National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: August 4, 2003

In reply refer to: H-03-22 and -24 through -27

Mr. William Clay Ford, Jr.
President and Chief Executive Officer
Ford Motor Company
16800 Executive Plaza Drive
Post Office Box 6248
Dearborn, Michigan 48121

Mr. G. Richard Wagoner, Jr.
President and Chief Executive Officer
General Motors Corporation
300 Renaissance Center
Detroit, Michigan 48265-3000

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organizations to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

These recommendations address the need for a training program for drivers of 12- and 15-passenger vans and improving occupant protection in 12- and 15-passenger vans. These recommendations are derived from the Safety Board's investigation of the May 8, 2001, rollover of a 1993 Dodge 15-passenger van on U.S. Route 82 near Henrietta, Texas, and the July 1, 2001, overturn of a 1989 Dodge Ram 15-passenger van on U.S. Route 220 near Randleman, North Carolina,[1] and are consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued 16 safety recommendations, 5 of which are addressed to Ford Motor Company (Ford) and General Motors Corporation (GM). Information supporting these recommendations are discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

[1] For additional information, read National Transportation Safety Board, *Dodge 15-Passenger Van Rollover on U.S. Route 82 Near Henrietta, Texas, on May 8, 2001, and Dodge 15-Passenger Van Overturn on U.S. Route 220 Near Randleman, North Carolina, on July 1, 2001*, Highway Accident Report NTSB/HAR-03/03 (Washington, DC: NTSB, 2003).

On May 8, 2001, about 8:57 a.m., central daylight time, a 1993 Dodge 15-passenger van was eastbound on U.S. Route 82 near Henrietta, Texas, en route from Burkburnett, Texas, to an outlet mall in Gainesville, Texas. The driver and 11 passengers, all members of the First Assembly of God Church, occupied the van. As the vehicle approached milepost 538 in the left lane, at a calculated speed of 61 to 67 mph, the left rear tire experienced a tread separation and blowout; subsequently, the van departed the roadway and rolled over at least two times in the median, ejecting seven passengers before coming to final rest. The driver and three of the ejected passengers sustained fatal injuries, and eight passengers sustained serious injuries.

On July 1, 2001, about 2:30 p.m., eastern daylight time, a 1989 Dodge Ram 15-passenger van was northbound in the left lane on U.S. Route 220, near Randleman, North Carolina, en route from Myrtle Beach, South Carolina, to Roanoke, Virginia. The van, owned by Virginia Heights Baptist Church of Roanoke, Virginia, was occupied by the driver and 13 passengers, ages 13 to 19. As the vehicle approached the Level Cross, North Carolina, exit, at a witness-estimated speed of 65 mph, the left rear tire experienced a tread separation and blowout; subsequently, the van moved from the left lane into the right lane, then back into the left lane, where it overturned and came to rest in the travel lanes. During the accident sequence, four passengers were ejected, one of whom was fatally injured and three of whom sustained serious injuries; the driver and the other nine passengers sustained injuries ranging from none to serious.

The National Transportation Safety Board determined that the probable cause of the accidents was tire failure, the drivers' response to that failure, and the drivers' inability to maintain control of their vans. Contributing to the accidents was the deteriorated condition of the tires, as a result of the churches' lack of tire maintenance, and the handling characteristics of the vans. Contributing to the severity of the injuries was the lack of appropriate *Federal Motor Vehicle Safety Standards* applicable to 15-passenger vans in the areas of restraints and occupant protection.

The National Highway Traffic Safety Administration's (NHTSA's) study on *The Rollover Propensity of Fifteen-Passenger Vans* demonstrated that 15-passenger vans are inherently unstable when loaded to the level for which they are designed—carrying more than 10 passengers. NHTSA therefore advises all van drivers to obtain specific training on the handling and operation of these vehicles. However, as investigators found during the Henrietta and Randleman accident investigations, the van owners were not aware of the information provided by NHTSA in its consumer advisory. The advisory has not reached all 15-passenger van operators, even those within the target group, such as churches, and the Henrietta and Randleman operators did not know that they should have specific training to operate the vans safely. Both accident drivers had experience operating 15-passenger vans, but no specialized training on the handling and driving characteristics of these vehicles; neither driver was able to control the van in an emergency.

As shown in the testing by Standards Testing Laboratories, Inc., and Safety Board staff, the van was controllable during an anticipated blowout, and the test driver thought that the effort required to control the vehicle was within the range of an unimpaired driver. However, even the professional test driver was unable to maintain the lane of travel in test 3 when the tires were inflated below the manufacturer's recommended inflation pressures, which were similar to those in the Henrietta accident; the van swayed from side to side as the test driver brought it under control. The professional test driver also stated that the van was more difficult to control at higher speeds, particularly with lower tire inflation pressures, and that steering inputs were magnified after the blowout. The test driver had experience operating 15-passenger vans during a blowout, and he triggered the tire blowout himself, so the situation was not unexpected, as it was during the accidents. Further, an experiment on driver reaction to tread separation that was conducted in the National Advanced Driving Simulator found that

> findings from test track studies in which test drivers were aware of an imminent tread separation may underestimate the extent to which tread separation occurring in the real world leads to instability and loss of vehicle control.[2]

Thus, even though the test van was configured similarly to the Henrietta van, the test did not replicate either accident in the critical area of operator behavior.

While both accident drivers were familiar with their respective vans and had driven them previously, investigators did not find evidence that either driver had experienced an emergency situation, such as tire failure, while operating the van. Both drivers are likely to have overcorrected and braked following the blowout because they did not know how to respond appropriately to the vehicle dynamics that occurred after the blowout and did not understand the potential instability problems associated with 15-passenger vans. The drivers are likely to have reacted instinctively by attempting to correct the rotation of the van while braking to slow it. Had the two drivers maintained their speed, not applied the brakes, and exerted more controlled steering, as the professional driver did during the tests, they may have been able to control their vans. Braking, the likely response on the part of both drivers, can lead to further vehicle instability during a tire failure, particularly in a fully loaded 15-passenger van with a high, rearward center of gravity. The drivers' lack of training on their vehicles' operating and handling characteristics, particularly in emergency situations, put them at a disadvantage in reacting to the blowout.

As the National Safety Council, the American Automobile Association, and most driver education programs recognize, acceleration is the appropriate response to a blowout, but that response is counterintuitive to the general public. Therefore, such groups emphasize that drivers need to refrain from braking and to decelerate slowly in the event of a tire blowout. This strategy requires that the driver provide steering input to counteract the lateral dragging force created by the blown tire. If a driver brakes, the lateral steering force experienced by the vehicle is greater and the driver must provide more steering input to maintain control of the vehicle. If the driver provides too much steering input, he or she will have to try to correct the direction of the vehicle and may oversteer. When the vehicle has a high, rearward center of gravity, as a loaded 15-passenger van does, the rapid changes in steering direction can lead to instability and rollover. A similar driver reaction to a blowout in a passenger car is unlikely to have such severe consequences because the passenger car's lower center of gravity makes it more forgiving of inappropriate driver inputs.

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[2] T.A. Ranney, G. Heydinger, G. Watson, K Salaani, E.N. Mazzae, and P. Grygier, *Investigation of Driver Reactions to Tread Separation Scenarios in the National Advanced Driving Simulator (NADS)*, DOT HS 809 523 (Washington, DC: National Highway Traffic Safety Administration, 2002).

Impressing upon 15-passenger van drivers the inherent dangers of operating these vehicles, particularly when fully loaded, and educating them about proper handling and control, particularly during emergency situations, can reduce the risk of rollover. Such training can also help dispel the expectation that these vans operate like large passenger cars. While the accident drivers had experience operating the vans, they did not have experience with how the vehicles would respond in this type of emergency situation or other emergency situations or the consequences of their instinctive reactions to such situations. Educating drivers on how such vehicles respond to, and on the consequences of, different driver input could help operators approach 15-passenger van driving more cautiously.

In addition, training would provide a forum for educating drivers about the tire pressures and maintenance required for 15-passenger vans. The rear tires on a fully loaded van, for instance, must be inflated to 80 psi, which is much higher than the rear tire pressure for most passenger cars. Stressing the importance of proper tire inflation during training will help drivers avoid potential problems. Drivers should also be taught to check the tires and tire pressure before driving the vehicle. In both these accidents, the tires were in very poor condition, which should have been readily apparent to someone who knew to look for cracks and rotting rubber.

Although NHTSA recommends that 15-passenger van drivers be trained to operate the vehicles, the agency does not provide information on the source of such training. The National Safety Council offers computer-based training, "Coaching the Van Driver," and many colleges and universities use this program to train their employees who drive vans. But this course does not educate drivers about emergency handling of the vans, nor does it discuss tire pressure and maintenance.

As NHTSA has acknowledged, 15-passenger van operators need training in the handling of those vehicles, and testing has demonstrated that controlling 15-passenger vans in a blowout is possible, albeit difficult, for a trained driver. The Safety Board concludes that safe operation of 15-passenger vans requires a knowledge and skill level different from and above that for passenger vehicles, particularly when the vans are fully loaded or drivers experience an emergency situation. Therefore, the Safety Board believes that Ford and GM, in conjunction with NHTSA, the American Driver and Traffic Safety Education Association, the National Safety Council, and the American Automobile Association, should develop a training program that incorporates the skills required for safe operation of 12- and 15-passenger vans and addresses the consequences of unsafe operation, including, but not limited to, operating in a fully loaded condition, emergency braking, high-speed lane changes, tire blowouts, and tire pressure and maintenance.

Federal Motor Vehicle Safety Standard (FMVSS) 201, "Occupant Protection in Interior Impact," specifies requirements for protecting occupants inside passenger cars, multipurpose vehicles, trucks, and buses that have a gross vehicle weight rating (GVWR) less than 4,536 kilograms (kg) (10,000 pounds); the requirements for upper interior components do not apply to buses, including 15-passenger vans, that have a GVWR greater than 3,860 kg (8,510 pounds). The requirements that apply to 15-passenger vans include those for instrument panels, seatbacks, interior compartment doors, sun visors, and armrests. Fifteen-passenger vans do not have to meet the phased-in requirement for upper interior components in passenger vehicles manufactured after September 1, 1998, which mandates that vehicles meet head injury criteria for impacts with the front header, rear header, side rails, sliding door track, all pillars, roof braces or stiffeners, and seat belt anchorages.

In both the Henrietta and Randleman accidents, occupants contacted and sustained injuries from one or more interior surfaces that are required to be protected in passenger vehicles but not in 15-passenger vans. The front passenger in the Henrietta accident was restrained by a lap/shoulder belt but sustained injuries due to contact with the interior roof and B-pillar during the rollover sequence. Four passengers in the Henrietta accident were seated on the left side of the vehicle (seats 3, 6, 9, and 12). A possible source of their injuries prior to ejection was deceleration into the noncrash-protected interior surfaces, including the roof, exposed window frame, and collapsed sidewalls, during the initial rollover and subsequent roof crush. Two passengers in the Henrietta van (seats 5 and 14) were unbelted but remained inside the vehicle, and both sustained serious injuries. The passenger in seat 14, for example, sustained a first rib fracture, which is rare unless extreme force is applied to the upper torso.[3] The injuries to these passengers most likely resulted from contact with interior vehicle components, roof crush deformation into the survivable space of the vehicle compartment, or striking or being struck by other occupants during the rollover.

While restraint use in rollovers increases an occupant's chance of survival by preventing ejections, seat belts cannot prevent head contact with the adjacent roof or window.[4] The most frequent harmful contact points for nonejected occupants are the roof, pillars, rails, and headers (28.1 percent combined).[5] Therefore, vehicles need to be designed with impact protection to minimize injuries when an individual's head strikes the roof or windows.

The Henrietta and Randleman accident vans did not afford passengers the occupant-protected surfaces that passenger cars would have provided. The Safety Board concludes that during the rollover sequences in the Henrietta and Randleman accidents, passengers remaining inside the vehicles, as well as some ejected occupants, sustained injuries as a result of contact with interior surfaces, which were not required to be protected from occupant impact. Even if these accidents had occurred in vans manufactured today, those passengers who remained within the vehicles or struck surfaces before being ejected may still have sustained injuries, since parts of FMVSS 201 do not apply to 15-passenger vans. FMVSS 201 reduces fatal injuries because it mandates use of technologies such as side airbags, curtain airbags, or energy-absorbing materials. Passenger cars today incorporate these technologies, but occupants of 15-passenger vans do not benefit from such protection. The Safety Board believes that Ford and GM should voluntarily develop and install technologies to provide upper interior component protection within 12- and 15-passenger vans by model year 2006.

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[3] David Viano, *Chest: Anatomy, Types and Mechanisms of Injury, Tolerance Criteria and Limits, and Injury Factors*, AAM and IRCOBI Biomechanics of Trauma Course Book, October 1997, p. 9.

[4] G.S. Bahling, R.T. Bundorf, G.S. Kaspzyk, E.A. Moffatt, K.O. Orlowski, and J.E. Stocke, "Rollover and Drop Tests – The Influence of Roof Strength on Injury Mechanics Using Belted Dummies," *Stapp Car Crash Conference 34th Proceedings, Orlando, Florida* (Warrendale, PA: Society of Automotive Engineers, 1990) 101-112.

[5] M.W. Arndt, G.A. Mowry, C.P. Dickerson, and S.M. Arndt, "Evaluation of Experimental Restraints in Rollover Conditions," SAE Paper 95712 (Warrendale, PA: Society of Automotive Engineers, 1995).

In the Henrietta accident, 7 of the 12 occupants were ejected from the van during the rollover, and 3 of the 7 ejected occupants sustained fatal injuries; none of the 3 belted occupants were ejected. In the Randleman accident, 4 of 14 occupants were ejected from the van during the rollover, 1 of whom sustained fatal injuries. None of the ejected Randleman occupants was wearing his or her seat belt, and at least five of the vehicle's lap belts were unusable.

When a passenger is ejected from a vehicle during an accident, he or she is exposed to rapid deceleration into injury-causing surfaces outside the vehicle. The orientation and speed of the passenger and the kind of surface struck are important factors in determining the nature and extent of the injuries sustained.

In both accidents, the ejected passengers' injuries were significantly more severe than those sustained by passengers who remained in the vehicles. Had the passengers been restrained, they may have benefited from the protection provided by the vehicle. The one exception was the Henrietta driver, whose injuries were due to roof crush and the loss of survivable space. One of the five passengers who remained within the vehicle (seat 11) in the Henrietta accident was restrained by a lap belt only and sustained injuries when her upper body struck the interior surfaces or when she contacted other unrestrained passengers during the accident sequence. A lap belt does not prevent movement of the upper body and acts as a fulcrum for flailing of the upper body and lower extremities.[6] However, the lap belt did prevent ejection, giving the passenger some protection as the van overturned and deformed. She did not experience the rapid deceleration into injury-causing surfaces inside or outside the vehicle that the ejected passengers did. Additionally, this passenger's injuries were not as severe as those of the unbelted passengers seated around her who also remained within the van, probably because she did not strike injury-causing surfaces within the vehicle or other passengers at as great a velocity. The simulation of lap-belted occupants within the van predicted a thorax injury for the simulated occupant in seat 15 during the first rollover sequence, further indicating that lap belts alone are not the most effective restraint. The accident simulation showed that during the first overturn, head, neck, and thorax injuries were not predicted for simulated occupants wearing lap/shoulder belts.

The Henrietta simulations showed that the amount of movement for unrestrained occupants was significantly greater than that of their restrained counterparts, resulting in far more serious predicted injuries and exposing them to the serious injuries associated with ejection. These predicted injuries occurred because the simulated occupants struck parts of the van during the accident sequence. Additionally, several simulated occupants in the unrestrained conditions were either partially or fully ejected, whereas neither of the restrained conditions resulted in predicted ejections during the first overturn. The Safety Board concludes that had the passengers in the accident vans been wearing lap/shoulder belts, their injuries may have been less severe because of fewer and less forceful impacts with nonoccupant-protected interior components and other occupants and because those who were ejected would have remained in the vehicle.

The Safety Board has advocated use of lap/shoulder belts for many years because they greatly reduce a passenger's risk of injury during a collision. Restrained by lap belts only, passengers sometimes sustain abdominal injuries as a result of pivoting about the lap belt or as

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[6] J.K. Mason, *The Pathology of Violent Injury* (London: Edward Arnold, 1978) 28.

the upper body flails about. Yet the Ford and GM vans being manufactured today are equipped with lap/shoulder belts only at the outboard locations, rather than at all seating locations. NHTSA is developing a rulemaking to require that all center seats be equipped with lap/shoulder belts but has not disclosed whether the rulemaking will apply to 15-passenger vans. Ford and GM have begun to equip the passenger vehicles in their fleets with center lap/shoulder belts but have not indicated whether they will so equip their 15-passenger vans, which are not classified as passenger vehicles. The Safety Board believes that Ford and GM should voluntarily install lap/shoulder belts at all center seating positions in 12- and 15-passenger vans and make all lap/shoulder belts in outboard and center seating positions adjustable by model year 2006.

The fatally injured occupant in the Randleman accident was seated in a position that had a seat belt that was completely unusable; the buckle was wedged so tightly inside the seat bight that investigators could not even remove the buckle for inspection. In four other seats in the van, the seat belts were unusable either because of missing components or because the seat belt was stuck in the seat bight or under the seat frame. Children, who are required to be restrained by North Carolina law, occupied four of the five seating positions with unusable belts. Thus, even if these passengers had wanted to wear their seat belts, they would have been unable to do so. In an informal survey of other 15-passenger vans, investigators found that the vehicles lacked any mechanism to ensure that seat belt latches and buckles remain accessible in the seat bight. The Safety Board believes that Ford and GM should redesign the seat belts in their 12- and 15-passenger vans to ensure that the buckle and latch components remain readily accessible to occupants at all times by model year 2006. The Safety Board plans to inform 12- and 15-passenger van owners and operators about the importance of maintaining seat belt accessibility.

One of the impact points between the Henrietta van and the ground during the rollover was the left front corner of the roof; the resulting roof crush at that location was so severe that it brought the roof in contact with the top of the driver's seatback. The driver was belted but sustained fatal head injuries as a result of the roof intrusion.

After the Henrietta accident, roof crush left 4 to 6 inches of space above each row of passenger seats; originally, the vehicle had 18 to 21 inches of space between the roof and the seats. Passengers probably sustained more serious injuries due to contact with the roof during the rollover and the resulting lack of interior space. The Safety Board concludes that roof crush to the Henrietta accident van contributed to the severity of the driver's injuries and diminished survivable space for the passengers. The roof in the Randleman accident did not sustain similar crush damage, probably due to the vehicle dynamics during the rollover sequence. The lack of roof crush damage may be one reason the injuries to those passengers who remained within the vehicle were less severe than in the case of the Henrietta accident. Other factors that may have contributed to the differing severity of injuries in these two accidents were the age of the occupants, the points of impact during the rolls, and the crash pulse experienced as the vehicles rolled over.

The Safety Board investigated another accident involving roof crush in a 15-passenger van that occurred on March 12, 2000, near San Antonio, Texas.[7] The driver, who had attempted to change lanes, left the roadway; when she tried to correct her path of travel, the vehicle rolled

[7] Docket No. HWY-00-IH-032.

over, landed on a guardrail, and the rear of the vehicle straddled the guardrail on its roof. A lap/shoulder-belted 15-year-old female passenger was fatally injured; a lap/shoulder-belted 15-year-old male passenger and an unrestrained 15-year-old female passenger were seriously injured. All three were seated in the area of roof crush damage. The driver and the other 10 passengers, also belted, were outside the roof crush area and did not sustain serious injuries.

Studies have shown that the initial roof crush usually does not increase injuries to unrestrained occupants; passengers generally sustain serious injuries during contact with the roof and upper door window areas and when the head is adjacent to these areas during contact the ground.[8] However, the reduction in survivable space due to roof crush for those who remain within the vehicle can lead to injuries, particularly during subsequent rollovers. NHTSA, which evaluated 1988-1999 National Automotive Sampling System and Fatality Analysis Reporting System data, found that, on average, 26,376 occupants sustain serious or fatal injuries in light-vehicle rollovers annually. Roof crush intrusion is estimated to occur and possibly contribute to serious or fatal injury in about 26 percent of rollover crashes.[9] If the roof does not crush, belted occupants may benefit because they have less chance of contacting the roof and being subjected to the forces of roof-to-ground contact during the rollover sequence.[10]

The purpose of Federal Motor Vehicle Safety Standard (FMVSS) 216, "Roof Crush Resistance," which establishes strength requirements for passenger compartment roofs, is to reduce death and injury due to roof crush in rollover crashes. The standard applies only to passenger cars, multipurpose vehicles, and buses with a GVWR of 2,722 kg (6,000 pounds) or less. The GVWRs of 15-passenger vans exceed 8,500 pounds and, therefore, the vans are not required to meet FMVSS 216. Yet statistics show that 15-passenger vans are involved in a higher percentage of rollover accidents than are passenger cars and smaller vans. About 52 percent of the 15-passenger vans involved in fatal single-vehicle accidents experience a rollover, while 33 percent of passenger cars involved in such accidents do.[11]

NHTSA requested comments on its proposed amendments to FMVSS 216 on October 22, 2001. In the request, NHTSA stated that it is considering whether to extend FMVSS 216 to vehicles weighing up to 10,000 pounds because the composition of the vehicle fleet has changed since the previous rulemaking was issued; in particular, the number of vehicles weighing more than 6,000 pounds has increased.

The Safety Board believes that Ford and GM should voluntarily redesign 12- and 15-passenger vans to minimize the extent to which survivable space is compromised in the event of a rollover accident by model year 2006.

Therefore, the National Transportation Safety Board recommends that Ford Motor Company and General Motors Corporation:

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[8] K.F. Orlowski, R.T. Bundorf, and E.A. Moffatt, "Rollover Crash Tests—The Influence of Roof Strength on Injury Mechanics," SAE Paper 851734 (Warrendale, PA: Society of Automotive Engineers, 1985).

[9] National Highway Traffic Safety Administration, *Federal Motor Vehicle Safety Standards; Roof Crush Resistance*, NHTSA-1999-5572; Notice 2 (Washington, DC: NHTSA, October 2001).

[10] G.S. Bahling, R.T. Bundorf, G.S. Kaspzyk, E.A. Moffatt, K.O. Orlowski, and J.E. Stocke.

[11] National Transportation Safety Board, *Evaluation of the Rollover Propensity of 15-passenger Vans*, Safety Report NTSB/SR-02/03 (Washington, DC: NTSB, 2002).

In cooperation with the American Driver and Traffic Safety Association, the National Highway Traffic Safety Administration, the National Safety Council, the American Automobile Association, and each other, develop a training program that incorporates the skills required for safe operation of 12- and 15-passenger vans and addresses the consequences of unsafe operation, including, but not limited to, operating in a fully loaded condition, emergency braking, high-speed lane changes, tire blowouts, and tire pressure and maintenance. (H-03-22)

Voluntarily develop and install technologies to provide upper interior component protection within 12- and 15-passenger vans by model year 2006. (H-03-24)

Voluntarily install lap/shoulder belts at all center seating positions in 12- and 15-passenger vans and make all lap/shoulder belts in outboard and center seating positions adjustable by model year 2006. (H-03-25)

Redesign the seat belts in your 12- and 15-passenger vans to ensure that the buckle and latch components remain readily accessible to occupants at all times by model year 2006. (H-03-26)

Voluntarily redesign 12- and 15-passenger vans to minimize the extent to which survivable space is compromised in the event of a rollover accident by model year 2006. (H-03-27)

The Safety Board also issued safety recommendations to the National Highway Traffic Safety Administration, the Federal Motor Carrier Safety Administration, the 50 States and the District of Columbia, the American Driver and Traffic Safety Education Association, the American Automobile Association, the National Safety Council, and the American Association of Motor Vehicle Administrators. In your response to this letter, please refer to Safety Recommendations H-03-22 and -24 through -27. If you need additional information, you may call (202) 314-6177.

Chairman ENGLEMAN, Vice Chairman ROSENKER, and Members GOGLIA, CARMODY, and HEALING concurred in these recommendations.

Original Signed

By: Ellen G. Engleman
Chairman