rollover test to produce a star rollover rating. The SSF is an indicator for the most frequent type of rollover, called a "tripped rollover," which occurs when a vehicle leaves the roadway and its wheels are tripped by a curb, soft shoulder, or other roadway object, causing the vehicle to roll over. About 95 percent of rollovers are tripped. Because the SSF is an indicator of the most frequent type of rollover, it plays a significantly larger role in a vehicle's star rating than do the results of the dynamic rollover test. The dynamic rollover test determines how susceptible a vehicle is to an on-road "untripped" rollover—a type that accounts for less than 5 percent of rollovers. Because untripped rollovers are so infrequent, the rollover test does not affect the vehicle's star rating significantly, resulting in a difference of no more than half a star in the rating.

Static Stability Factor

The SSF is a calculation of a vehicle's top-heaviness, defined as one-half of the vehicle's track width divided by the height of the center of gravity (c.g.). A higher SSF value equates to a more stable, less top-heavy vehicle. SSF values across all vehicle types range from around 1.0 to 1.5. Most passenger cars have values in the 1.3 to 1.5 range, as shown in figure 37. Higher riding SUVs, pickups, and vans usually have values in the 1.0 to 1.3 range, also shown in figure 37. Many of the higher riding vehicles of previous model years are being redesigned to ride lower on a wider track to improve their rollover resistance and obtain a higher SSF rating.

Figure 37: Static Stability Factor of a Passenger Vehicle Compared with an SUV



Source: National Highway Traffic Safety Administration.

After determining the SSF, NHTSA selects certain vehicles for the dynamic rollover test. Not all passenger cars selected for NCAP testing undergo the dynamic test. Thus far, for most passenger cars, NHTSA has imputed or assigned a no-tip result for the dynamic test based on the testing of other passenger cars that are more top heavy (according to the SSF score) but did not tip up during the dynamic test. NHTSA periodically tests passenger cars to validate the imputed results.

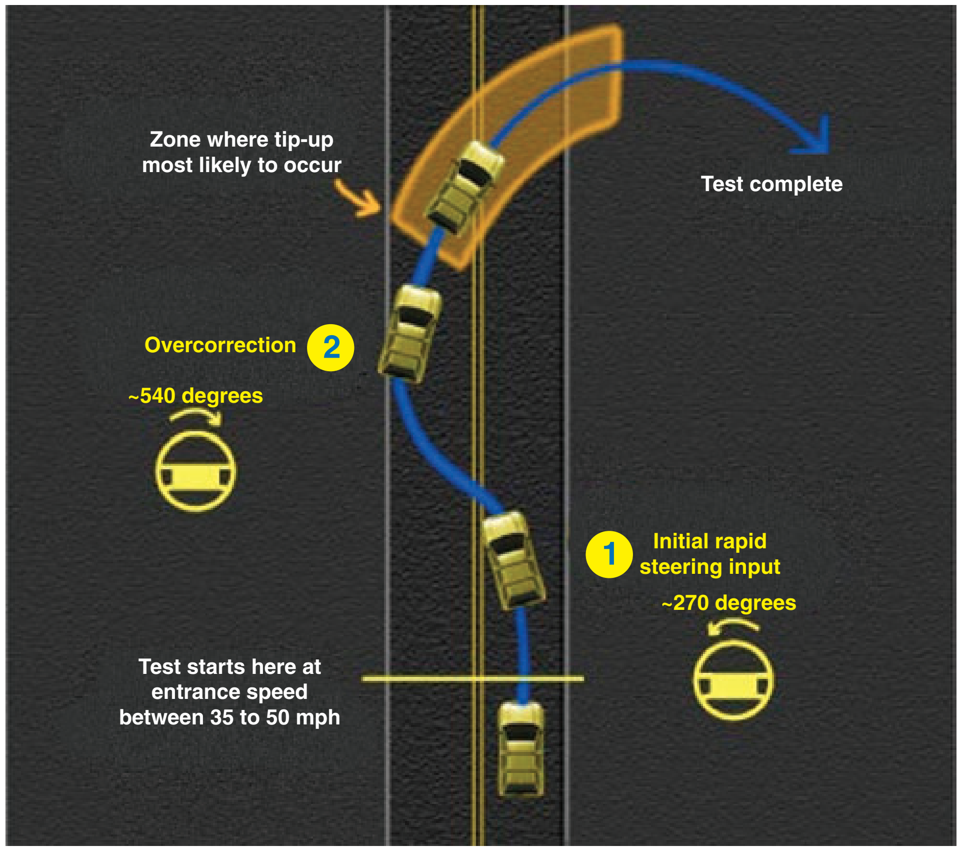
Dynamic Rollover Test

In the dynamic rollover test, a driver sits in the vehicle and conducts the test by applying the accelerator and initiating commands for the programmable steering controller, which actually maneuvers the vehicles, as shown in figure 38. The general steering parameters are 270 degrees (about a three-quarters turn) for the initial turn and 540 degrees (about one and one-half turn) for the correction turn, as shown in figure 39. Outriggers are attached to the vehicle to prevent the vehicle from tipping all the way over.

Figure 38: Programmable Steering Controller

Source: National Highway Traffic Safety Administration.

Figure 39: Diagram of the Dynamic Test, Showing Steering Parameters



Source: National Highway Traffic Safety Administration.

The result of the dynamic rollover test is either "tip-up" or "no tip-up." To receive a "no tip-up" result, a vehicle must reach a speed of 50 miles per hour (mph) on four dynamic test runs—two from left to right and two from right to left—without the inside wheels on either side of the vehicle simultaneously lifting at least 2 inches off the surface, and it must do this at two different steering wheel angles. Sensors are used to detect wheel-lift, as shown in figure 40. For the first run of each test, the speed is 35 mph, and subsequent runs are conducted at about 40 mph, 45 mph, 47.5 mph, and 50 mph, until the vehicle tips up or attains an entrance speed of 50 mph on the last run of each test without tipping up. The same series of tests is repeated at a different steering wheel angle.

Figure 40: Sensors to Detect Wheel-lift

Source: National Highway Traffic Safety Administration.

NHTSA first began to rate vehicles' rollover avoidance in model year 2001, using the SSF alone to determine the star rating. At that time, NHTSA used a statistical procedure to determine how the SSF affects the risk of rollover.[1] Physics theory would suggest that vehicles with a low SSF—vehicles that are more top-heavy—are more likely to roll over than vehicles

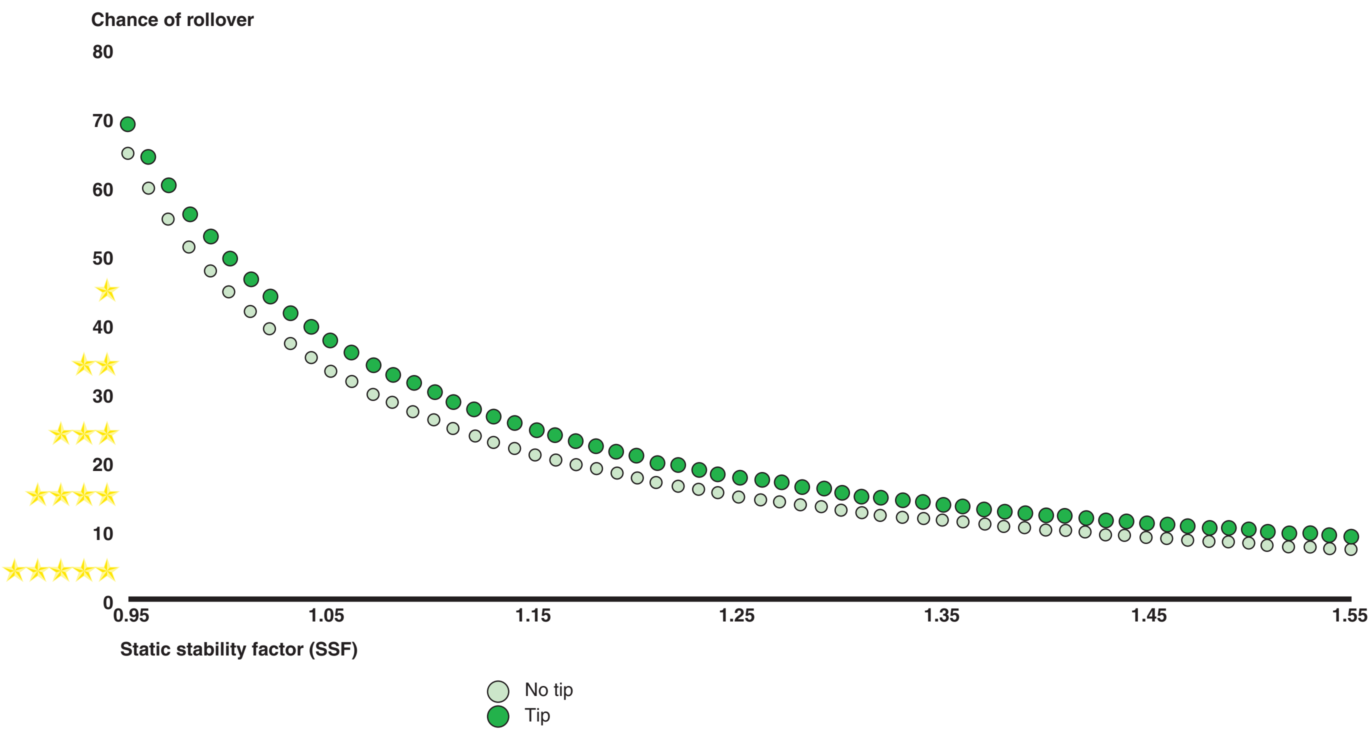
[1]NHTSA used linear regression to determine the relationship between a vehicle's probability of rollover per single vehicle crash and its Static Stability Factor controlling for road use and state dummy variables. It is important to emphasize that this relationship may only be imputed to vehicles involved in single-vehicle crashes and not to the vehicle fleet at large.

with a high SSF. NHTSA's empirical model confirmed this theory, showing that the lower the SSF, the more likely a vehicle is to roll over in a single-vehicle crash. For the first 3 years that NHTSA rated rollover risk, it used a linear model that examined accident report data at the state level. Following the passage of the TREAD Act, which required NHTSA to include a dynamic rollover test in NCAP, and the publication of a National Academy of Sciences report, which recommended that NHTSA use a nonlinear model to predict rollover risk, NHTSA altered its method of calculating rollover risk.[2] NHTSA now links the SSF and the risk of rollover using a nonlinear model.[3] In addition, NHTSA includes the results of the dynamic test—that is, whether a vehicle tips or not—in this new model, as shown in figure 41.

[2]*The National Highway Traffic Safety Administration's Rating System for Rollover Resistance: An Assessment*, TRB Special Report 265 (Washington, D.C. : National Academy of Sciences, 2002).

[3]NHTSA's new model uses logistic instead of linear regression. In addition, NHTSA performs a log transformation of the Static Stability Factor to increase the accuracy of the model for vehicles with low Static Stability Factors.

Figure 41: NCAP Logistic Model Used to Determine Rollover Ratings



Source: National Highway Traffic Safety Administration.

A vehicle's rollover rating is an estimate of its risk of rolling over in a single-vehicle crash, not a prediction of the likelihood of a rollover crash.

Insurance Institute for Highway Safety

The Insurance Institute for Highway Safety is a nonprofit research and communications organization funded by the U.S. auto insurance industry. The Insurance Institute has been conducting vehicle safety research since 1969, and in 1992 it opened the Vehicle Research Center to conduct vehicle crash tests. The Insurance Institute began crash testing and rating vehicles for frontal collisions in 1995 and for side collisions in 2003.[1] The center conducts the Insurance Institute's vehicle-related research, which includes controlled tests of vehicles and their components using instrumented crash tests, as well as studies of real collisions. Insurance Institute officials told us that scrutinizing the outcomes of both controlled tests and on-the-road crashes gives researchers—and ultimately the public—a better idea of how and why vehicle occupants are injured in crashes. This research, in turn, leads to vehicle designs that reduce injuries. The Insurance Institute buys the vehicles for crash tests directly from dealers. It also chooses vehicles for testing to represent both a range of manufacturers and the largest portions of new car sales, in an effort to cover as much of the marketplace as possible. The Insurance Institute tests vehicles in categories, such as small cars, minivans, and midsize SUVs.

Testing Conducted

The Insurance Institute conducts two types of crash tests—an offset frontal test and a perpendicular side test. The offset frontal test is conducted at about 40 mph to simulate a typical head-on collision of two vehicles. The offset frontal test evaluates the potential for injuries caused to occupants by intrusion into the occupant compartment. The Insurance Institute uses a frontal impact dummy, called the 50^{th} percentile Hybrid III dummy, in its frontal crash tests. This dummy represents a man of average size, 5 feet 9 inches tall and weighing about 170 pounds. Such dummies were designed to measure the risk of injury to the head, neck, chest, and lower extremities in a frontal crash.

The Insurance Institute's perpendicular side test measures the impact of a moving deformable barrier striking the driver's side of a passenger vehicle at 31 mph. The barrier weighs 3,300 pounds and has a front end shaped to simulate the typical front end of a pickup truck or SUV. Two instrumented 5^{th} percentile side-impact dummies (SID-IIs), representing small females or 12-year-old adolescents who are 5 feet tall and weigh about 110 pounds, are positioned in the driver's seat and in the rear seat behind the driver to

[1]The Insurance Institute began evaluating head restraint geometry in 1995, and dynamic seat/head restraint tests were added in 2004.

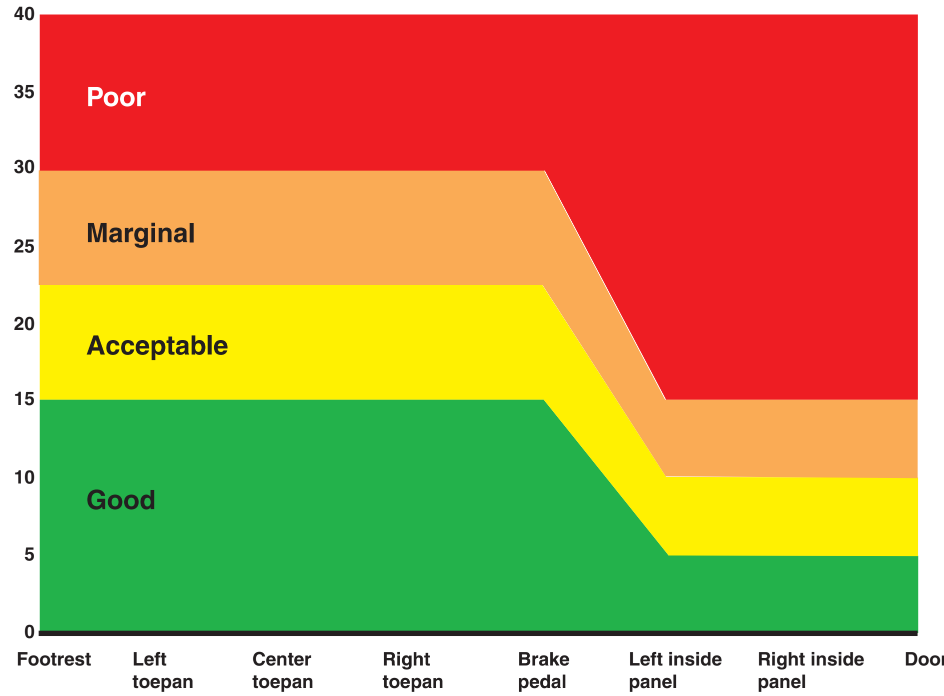
measure the impact of the vehicle crash. The SID-IIs dummies were designed to measure acceleration of the spine and ribs plus compression of the rib cage in a side crash.[2] They are also equipped with unique load cells, which measure the force of the impact applied to the dummies during the crash.

Scoring Tests

To evaluate a vehicle's performance in the frontal crash test and develop an overall rating for the frontal test, the Insurance Institute uses three types of measures: (1) structural performance, the amount and pattern of intrusion into the occupant compartment during the offset test; (2) injuries measured by a Hybrid III dummy positioned in the driver's seat; and (3) dummy kinematics, or the dummy's movements during the test, as determined through an analysis of a slow-motion film. The structural performance assessment indicates how well the front-end crush zone managed the crash energy and how well the safety cage limited intrusion into the driver space. Figure 42 shows the intrusion levels on which a vehicle's structural performance is rated. Injury measures are used to determine the likelihood of injury to various regions of the driver's body. The measures recorded from the head, neck, chest, legs, and feet of the dummy indicate the level of stress/strain on that part of the body. Thus, greater numbers mean larger stresses and strains and a greater risk of injury. Because significant risk of injury can result from undesirable dummy kinematics in the absence of high injury measures, such as partial ejection from the occupant compartment through a window, a slow-motion film is used during the crash test. An analysis of this slow-motion film helps evaluate the interactions of the restraint system's components—including the safety belts, air bags, steering columns, head restraints, and other components—to control the dummy's movement.

[2]Compression refers to the extent body regions are squeezed during the impact and is used as an indicator of injury to internal organs.

Figure 42: Guidelines for Rating Occupant Compartment Intrusion Measured in Centimeters



Source: Insurance Institute for Highway Safety.

A vehicle's overall frontal rating depends on the effectiveness of its structure, or safety cage, in protecting the occupant compartment, the risk of injury measured for an average-size male, and the effectiveness of the restraint system in controlling occupants' movements. The structural performance and injury assessments are the major components of each vehicle's overall frontal rating; the dummy kinematics (movement) contributes less to the rating.

A vehicle's side crash test performance and overall rating are based on (1) the injury measures recorded on the two instrumented SID-IIs dummies positioned in the driver's seat and in the rear seat behind the driver, (2) an assessment of head-protection countermeasures, and (3) the vehicle's structural performance during the impact. The injury measures are used to determine the likelihood that the driver, the passenger, or both would have sustained serious injury to various body regions. Measures are recorded from the head, neck, chest, abdomen, pelvis, and leg. These injury measures, especially from the head and neck and from the torso (chest and abdomen), are the major components of the vehicle's overall rating. To supplement head injury measures, the movements and contacts of the dummies' heads during the crash are evaluated. High head injury measures typically are recorded when the moving deformable barrier hits a dummy's head during impact. Moreover, a “near miss” or a grazing contact also indicates a potential for serious injury in a real-world crash because small differences in an occupant’s height or seating position, compared with a dummy’s, could result in a hard contact and high risk of serious head injury. The vehicle’s structural performance is based on measurements of intrusion into the occupant compartment around the B-pillar (between the doors). This assessment indicates how well the vehicle's side structure resisted intrusion into the driver’s and rear-seat passenger space. Some intrusion into the occupant compartment is inevitable in serious side crashes.

The overall side rating depends on the risk of injury measured for small female occupants mainly to the head and neck and torso (chest and abdomen); the effectiveness of the occupant compartment in protecting the head; and the vehicle's structure performance during the impact. The overall side rating for any body region, based on the injury measures recorded on the two SID-IIs dummies, is the lowest rating scored for any injury within that region.

Sharing Results with the Public

The Insurance Institute’s rating system provides qualitative ratings of Good, Acceptable, Marginal, and Poor. The Insurance Institute provides one rating for the frontal test and one rating for the side test. Vehicle rating information is available on the Insurance Institute’s Web site, through press releases, and through television coverage. Figure 43 shows how the Insurance Institute communicated its ratings to consumers on the Internet. In addition to the ratings for frontal and side crashes, the Insurance Institute provided the results of various tests, such as those of the vehicle’s structural performance and of injuries to various body regions.

Figure 43: Insurance Institute Rating of a Mid-size Passenger Car

Overall FRONTAL	G
Structure/safety cage	G
Injury measures	
Head/neck	G
Chest	G
Leg/foot, left	A
Leg/foot, right	G
Restraints/dummy kinematics	A

Overall SIDE		P
	Driver	Rear passenger
Injury measures		
Head/neck	P	A
Torso	A	G
Pelvis/leg	P	G
Head protection	P	M
Structure/safety cage		P

P = Poor; M = Marginal; A = Acceptable; G = Good

Source: Insurance Insitute for Highway Safety.

Figure 44 shows how the Insurance Institute presented its ratings to consumers in its *Status Report*. The print version is available only to subscribers, and some of the publications can be downloaded from the Insurance Institute's Web site.

Figure 44: Insurance Institute Crash Ratings Provided to Public in its *Status Report* Publication

Crashworthiness evaluations of midsize 4-door cars

Overall side evaluation		Head protection	Injury measures: Head/neck	Injury measures: Torso	Injury measures: Pelvis/leg	Structure/ safety cage	Overall frontal evaluation
G	driver	G	G	G	A	A	G BEST PICK frontal
	rear passenger	G	G	G	G		
G	driver	G	G	G	G	M	G BEST PICK frontal
	rear passenger	G	G	G	G		
A	driver	G	G	M	G	M	G
	rear passenger	G	G	G	G		
P	driver	P	M	P	G	G	G
	rear passenger	M	G	G	G		
P	driver	G	G	P	P	P	A
	rear passenger	M	G	G	G		

Poor Marginal Acceptable Good

Source: Insurance Institute for Highway Safety.

Note: The names of vehicles that received the crash ratings above were purposely removed.

News magazine television shows, such as *Dateline NBC*, periodically use Insurance Institute crash test results and interview representatives, including the president or chief operating officer, as report segments for their programs.

Australian New Car Assessment Program

The Australian New Car Assessment Program (NCAP) provides information for consumers on the safety performance of new vehicles sold in Australia and New Zealand. The main purposes of the program are to provide new vehicle buyers with independent advice on vehicle occupant protection and to develop strategies for vehicle manufacturers to increase the level of passive safety in their vehicles.[1] The program is funded by a consortium of the state government transport departments of New South Wales, Queensland, Victoria, South Australia, Tasmania, and Western Australia; automobile clubs through the Australian Automobile Association and New Zealand Automobile Association; the Land Transport Safety Authority of New Zealand; and the FIA Foundation for the Automobile and Society.[2] The Australia Commonwealth Department of Transport and Regional Services has established minimum safety standards for vehicles sold in Australia and has conducted joint research projects with NCAP but has not contributed to the support of the crash test program.

The Australia NCAP buys the vehicles that it crash tests directly from dealers, as would any consumer. The program selects vehicles on the basis of (1) actual or projected sales, to target vehicles that are most popular; (2) vehicle model, to account for standard or deluxe models, which may contain more expensive passive safety features such as air bags and advanced restraint systems; (3) new and popular body designs, to select the body design that is most popular or to allow for direct comparisons across different makes and models; (4) market segment, to target individual segments of the market to allow comparisons of results; and (5) vehicle price. Using these selection criteria, the Australia NCAP covers more than 70 percent of the new vehicle fleet by volume. The program also uses European NCAP (Euro NCAP) crash test results. However, the Euro NCAP results are intended to be used as a guide only, because the structure and equipment of the European specification model may differ materially from

[1]Passive safety is the term used to refer to automobile designs and technologies that help mitigate the injury potential in vehicle crashes (sometimes called “crashworthiness”). Passive safety comes from an optimized vehicle structure and vehicle restraint technologies.

[2]The Australia New Car Assessment Program is supported by a consortium of 15 members of the Australian Automobile Association. The membership includes the National Roads and Motorists Association; the Royal Automobile Clubs of Victoria, Queensland, South Australia, Western Australia, and Tasmania; the Automobile Association of the Northern Territory; the FIA Foundation for the Automobile and Society; the state road and transport authorities in New South Wales, Victoria, Queensland, South Australia, and Western Australia; the New Zealand Automobile Association; and the New Zealand Land Transport Safety Authority.

the model of the same name sold in Australia or New Zealand. The Australia NCAP tests and reports on vehicles in seven categories—small, medium, and large passenger cars; luxury cars; four-wheel drive vehicles (SUVs); multipurpose utility vehicles (small trucks); and sports cars.

Testing Conducted

The Australia NCAP's testing has evolved over time. Established in 1992, the Australia NCAP was originally modeled on the U.S. program and began rating vehicles in 1993. Initially, it conducted only a full frontal crash test, but it added an offset frontal test in 1994. In 1999, the Australia NCAP harmonized its tests and assessment procedures with the Euro NCAP through a memorandum of understanding. By harmonizing, it discontinued the full frontal crash test and began conducting the perpendicular side-impact test and pedestrian test. Australia NCAP officials have been considering eliminating the perpendicular side-impact test in favor of a pole test that they believe will more accurately test vehicles of all sizes for occupant protection.

In 2004, the Australia NCAP performed three crash tests and a pedestrian protection test. The three crash tests include the 40 percent offset frontal, the perpendicular side-impact, and the side-impact pole tests. The offset frontal test involves pulling a test vehicle traveling at 40 mph (64 km/h) and crashing it into an offset deformable aluminum barrier. The deformable barrier has a crushable aluminum honeycomb face attached to a solid barrier. The deformable structure resembles the front-end characteristics of another vehicle. Two instrumented 50th percentile Hybrid III dummies (weighing about 194 pounds each) are used to collect data during the crash and are placed in the front driver's and front passenger seats. Two child dummies, representing a 3-year-old and a 1-1/2-year-old child, are placed in the rear seats in appropriate restraints. While Australia NCAP does not use the measurements from the child dummies in its crash test rating, the dummies are included in the tests to maintain alignment with Euro NCAP testing.

The perpendicular side-impact test involves pulling a barrier with a deformable face at about 31 mph (50 km/h) and crashing it into a stationary test vehicle at a 90 degree angle centered on the driver's seating position. The moving deformable barrier has a mass of 2,095 pounds (950 kg) compared with 3,015 pounds (1,367 kg) for the U.S. barrier. One instrumented 50th percentile EuroSID-II dummy (weighing about 176 pounds) is used to collect data during the crash and is placed in the front driver seat. As in the frontal test, to maintain alignment with Euro NCAP's testing, the two child dummies are placed in the rear seats in appropriate restraints.

The pole side-impact test involves propelling a vehicle placed on a platform at 18 mph (29 km/h) into a cylindrical pole. The pole has a diameter of about 10 inches, or about 254 millimeters (mm), and its vertical axis is aligned with the front seat dummy's head. One instrumented 50th percentile EuroSID-II dummy is used to collect data during the crash and is placed in the front driver's seat.

The pedestrian protection test evaluates the interaction of dummy parts and the bumper, hood, and windshield area of a vehicle. Adult and child-size dummy parts are propelled at specified areas of the hood and front bumper of a vehicle to simulate a 25 mph (40 km/h) car-to-pedestrian collision. The test simulates the impact of a lower leg against a bumper, a thigh against the lower edge of the hood, and an adult and a child head against the upper portion of the hood.

Scoring Tests

Frontal tests in the Australia NCAP are scored on the basis of three types of observations–dummy measurements, a vehicle's structural performance, and a post-crash inspection of the vehicle. The injury measurements are recorded from two Hybrid III dummies positioned in the front driver's seat and front passenger seat. The injury assessment evaluates four body regions: (1) head and neck; (2) chest; (3) knee, femur, and pelvis; and (4) legs and feet. Structural performance is based on measurements indicating the amount and pattern of intrusion into the occupant compartment during the test. Dummy injury measurements and vehicle deformation can be compared with predicted values. Evidence of structural collapse can be determined by a post-crash inspection and by viewing a high-speed video recorded from various angles during the crash test. The post-crash inspection and video allow trained inspectors to assess dummy kinematics, evaluate the evidence of interior contacts, and inspect safety belts, seats, and air bags to ensure they operated as intended.[3] For example, according to Australia NCAP officials, air bag performance could be compromised by the dynamics of a crash in ways that might not be evident from a post-crash inspection but could be revealed through careful analysis of the video.

[3]Dummy kinematics (movement) are evaluated by how well the safety belt and air bag perform and interact with the steering column and other vehicle parts to control movement.

Each body region receives a score based on the dummy measurements, the vehicle deformation data, and the findings of the post-crash inspection (using modifiers). For example, excessive rearward movement of the steering wheel could lower the head score by a point to reflect identified risks. Other modifiers include lack of air bag stability, steering column movement, A-pillar movement, structural integrity, hazardous structures in the knee impact area, and brake pedal movement.[4]

For the side-impact and pole tests, the scores are based on injury measurements recorded on one EuroSID-II dummy positioned in the front driver's seat. The injury assessment evaluates four body regions: the head, ribs, abdomen, and pelvis. A post-crash inspection and high-speed video are also used to evaluate structural collapse.

A summary star rating shows the protection level indicated by the front and side-impact tests together. The summary score for the two tests is based on the point scores achieved in each test. Sixteen points can be achieved in the frontal test and 18 points in the side tests, for a maximum of 34 points. Two of the 18 points available in the side test come from the optional pole test, which assesses only one body region—the head. Each of the four body regions in the frontal test could receive a maximum score of 4 points, for a cumulative score of 16 points. Similarly, the four body regions in the side-impact test could receive a maximum score of 4 points, for a cumulative score of 16 points. If a vehicle has head-protecting side air bags, the manufacturer of the vehicle has the option of accepting a side impact pole test, through which 2 bonus points can be earned.

The offset and side-impact scores are added together to produce an overall score with a maximum of 32 points. In addition, if a pole side test is conducted and shows good head protection, then 2 extra points can be earned, and up to 3 more points can be earned for having a safety belt reminder system. The points are translated into stars, as shown in table 3.

[4]The A-pillar is the side support for the roof that is in the front of the passenger compartment and the B-pillar provides side roof support in the center of the passenger compartment just behind the door.

Table 3: Scoring Basis for Australia NCAP Frontal and Side Star Ratings

Star rating	Minimum score in offset test	Minimum score in side impact test	Minimum combined score (including pole test)
1	-	-	0.5
2	1.5	1.5	8.5
3	4.5	4.5	16.5
4	8.5	8.5	24.5
5	12.5	12.5	32.5[a]

Source: Australian NCAP, Australian Automobile Association.

[a]To earn five stars a vehicle must achieve at least 1 point in the optional pole test (maximum 2 points). This is an Australia NCAP requirement.

If the injury score for the head, chest, abdomen, or pelvis is 0, then there is a high risk of a life-threatening injury. A warning note is added to the overall rating to highlight concern that there is a serious risk of injury in at least one vulnerable body region. The regions are the head or chest for the frontal impact test and the head, chest, abdomen, or pelvis for the side-impact test.

For the pedestrian test, the scores are based on adult and child-size dummy parts (head and lower limbs) used to assess the severity of impact. The two different size dummy heads are tested at six areas of the hood, and the lower limbs for an adult and child are tested at three areas, for a total of 18 impacts tested for each vehicle. Based on the injury measurements recorded from the dummy parts, each impact can receive up to 2 points, and the maximum number of points that can be received is 36, as shown in table 4.

Table 4: Australia NCAP Point System for the Pedestrian Test

Type of test	Impact locations	Maximum Points
Child head	6	12
Adult head	6	12
Upper leg	3	6
Lower leg	3	6
Total	**18**	**36**

Source: Euro NCAP.

A separate rating of one to four stars shows the level of pedestrian protection. The score reflects the results of the 18 impacts of the dummy parts against the specified areas of the bumper and hood. These results are summed to provide an overall score. The pedestrian protection star rating for a vehicle is based on the number of points received, or a maximum of 36 points. The points are translated into stars, as shown in table 5.

Table 5: Scoring Basis for Australia NCAP Pedestrian Rating

Star rating	Points
0	0
1	1-9
2	10-18
3	19-27
4	28-36

Source: Euro NCAP.

Sharing Results with the Public

The Australia NCAP's reporting of results to the public has evolved over time. Initially, the program reported the raw test results for the head, chest, and legs. The program also portrayed the risk of injury in each area as high (red), medium (yellow), or low (green) and graphically represented the risk on an outline of a human figure in each area. When the offset frontal crash test was added in 1994, its results were reported in the same way. Also in 1994, the program began publishing tables comparing the results of the vehicles tested.

In 1995, the Australia NCAP began summarizing full frontal and offset frontal head, chest, and leg test results by using bar charts to represent the percentage of risk of a life-threatening injury to drivers and to passengers. In 1996, the program began differentiating between upper and lower leg injuries, reported the results separately, and adopted the Insurance Institute for Highway Safety rating scale of Good, Acceptable, Marginal, and Poor. However, the program combined the scores for the full frontal driver and passenger tests with the score for the offset frontal driver test to arrive at an overall vehicle rating. According to Australia NCAP officials, subsequent research with focus groups supported the decision because the results indicated that consumers wanted the safety information in a simplified, summary form. In November 1999, to align with the Euro NCAP, the Australia NCAP first used a five-star system to report crash test performance. This system provided an overall rating along with a bar chart that enabled consumers to differentiate between vehicles with different scores that received the same number of stars.

Today, the Australia NCAP makes vehicle rating information available on its Web site, through press releases, and through a safety brochure. Figure 45 shows how the program communicates its overall and pedestrian ratings to consumers on the Internet.

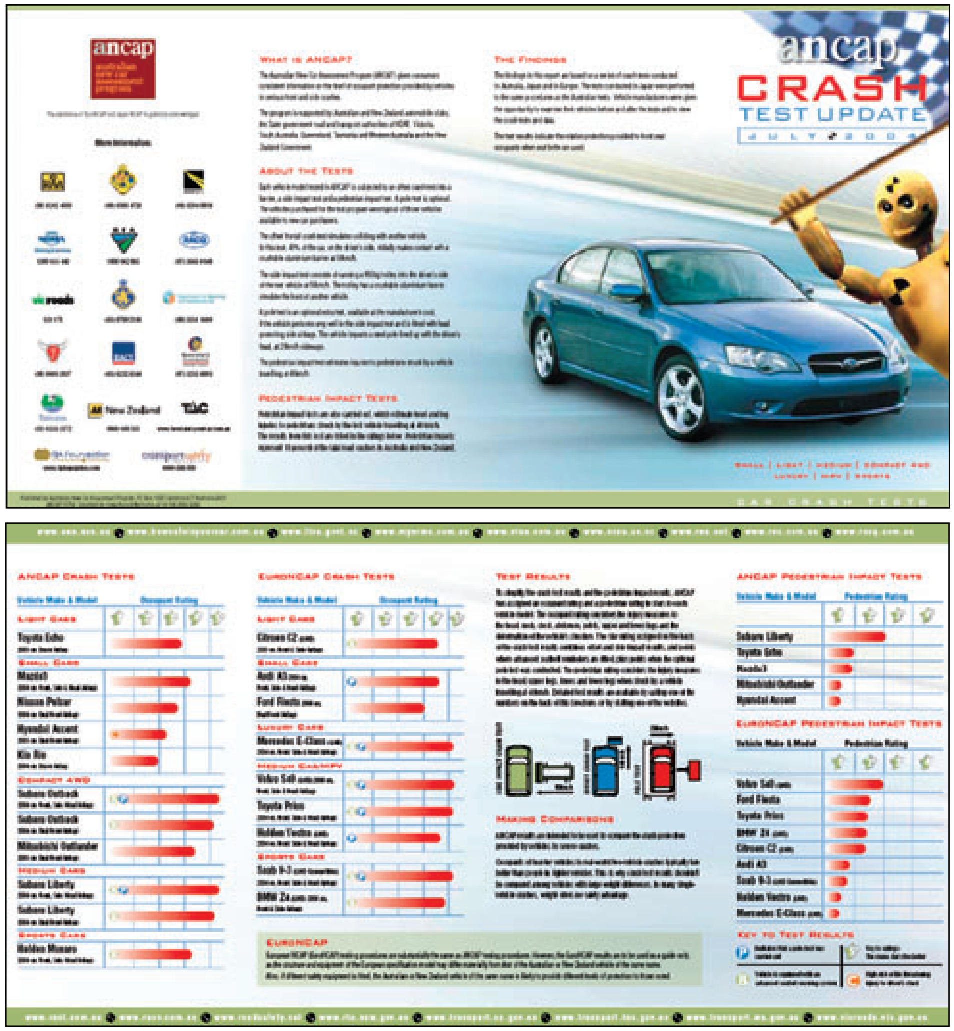
Figure 45: Example of Australian NCAP Rating of a 2004 Mid-size Passenger Car

Overall evaluation	★★★★★
Pedestrian rating	★

Source: Australian NCAP, Australian Automobile Association.

According to Australia NCAP officials, the Australia NCAP also publishes the *Crash Test Update*, a brochure that provides new crash test results about twice a year. In addition to an overall star rating for each type of tested vehicle, the brochure presents star ratings with comparative bar graphs showing how well vehicles scored within the star levels. Figure 46 shows the brochure Australia NCAP officials provide for consumers.

Figure 46: Australian NCAP July 2004 *Crash Test Update* Brochure



Source: Australian NCAP, Australian Automobile Association.

European New Car Assessment Programme

The European New Car Assessment Programme (Euro NCAP) provides information for consumers with an assessment of the safety performance of some new vehicles sold in Europe. The program was established and began rating vehicles in 1997. Its main purposes are to make comparative safety rating information available to consumers for vehicles in the same class and to provide incentives for manufacturers to improve the safety of their vehicles. The program is operated and funded by a consortium of six European governments—Catalonia, France, Germany, the Netherlands, Sweden, and the United Kingdom—and of various motoring and consumer organizations throughout Europe, including the General German Automobile Association (*Allgemeiner Deutscher Automobil-Club e V*); German Federal Ministry for Traffic, Building and Housing (*Bundesministerium für Verkehr, Bau- und Wohnungswesen);* United Kingdom Department for Transport; Dutch Ministry of Transport—Public Works and Water Management; FIA (*Fédération Internationale de l'Automobile*) Foundation for the Automobile and Society; Catalonia Department of Employment and Industry (*Departament de Treball i Indústria*); International Consumer Research and Testing; French Ministry of Equipment (*Ministère de l'Equipement*); Swedish Road Administration; and Thatcham. The Euro NCAP crash testing program was modeled from the U.S. NCAP (1979) and the Australia NCAP (1992).

The decision process for Europe involves the use of technical working groups and subgroups to examine vehicle safety issues and make recommendations for change. Such groups are investigating the feasibility of incorporating such safety features as braking and handling, visibility and lighting, ergonomics, driver information, and whiplash into Euro NCAP. The automobile industry and public safety organizations may be involved in providing research or opinions, but the committees are free to make decisions they believe appropriate. Generally, decisions are made through two working groups, one for primary safety systems and one for secondary safety systems, that perform research and analysis. The Euro NCAP allows industry representatives to participate in the discussions of the subgroups of its two technical working groups. Also, the technical working groups and automobile manufacturers engage in direct dialogue in industry liaison meetings to address issues such as whiplash.

Each member of the Euro NCAP is required to sponsor at least one vehicle for crash testing each year. The vehicles are normally acquired by the Euro NCAP Secretariat by various methods, including purchasing directly from dealers and selecting from manufacturers' production lines. The Euro NCAP tests vehicles in categories—superminis, family cars, executive cars, roadsters, off-roaders, and multipurpose vehicles. The following further describes (1) the testing conducted, (2) the methods used for developing the vehicle crash ratings, and (3) the approaches taken to share the safety results with the public.

Testing Conducted

The Euro NCAP performs three vehicle crash tests, a pedestrian protection test, and a child restraint test. The three crash tests are the 40 percent offset frontal test, the perpendicular side-impact test, and the side-impact pole test. The frontal test involves a moving test vehicle traveling at 40 mph (64 km/h) crashing into an offset deformable aluminum barrier where 40 percent of the vehicle's width engages the barrier on the driver's side. The deformable barrier used is a crushable aluminum honeycomb face attached to a solid barrier. The deformable structure is designed to replicate the essential characteristics of the front end of another car. Two instrumented 50^{th} percentile Hybrid III dummies (each weighing about 194 pounds) are used to collect data during the crash and are placed in the front driver's and front passenger seats.

In the side-impact test, a moving trolley with a deformable barrier is towed at about 31 mph (50 km/h) into a stationary test vehicle at a 90 degree angle centered on the driver seating position. This test simulates a side-impact collision. The moving deformable barrier has a mass of 2,095 pounds (950 kg) compared with 3,015 pounds (1,367 kg) for the U.S. barrier. The European barrier's face is smaller and much softer than the face of the barrier used in the U.S. NCAP. However, Euro NCAP officials said that because the barrier strikes a vehicle at a 90 degree angle, their side-impact test is more aggressive than NHTSA's side-impact test. One instrumented 50^{th} percentile EuroSID-II dummy (weighing about 176 pounds) is used to collect data during the crash and is placed in the front driver seat.

The pole side-impact test consists of a vehicle placed on a platform and propelled at 18 mph (29 km/h) into a cylindrical pole. The pole has a diameter of 10 inches (254 mm), and its vertical axis is aligned with the front seat dummy's head. One instrumented 50^{th} percentile EuroSID-II dummy is used to collect data during the crash and is placed in the front driver's seat.

The pedestrian protection test evaluates the impact of dummy parts against the bumper, hood, and windshield areas of a vehicle. Adult and child-size dummy parts are propelled at specified areas of the hood and front bumper of a vehicle to simulate a 25 mph (40 km/h) car-to-pedestrian collision. The test simulates the impact of a lower leg against a bumper, a thigh against the lower edge of the hood, and adult and child heads against the upper portion of the hood.

The child protection test evaluates a vehicle's ability to protect children by assessing the performance of the vehicle's child restraint system in front and side-impact tests. During these tests, two child-size dummies are placed in the manufacturer's recommended child restraints in the rear seat of a vehicle. In the frontal test, a dummy with the weight and size of an 18-month-old child (about 24 pounds) is placed behind the passenger, and a dummy with the weight and size of a 3-year-old child (about 33 pounds) is placed behind the driver. In the side-impact test, the positions of the two dummies are reversed.

Scoring Tests

The Euro NCAP bases its assessment of crashworthiness on three types of observations made during or after a crash test: (1) dummy measurements of forces to the body, used to assess injuries; (2) five measurements of vehicle deformation, used to assess the vehicle's structural performance; and (3) post-crash inspection data for six areas, which are termed "modifiers" because problems in any one of them may result in a penalty that modifies the vehicle's assessment score.

In the offset frontal crash test, two instrumented Hybrid III dummies are positioned in the front driver's seat and front passenger seat to measure injuries to four regions of the body: (1) head and neck; (2) chest; (3) knee, femur, and pelvis; and (4) legs and feet. The five structural measurements provide vehicle deformation data, indicating the amount and pattern of intrusion into the occupant compartment. The post-crash inspection provides information about air bag stability, steering column movement, A-pillar movement, structural integrity, hazardous structures in the knee impact area, and brake pedal movement. The dummy measurements and the vehicle deformation data are combined to generate a score—up to four points—for each body region. This score may be modified by findings from the post-crash inspection.

In the side-impact and pole tests, injury measurements are recorded on one EuroSID-II dummy positioned in the front driver's seat. These measurements provide data for assessing injuries to four body regions: the head, ribs, abdomen (chest or thorax), and pelvis. No structural or post-crash inspection data are gathered during these tests. Thus, the score for each body region is based on the dummy measurements alone.

In the pedestrian test, readings taken from the adult and child-size dummy parts (head and lower limbs) are used to assess the risk of injury. The two different size dummy heads are tested at six different areas of the hood, and the lower limbs are tested at three areas, for a total of 18 impacts tested for each vehicle. Depending on the injury measurements recorded from the dummy parts, each impact can receive up to 2 points, and the maximum number of points that can be received is 36 points. See table 6.

Table 6: Euro NCAP Pedestrian Test Assessment Criteria

Type of test	Impact locations	Maximum points
Child head	6	12
Adult head	6	12
Upper leg	3	6
Lower leg	3	6
Total	**18**	**36**

Source: Euro NCAP.

The child protection test consists of three assessments that are based on (1) dummy measurements and dynamic evaluations, (2) marking requirements for child restraint systems, and (3) a vehicle-based assessment. Points reflect the results of the three assessments. The first assessment uses dummy measurements taken from the two child dummies in the frontal and side tests, together with dynamic evaluations of ejection from the child restraint system and head contact within the vehicle. Another assessment evaluates whether the markings on the child restraint fully comply with the test requirements. The final assessment evaluates how easily the child restraint system can be used inside the vehicle.

A combined star rating is used to show the protection level achieved in the offset frontal and side impact tests together. The score for this rating is the sum of the scores achieved in these two tests—up to 16 points for the frontal test and up to 18 points for the side test, for a maximum of 34 points. For both tests, each of four body regions can receive up to 4 points, for a cumulative score of 16 points per test, and for the side test, 2 additional points can come from an optional pole test, which assesses protection for only one body region—the head. The pole side-impact test is an option for the manufacturer of a vehicle that has head-protecting side air bags. Finally, up to 3 more points can be earned for having a safety belt reminder system. The points are translated into stars, as shown in table 7.

Table 7: Euro NCAP Front and Side-Impact Star Rating System

Star rating	Points
1	1-8
2	9-16
3	17-24
4	25-32
5	33-40

Source: Euro NCAP.

If the crash tests demonstrate a high risk of a life-threatening injury, indicated by an injury score of 0 for the head, chest, abdomen, or pelvis, then a warning note is added to the overall rating. Euro NCAP uses a “struck star” to convey this warning. When the star is struck through, it highlights concern that there is a serious risk of injury in at least one vulnerable body region. These concerns are based on data from the offset frontal test for the head or chest and from the side-impact test for the head, chest, abdomen, or pelvis. A star cannot be struck because of findings from post-crash inspections showing the effects of modifiers.

Euro NCAP provides a separate rating of one to four stars to show the level of pedestrian protection. The score for this rating sums the results of the 18 impact tests of dummy parts propelled into the specified areas of the bumper and hood. A vehicle can earn up to 2 points for each test, for a maximum of 36 points. The points are translated into stars, as shown in table 8.

Table 8: Scoring Basis for Euro NCAP Pedestrian Ratings

Star rating	Points
0	0
1	1-9
2	10-18
3	19-27
4	28-36

Source: Euro NCAP.

Euro NCAP also provides a separate rating of one to five stars to show the level of child protection. Currently, the tests on which this rating is based can produce a maximum of 49 points, but the rating scale allows further points to be awarded for future developments in child protection. Table 9 shows how the points are translated into stars.

Table 9: Scoring Basis for Euro NCAP Child Protection Star Ratings

Star rating	Points
0	0
1	1-12
2	13-24
3	25-36
4	37-48
5	49-60

Source: Euro NCAP.

Sharing Results with the Public

Vehicle rating information is available on the Euro NCAP Web site, through press releases, and through popular consumer magazines. Figure 47 shows the ratings that the program makes available to consumers on the Internet—a front and side-impact rating, a pedestrian protection rating, and a child restraint protection rating. The pedestrian protection rating is intended to encourage manufacturers to start designing for pedestrian protection. The child restraint protection rating is based on a vehicle's performance using the child seats recommended by that vehicle's manufacturer. Specifically, the rating depends on the fitting instructions for the child seats, the car's ability to accommodate the seats safely, and the seats' performance in front and side impact tests.

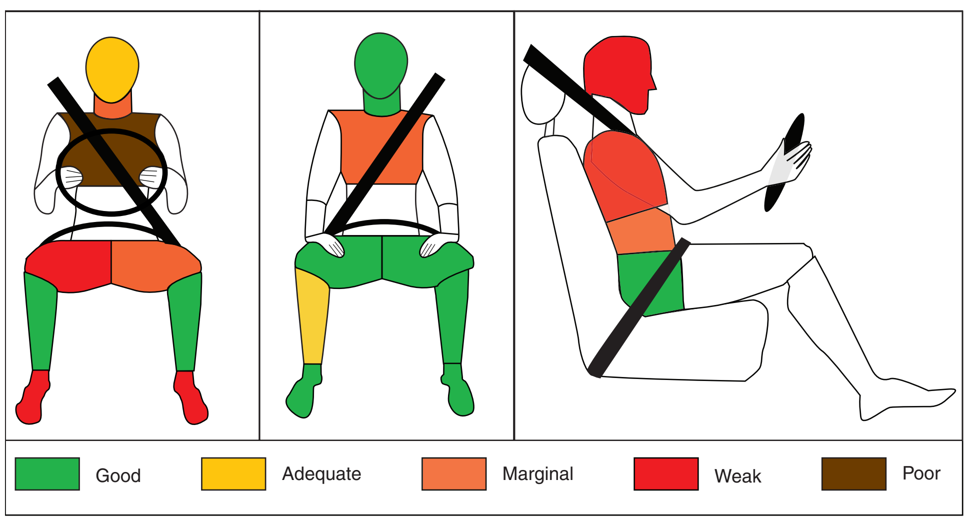
Figure 47: European NCAP Rating of a 2004 Mid-size Passenger Car

Year	Front and Side Impact Rating	Pedestrian Rating	Child Protection Ratings
2004			

Source: Euro NCAP.

In addition to star ratings, the Euro NCAP uses color-coded dummy injury diagrams to show how specific body regions performed in the frontal, side, and pole crash tests. The color-codes are: Good (green), Adequate (yellow), Marginal (orange), Weak (red), and Poor (brown). The colored injury diagrams display the risk of injury to the various body regions, as shown in figure 48.

Figure 48: Dummy Injury Diagrams of Driver and Passenger in Frontal Test, and Driver in Side Test



Source: Euro NCAP.

The Euro NCAP divides its testing into two phases and releases the results twice a year, in November and June. The results are posted on the program's Web site, issued in press releases, and published by *What Car?* (a British car magazine), *Which? Car* (a magazine owned and produced by British consumer associations), and the General German Automobile

Association (ADAC) magazine. Other consumer magazines in Europe provide additional crash test information.

Japan New Car Assessment Program

The National Agency for Automotive Safety and Victims' Aid (NASVA) conducts the Japan NCAP and is funded by the government through the Ministry of Land, Infrastructure, and Transportation. According to NASVA officials, the Automobile Assessment Committee, made up of 12 members appointed by the ministry, oversees the program. The committee includes four working groups, each focusing on specific areas: crash tests, tests of active safety systems such as brakes, pedestrian tests, and tests of child restraint systems. NASVA officials conduct research in these areas and propose changes to the program that must be approved by the committee. NASVA officials said that the Japan NCAP is funded through appropriations from the Compulsory Automobile Liability Insurance that every car owner must pay.

The Japan NCAP began testing vehicles in 1995, starting with a full frontal collision test. The program added the side-impact test in 1999 and the offset frontal test in 2000. Vehicles are selected for testing on the basis of sales. By 2004, the program had evaluated 79 vehicles representing over 80 percent of those that were on the market at that time. Ratings for 60 of these vehicles were carried over from previous years' testing, and ratings for 19 vehicles were based on tests performed in 2003. Testing is conducted at the Japan Auto Research Institute under the control and supervision of NCAP officials. The institute crash tests cars, minivans, and SUVs and performs other NCAP tests, such as the brake and pedestrian tests. The research laboratory has one track for conducting frontal and side-impact tests. In these tests, either the vehicle is towed to strike the barrier, or, in side-impact tests, the barrier is moved to strike the vehicle. In 2005, the institute plans to open a new test facility with multiple tracks that will enable researchers to conduct vehicle-to-vehicle crash tests at various angles.

Testing Conducted

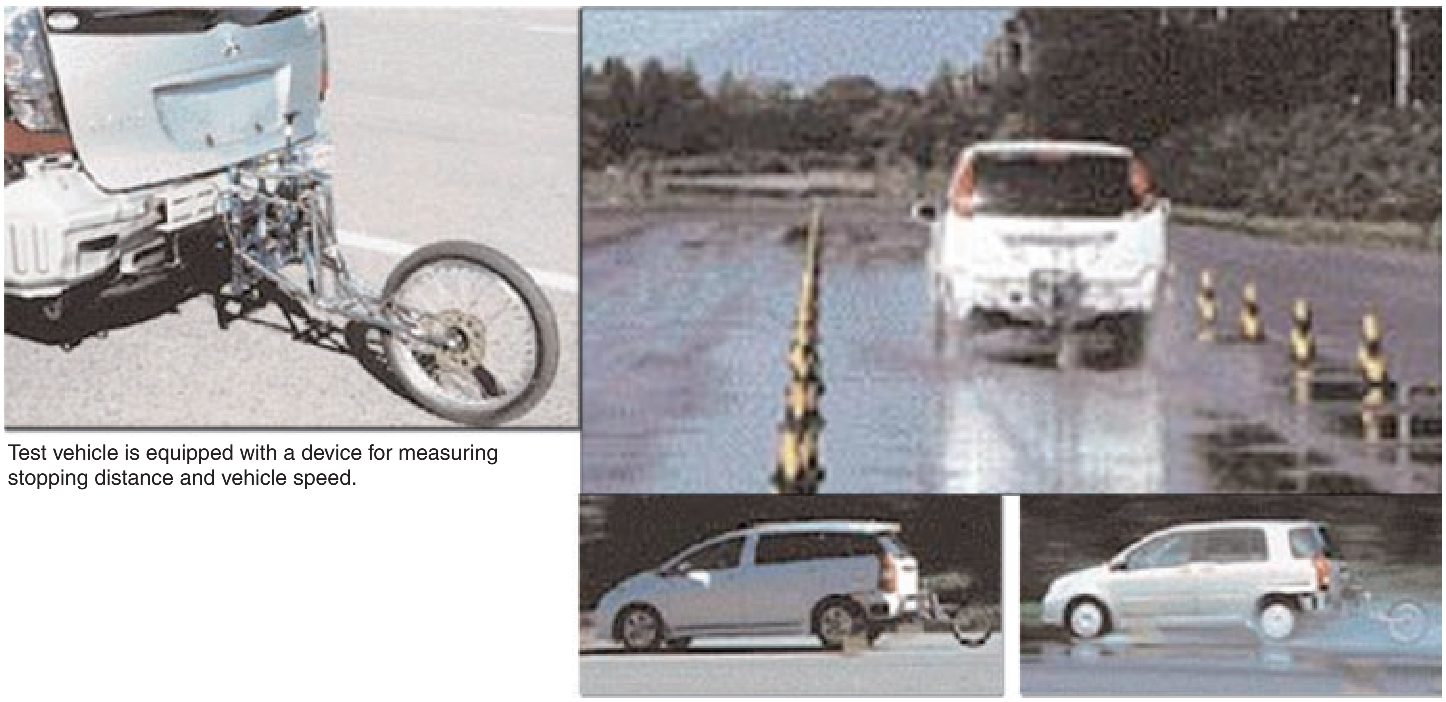
The Japan NCAP performs a variety of safety tests and rates vehicles according to the results. It conducts three types of crash tests—a full frontal test, an offset frontal test, and a perpendicular side-impact test. In addition, it performs a braking test, which measures the performance of an active safety system that enables a driver to avoid a crash. The program further assesses how easily doors are opened and occupants are removed after a crash and how well vehicles perform if they strike pedestrians. The program also evaluates how well child safety seats perform.

The Japan NCAP is the only program that conducts both the full frontal and the offset frontal crash tests. Together, the two tests assess both the potential for injuries caused by intrusion and the effectiveness of the vehicle's restraint system. The full frontal test is performed by towing a vehicle to collide with a rigid barrier at 55 km/h (about 34 mph). This test simulates a head-on collision between two vehicles of the same size traveling at the same speed. The offset frontal test involves towing a vehicle into a deformable barrier that represents the front end of another vehicle and simulates a head-on collision of two vehicles traveling at 40 mph. In this test, only a portion of the front end (40 percent) engages the barrier, and the impact on the vehicle body is greater than the full frontal test because much of the crash energy is distributed to one side of the vehicle. Thus, there is the possibility of substantial vehicle deformation, which makes this test suitable for evaluating injuries caused to occupants by intrusion into the occupant compartment. The program uses the Hybrid III dummy that represents a man of about 5 feet 10 inches tall and weighing about 185 pounds.

The side-impact test propels a moveable deformable barrier weighing about 2,090 pounds into the driver's and passenger's side of the vehicle, simulating a perpendicular collision at 55 km/h (about 34 mph). The barrier is shaped like the front end of a car, and because it is not rigid, its performance is intended to simulate a vehicle's response in an actual collision. A EuroSID-I dummy is placed in the driver's seat. This dummy is the same height as the Hybrid III dummy but weighs about 20 pounds less. The EuroSID-I dummy was designed to measure the risk of injury to the head, chest, abdomen, and pelvis.

The Japan NCAP conducts a braking performance test that measures how far a vehicle travels before it stops and how stable it is at the time of braking when it is stopped abruptly while traveling at about 62 mph. The braking test is a test of an active safety system because it enables the driver to avoid a crash. The test is performed under wet and dry road conditions for a vehicle with a driver and a weight on the front passenger seat. To ensure consistent testing, Japan NCAP officials said, the dry road surface temperature must be 95.0 degrees plus or minus 18.0 degrees Fahrenheit and the wet road surface temperature must be 80.6 degrees plus or minus 9.0 degrees Fahrenheit because the temperature of the road surface affects the distance it takes to stop the vehicle. Japan NCAP officials also said that all braking tests must be performed at the same location because road surfaces vary and surface differences could affect test results. Professional drivers conduct the tests, and the speed of the vehicle and force with which the drivers depress the brake pedal are monitored electronically to ensure consistency. Three braking tests are conducted to be sure that the result is not due to a flaw in the testing process. Figure 49 illustrates the braking test.

Figure 49: Test Vehicle Undergoing Brake Tests Under Dry and Wet Conditions

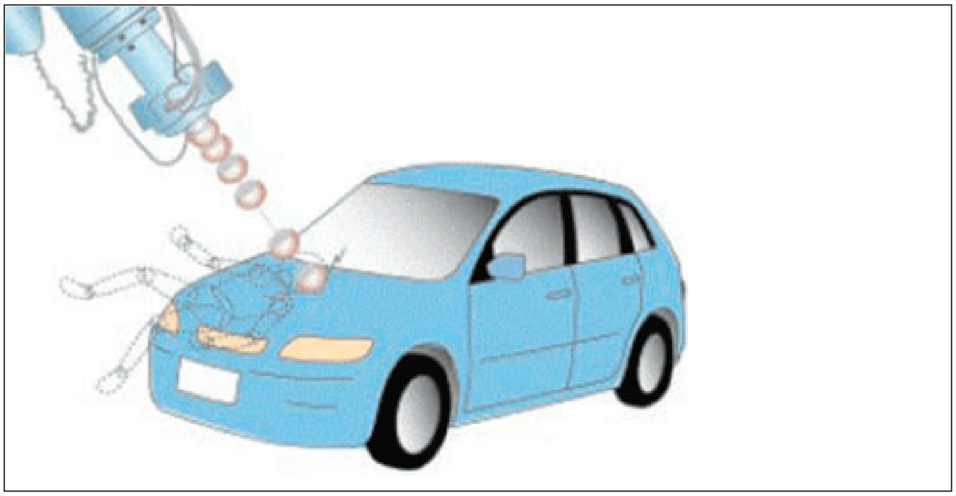


Test vehicle is equipped with a device for measuring stopping distance and vehicle speed.

In addition, the Japan NCAP assesses and scores the ease with which doors can be opened and the dummies removed after a crash test. The purpose of the accessibility assessment is to rate how easily emergency responders can assist injured persons. The rating is based on whether the doors can be opened with one hand, two hands, or whether tools are needed to open the doors.

The pedestrian test measures the effect of a pedestrian being hit by a vehicle traveling at about 22 mph if the pedestrian's head strikes part of the hood or windshield. This test was initiated because pedestrian fatalities represent a high percentage of total vehicle fatalities in Japan. Dummies modeling the head of an adult or a child (head impactor) are projected toward the car hood from a testing machine. The force received by the head impactor is measured and then evaluated using a head injury criterion. The test is conducted on multiple points on each car, and the impact angles differ according to the shape of the front part of three types of vehicles—sedan, SUV, and van. Figure 50 illustrates how the test is performed.

Figure 50: Pedestrian Head Impact Test and Target Area



Note: The distance between the ground and where the pedestrian's head hits the car in crashes is called the wrap-around distance, which is measured according to the length of that area. The location of the impact area for adult's and children's heads is based on the data from actual crash data.

The pedestrian test is conducted on vehicles with three different body types, as shown in table 10.

Table 10: Japan NCAP Vehicle Types Used for Pedestrian Test

Vehicle type	Definition
Sedan	With the hood leading edge height less than 835 mm
SUV	With the hood leading edge height more than 835 mm
Van	With the hood angle more than 30 degrees

Source: Japan NCAP, National Agency for Automotive Safety and Victims' Aid.

The Japan NCAP also assesses the safety performance of child seats in a car crash and the ease of using the seats. Child seats are installed in the rear passenger seats of a test vehicle stripped down to its body frame. The test uses dummies to represent a 9-month-old child and a 3-year-old child. The test vehicle is placed on a sled and subjected to a shock identical to the test speed used in the full frontal crash test.

Scoring Tests

The Japan NCAP measures injuries to the head, neck, chest, and upper (femur) and lower (tibia) legs for both the full frontal and offset frontal crash tests. Points vary by body region, from 2 points for upper and lower leg injuries to 4 points for head, neck, or chest injuries, according to the extent of injuries as measured by crash test dummies. Vehicle deformation is measured after the crash test, and if certain limits are exceeded, a point is deducted from the score for one body area, according to where the deformation occurred. In addition, weighting factors are assigned according to the frequency of injuries to these body areas in vehicle crashes. The weighted points for each body area are then combined to arrive at separate total point scores for the driver and the passenger in full frontal and offset frontal crash tests. The maximum score that a vehicle can achieve is 12 points because of the way the injuries are weighted.

For the side-impact crash test, the Japan NCAP measures injuries to the driver's head, chest, abdomen, and pelvis.[1] Four points are assigned for each body area and then weighted according to the incidence of injuries in this type of accident, with lesser weights assigned to the abdomen and pelvis than to the head and chest. Again, the maximum score that a vehicle can achieve is 12 points, because of the way injuries to the driver are weighted.

The Japan NCAP is the only program that adjusts its test results by weighting the injury scores according to historical crash data. NCAP officials said they can do this because the police are well trained to investigate every accident and provide thorough reports to the government.

For the pedestrian test, a series of head injury scores is used to assign injury probability levels from 5 (the best) to 1 (the worst). The results are then combined to arrive at an overall score. According to NCAP officials,

[1]The side-impact crash test can also be performed on the passenger side of the vehicle, but the rating applies to only one occupant position.

vehicles with hoods that are more flexible and compress upon impact can receive better scores than those that are rigid and leave no room between the hood and the engine for the impact to be absorbed.

Child seats are evaluated according to their performance in a collision and their ease of use. For the collision test, overall ratings of Excellent, Good, Normal, and Not Recommended are assigned. The ratings are primarily based on the head and chest injury scores taken from the dummies used in the test. Five child seat specialists assessed the ease of installation, the ease of understanding the instructions, the product warning labels and markings to aid in installation, the structural design, and the ease of securing the child in the seat. For each area, the specialists assigned points, from 5 (the best) to 1 (the worst). The scores given by the specialists were averaged and reported separately for each area.

Sharing Results with the Public

Initially, the Japan NCAP used a four-letter system to rate vehicles' crashworthiness, in which "A" reflected the highest scores for performance and "D" reflected the lowest scores. As vehicles' performance improved, more and more vehicles achieved an "A" rating. To help consumers better differentiate vehicles' performance, NCAP officials expanded the range of ratings to include AA and AAA. This same scale was later converted to six stars. Many vehicles have achieved a five-star rating, and some have received a six-star rating for occupant protection. In addition to the star ratings, the Japan NCAP reports the percentage of possible points that each vehicle received and provides a bar chart indicating how well the vehicles performed in these tests.

Figure 51 shows how the Japan NCAP communicates its ratings to consumers as two overall ratings—one for the driver's seat and one for the passenger's seat. The overall safety rating for the driver's seat combines the results of the two frontal crash tests (full and offset) and the side-impact test. The overall safety rating for the passenger's seat includes the results of the full frontal and offset frontal tests. The Japan NCAP also provides consumers with star ratings by type of test for the driver's and passenger's seats and makes the detailed test information available to consumers for each crash test, as shown in figure 52. Consumers are also provided with ratings on how difficult it was to open the door after the test (openability) and how difficult it was to retrieve the dummy from the vehicle after the crash test (rescueability), as shown in figure 53 and 54 respectively. Although not shown as part of the crashworthiness rating, the ratings for the pedestrian tests are provided, as well as the ratings for the child restraint seats (Excellent, Good, Normal, and Not Recommended). Furthermore, the Japan NCAP has provided consumers with comparative information on vehicles' braking capability on wet and dry pavements.

Figure 51: Japan NCAP Rating of a 2003 Mid-sized Passenger Car

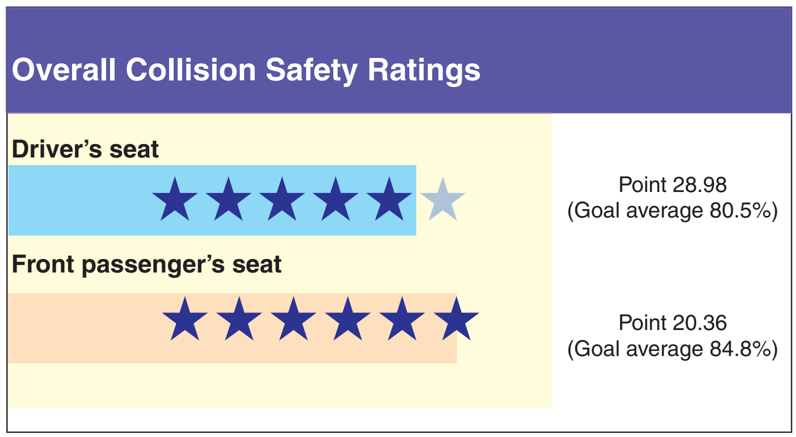
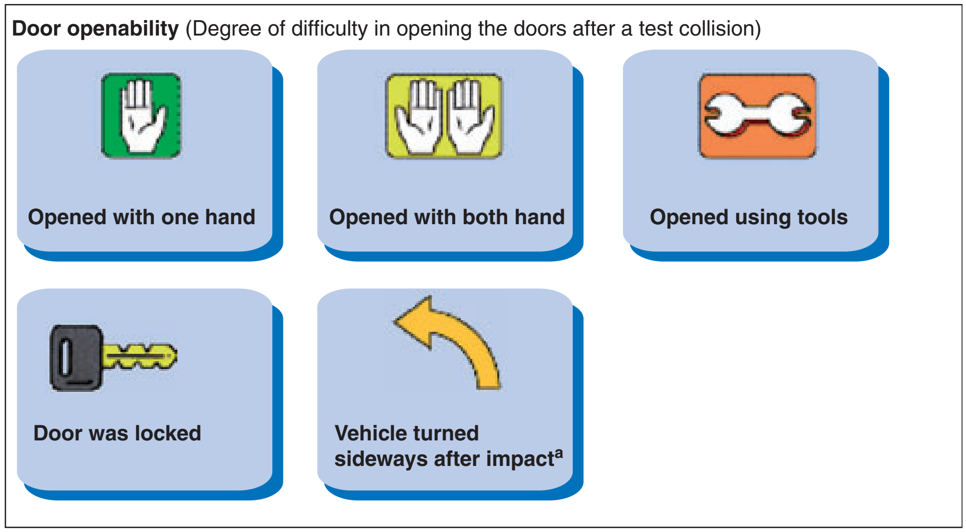


Figure 52: Example of Japan NCAP Detailed Full Frontal Data Available for a 2003 Test

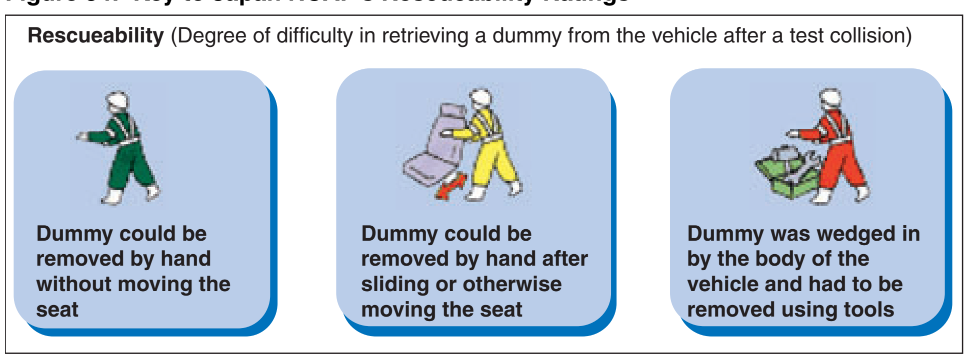
Passenger protection performance			Head	Neck			Chest		Legs			Body Deformation		Door open ability fuel leakage after collision	Rescue ability
	Level 1 2 3 4 5		Injury value [HIC]	Shearing load [kN]	Tensile load [kN]	Moment of extension [Mm]	Restart accelera-tion [G-3 mm/sec]	Chest displace-ment [mm]	Femur load [kN] Right leg / left leg	Right tibia Upper TI / Lower TI	Left tibia Upper TI / Lower TI	Steering column destination mm Roof displacement / Upper displacement	Brake pedal destination mm Rear displacement / Upper displacement		
Drivers seat	Level 3	8.33 (69.4%)	777.6	0.57	1.78	36.57	50.13	40.85	0.10 2.10	0.58 0.65	0.60 0.58	0 59	25 11		
Front passenger seat	Level 3	8.61 (71.7%)	365.5	.95	1.58	55.28	50.14	32.55	2.19 0.22	0.47 0.48	0.66 0.32				

Figure 53: Key to Japan NCAP's Door Openability Ratings



[a]At times, a vehicle may turn sideways (roll over) after a side impact. This test is performed to measure how well passengers are protected when a vehicle is hit while stopped; it is not intended to evaluate the stability of the vehicle while it is in motion.

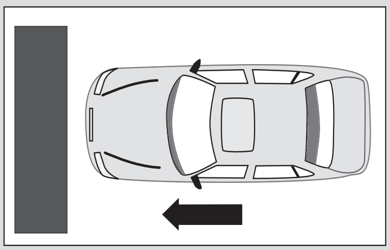
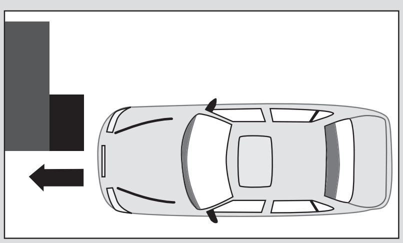
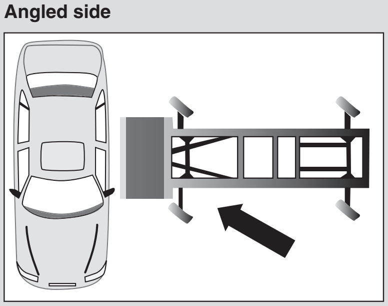
Figure 54: Key to Japan NCAP's Rescueability Ratings



The Japan NCAP publicizes ratings through the NASVA Web site and publishes a brochure that contains summary information on vehicle ratings. In addition to the summary ratings, detailed information for each vehicle tested is posted on the Web site and published in a book by NASVA every year. The Japan Automobile Federation also publishes NCAP vehicle ratings in its magazine and posts the information on its Web site. According to Japan NCAP officials, vehicle ratings and new tests under the program are further publicized in television specials. According to NASVA officials, the public response was very positive after these specials because the number of hits to NASVA Web site increased by 15 to 20 percent in the few days after each broadcast.

Different Types of Tests Used by the Programs

Table 11: Description of Different Types of Tests Used by the Programs

Test type	Description of test	Assessment	Considerations
Frontal tests			
Full-frontal test  Source: GAO.	The test vehicle's entire front end is crashed into a fixed rigid barrier at 35 miles per hour (mph), which is equivalent to a head-on collision between two similar size vehicles, each moving at 35 mph. Only the U.S. NCAP and Japan currently conduct this test.[a]	The test assesses the ability of vehicle restraint systems, such as safety belts and air bags, to restrain occupants. The test maximizes the energy absorbed by the front of the vehicle so that the occupant compartment is more likely to remain intact.	Test results cannot be compared between vehicles of different weight classes.
Off-set test  Source: GAO.	The test vehicle is the equivalent of two vehicles of the same weight crashing into each other. The vehicle is crashed into a deformable barrier at 40 mph where approximately 40 percent of the vehicle's width makes contact with the barrier. Australia, Europe, Japan, and the Insurance Institute currently conduct this test.	The test assesses a vehicle's structural integrity and its ability to manage the energy generated in the crash entirely on the driver's side of the vehicle. This type of crash forces a smaller area of the vehicle's structure to absorb the energy from the crash.	Test results cannot be compared between vehicles of different weight classes.
Side tests			
Angled side  Source: GAO.	The test vehicle is struck by a moving deformable barrier at 38.5 mph at an angle. Both the barrier and the driver's side of the vehicle are parallel, so that the entire face of the barrier impacts the side of the vehicle. Only the U.S. NCAP currently conducts this test.	The test represents an intersection-type collision. The barrier striking the test vehicle is shaped like a passenger car and is about the size of a medium passenger car, weighing 3,015 pounds.	Test results can be compared across vehicle weight classes because each vehicle is struck by a barrier of the same size and weight. The test does not assess the risks of head injury from side impacts from vehicles like SUVs and pickups.

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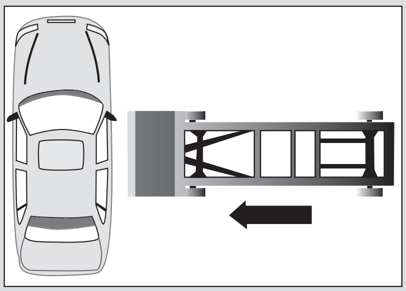
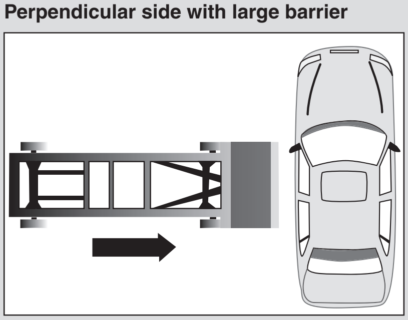
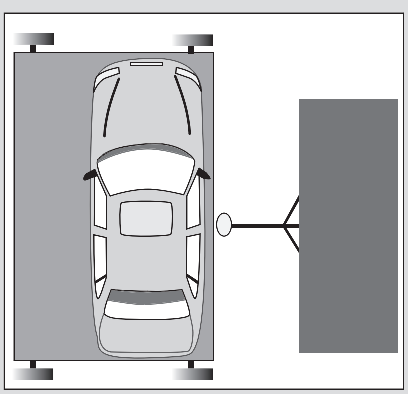
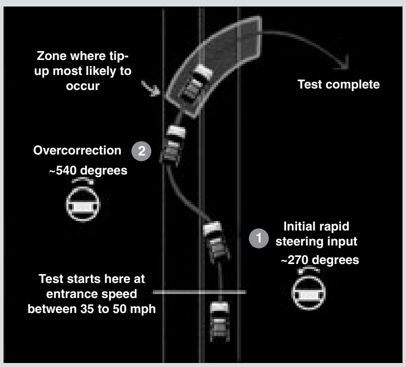
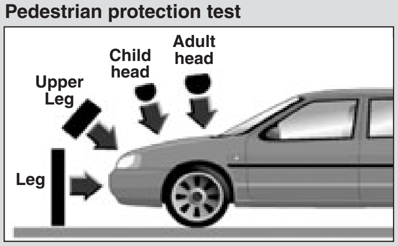
Test type	Description of test	Assessment	Considerations
Perpendicular side with medium barrier  Source: GAO.	The test vehicle is struck by a moving deformable barrier traveling at about 31 mph (50 km/h) at a 90 degree angle centered on the driver side seating position. Australia, Europe, and Japan currently conduct this test.[b]	The test represents a 90 degree intersection-type collision. The barrier that strikes the test vehicle weighs 2,095 pounds (950 kg) and has a front end shaped to simulate the typical front end of a passenger car.	Test results can be compared across vehicle weight classes because each vehicle is struck by a barrier of the same size and weight.
Perpendicular side with large barrier  Source: GAO.	The test vehicle is struck by a moving deformable barrier traveling at 31 mph (50 km/h) perpendicular impact into the driver side of a passenger vehicle. The Insurance Institute currently conducts this test.	The test represents a 90 degree intersection-type collision. The moving deformable barrier that strikes the test vehicle weighs about 3,300 pounds (1,500 kg), is higher than other barriers with a front end shaped to simulate the typical front end of a pickup or SUV.	Test results can be compared across vehicle weight classes because each vehicle is struck by a barrier of the same size and weight. The test was designed to encourage automakers to provide side-impact head protection by installing air curtain bags that extend low enough to protect smaller occupants in front and rear seats.
Pole side test  Source: GAO.	The test vehicle is placed on a platform and propelled at 29 km/h (about 18 miles per hour) into a stationary cylindrical pole producing a side-impact crash on the driver's door. Australia and Europe currently conduct this test.	The test represents a side-impact collision involving a narrow object such as a tree or pole. The diameter of the pole is 10 inches (254 mm) and aligned with the front occupant's head.	The side-impact test is demanding on vehicles' structures, and heavy vehicles have to cope with higher loads than lighter vehicles.

(Continued From Previous Page)

Test type	Description of test	Assessment	Considerations
Other tests			
Rollover test  Source: National Highway Traffic Safety Administration.	The test vehicle is subjected to a series of left/right tests and right/left tests at different speeds and steering wheel angles.The first run of tests is conducted at 35 mph, with each subsequent run conducted at about 40 mph, 45 mph, 47.5 mph, and 50 mph, until the vehicle "tips up" (fails) or attains a speed of 50 mph on the last run of each test without tipping up (pass). Only the U.S. NCAP currently conducts this test.	The dynamic test represents an untripped rollover by simulating a high-speed collision-avoidance maneuver. The Static Stability Factor is a measurement used to determine the top-heaviness of a vehicle, accounting for situations of potential tripped rollovers such as when a vehicle strikes a curb.	Rollovers where the vehicle is not tripped account for less than 5 percent of all rollover crashes.
Pedestrian protection test  Source: Euro NCAP.	Adult and child-size dummy parts (such as heads) are projected at specified areas of a test vehicle front end to replicate a car colliding with a pedestrian. Australia, Europe, and Japan currently conduct this test.	The test is used to assess the risk to pedestrians if struck by the front of a car.	This test evaluates the front end design of vehicles and the effect on pedestrian injuries.
Child restraint test  Source: Euro NCAP.	Euro NCAP tests child restraints by placing child-size dummies in child seats during frontal and side crash tests. The Japan NCAP test evaluates child seats by placing child-size dummies in child seats using a test sled instead of actual collisions.	The Euro NCAP test is used to evaluate child protection focusing on the interaction of a vehicle's child restraint system and a child seat. The Japan NCAP test evaluates the ease of correctly using the child seats.	The Euro NCAP test evaluates the performance of a car seat during a front or side collision. Japan NCAP tests child restraint systems independent of vehicle performance in a simulated frontal crash and evaluates the ease of use.

[a]The Japan NCAP full frontal test is performed at 55 km/h (about 34 mph).

[b]The Japan NCAP perpendicular side test is performed at 55 km/h (about 34 mph).

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Acknowledgments

In addition to those named above, Vashun Cole, Michelle Dresben, Colin Fallon, Kathleen Gilhooly, Doug Manor, Terry Richardson, Beverly Ross, Brian Sells, Jena Sinkfield, Stacey Thompson, and Frank Taliaferro made key contributions to this report.

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