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MINI AND MICROAUTOMOBILE FORUM: OVERVIEW AND POTENTIAL PROBLEMS

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Group 3 Council
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FOREWORD

During the past few years, there have been considerable discussion and concern about the downsizing of the automobile in relation to highway safety. A number of people have expressed the belief that an increase in the number of smaller vehicles will have significant impacts on safety. After some consideration, the Group 3 Council of the Transportation Research Board decided that it was appropriate to organize a forum for presentations on this subject.

The Mini and Microautomobile Forum was scheduled and held during the 61st Annual Meeting of TRB in Washington, DC, on January 19, 1982. The objective was to address the merit of smaller automobiles and the expected increase in their number and to identify related problems that should be considered by the transportation community. It was expected that the TRB Annual Meeting would provide a diverse audience -- representatives from transportation, education, business, research, and government as well as other interested parties -- to generate the needed participation.

The sessions were well-attended. The presentations by the speakers gave a total overview of the smaller-vehicle problem and provided some perspective on what to expect in the next few years. This Circular presents an edited text of the speakers' presentations along the pertinent discussion on each subject.

To summarize the Forum, it appears that a market does exist for smaller vehicles either as a second vehicle or where vehicle use is limited. Among younger drivers, there is some demand for the smaller vehicle as a first car because of both lower initial cost and lower operating costs. It is projected that the smaller vehicle would account for only 6-9 percent of total passenger car sales. This sales percentage probably would not cause a major increase in total highway safety statistics because certain limits would normally be imposed on the use of smaller vehicles by their purchasers. However, the presence of these smaller vehicles on the nation's roadway systems will still cause a number of problems.

The smaller vehicle always loses in any competition for space with larger vehicles. The result is increased fatalities and injuries for small-vehicle passengers. But it is possible to incorporate certain safety features in the vehicle design to ameliorate the size disparity between smaller and larger vehicles. In addition, although roadway design geometrics generally accommodate vehicle downsizing, some roadside appurtenances will have to be modified to provide passenger protection in small-vehicle collisions.

Questions arise as to who is responsible for incorporating safety features for this type of vehicle: Should the government retrofit all roadside appurtenances at taxpayers' expense? Should the manufacturer make the car buyer pay the cost of incorporating minimum safety standards in the vehicle? It was noted that the courts are assigning more responsibility to the manufacturer under product liability, thus modifying the prospect of fatalities.

Finally, there is a compatibility requirement that needs to be addressed by the transportation community -- i.e., assigning responsibility for safety among the driver, the vehicle, and the highway.

It is hoped that these presentations from the Forum will generate some discussion and resolution of the noted problems.

JAMES L. PLINE

INTRODUCTION

Patricia F. Waller, Chairman, Group 3 Council TRB
and Associate Director of Driver Studies,
University of North Carolina

As you all know, our automobile industry has seen a larger and larger share of the passenger car market move to foreign manufacturers as Americans, albeit somewhat reluctantly at first, have opted for smaller, more fuel efficient cars. The Detroit automakers belatedly are making serious efforts to regain at least a portion of the market that they have lost. Now while the move to smaller cars was almost necessitated by fuel considerations, it brings with it many problems and issues for which we are not adequately prepared. Vehicles in the 2000-pound range have become common, and even smaller vehicles are emerging weighing 1500, 1000, and even below 1000 pounds. It appears that there's a very real possibility that these vehicles will increase significantly in number, and if this does occur, we're going to need to cope with a wide range of considerations that have not been addressed. First, how feasible is such a vehicle? Several years ago I had the opportunity to collaborate with several professors in the School of Engineering at North Carolina State University in Raleigh. One of them had a replica of a 1903 Oldsmobile that had been manufactured in the early 1960's. The gas tank held only one gallon, but the car obtained around 100 miles to the gallon. It had a top speed of around 25 miles per hour, and it could carry two occupants plus a couple of bags of groceries. The professor drove this vehicle between home and campus and his consulting firm for a number of years until he placed it in the lobby of his firm. He used it mainly on roads with posted speed limits no higher than 35 miles per hour. How many of our trips include only one occupant, or at the most two? How many are for short distances near home? How many could be accomplished on roads with low posted speeds? If the technology used in a 1903 Oldsmobile could produce such a machine, how much more could we accomplish today? Clearly the questions and problems are many. What would it cost to manufacture, maintain and operate such vehicles? Is there sufficient use for them? If they could not serve as the primary family car, could they meet the need for a second vehicle? Is there any market for such a car? How would our roads and highways accommodate them? What are the implications for pavement maintenance? On the one hand, such a car would not create a great deal of wear and tear, but on the other hand, it may be much more vulnerable to pavement imperfections. A pothole could have much more devastating effects, and hence such a car may require higher pavement maintenance standards. Parking facilities would need to be modified further, just as many have already been modified to accommodate compact cars.

Perhaps the most important issue is that low speed lightweight vehicles pose serious safety problems. Such cars might not be able to meet federal safety standards. I do understand, and I'm sure there are people here who know more about this than I, that in Japan they make a distinction between their very lightweight automobiles and heavier ones, and allow somewhat different safety standards for the lighter ones. In this country, we do not apply the same safety standards to motorcycles that apply to cars. If a very small vehicle were viewed as an alternative to a motorcycle or a moped, would it then appear less hazardous? How much could we offset some of the safety problems tnrough more innovative traffic engineering and enhanced visibility? Clearly, we cannot build new facilities for such cars, but could we designate or dedicate certain existing routes for these vehicles, or existing lanes, and exclude heavier vehicles from these routes, just as we now limit heavy trucks to certain routes or lanes? On a dedicated route, the smaller car would allow ample space for bicycle paths and mopeds as well.

However, there would still be the problem of getting the small vehicles to and from these special routes and getting them through intersections. How much could we achieve through enhanced visibility? There's ample evidence that increasing the conspicuity of motorcycles and motorcyclists through lights-on laws and reflectorized materials leads to marked reductions in daylight multi-vehicle crashes. Likewise, the use of high mounted, central brake lights on the rear of passenger cars significantly reduces rear end collisions. To what extent could we apply such principles to these small vehicles? Henry Ford once said, "You can have a Model T in any color you want so long as it's black." Could we say, you can have one of these small cars in any color you want so long as it's reflective and fluorescent?

I realize these ideas are unorthodox, and any kind of regulation is in ill repute today. Yet there is an urgent need to think some new and different thoughts and develop strategies that are relatively inexpensive. The forum we're conducting today is bringing together some of the top experts in this field. While we will not cover all the issues, we will make a healthy start on what is an important emerging issue in highway transportation. The Transportation Research Board has the potential to bring to bear the range of expertise needed to address this issue. We hope to identify some of the problems and the corresponding research needs, so that perhaps we can be better prepared to cope with the coming changes.

ECONOMIC CONSIDERATIONS

Dr. Charles Lave, Professor of Economics
University of California

PAT WALLER: Our speaker is Dr. Charles Lave, who is Chairman of the Economics Department at the University of California in Irvine. He's currently on sabbatical at MIT with the Future of the Automobile Research Program. I first came across his work when he edited an issue of "Transportation Research". He's done a great deal of work in the state of the art on models of demand for automobiles. As I recall, I believe that issue was entitled, "Economic Implications of Automobile Choice", and that immediately caught my eye. I thought, "Oh, here's somebody who is really doing something interesting," and it was just this morning that I had the opportunity to meet him in person. I am delighted to have the chance now to hear what he has to say on the question of economic considerations.

DR. CHARLES LAVE: Rather than an abstract discussion of economic considerations, I will focus on a specific mini-car that was recently introduced in Japan. It's not available here yet; and, as you will see, that's fortunate for us. The car is the Honda "City Car," and I want to organize my talk around the theme: if that car were here, what kind of market share would it get? In essence, what I'm doing is market analysis. I think market analysis is probably a good thing to do at this time of the morning. It's certainly more fun than economics or engineering. God knows, it pays better.

Anyway, let's talk about the Honda City Car. The following quotes are from "Automotive News," which is published in Detroit, and is at least somewhat biased toward American cars. Thus the positive comments of their writer are quite significant. The review of the Honda City Car, on December 7, said: "It's styled with plenty of character, has lots of room inside, really lively performance, and it cruises quietly at 70 miles per hour." So we're not going to need bicycle lanes for this car. "It has very good handling, holds four people with reasonable comfort, has sporty looks, and goes 0 to 60 mph in 12 seconds," which is very fast by the standards of U.S. cars. On the Japanese city cycle it gets 45 miles per gallon, and on the highway at 37 miles per hour, it gets 68 miles per gallon. Clearly, this particular mini-car is not going to require much sacrifice of looks, performance, or comfort. And now for the really bad news -- and I've checked this with two different sources--it seems that the car could be sold in the United States for a mere $3,500.

Now remember, this is not a dream car. It's a production vehicle, and it's selling extremely well in Japan. Suppose it were available here at something like that price. What market share might it achieve? In particular, since the U.S. cannot produce a similar car at that price, I want to see how much of the auto market would remain for American manufacturers. What would we have left? In the context of talking about sharing, it's worthwhile to remember a remark that Will Rogers once made about marital relations and reciprocal behavior. "Never forget that one good turn, gets all the blanket."

Is Honda going to get all the blanket with this particular car? Let's try a number of alternative forecasting approaches to see what happens. The first task is to set some kind of upper boundary on market share. One characteristic of this car, after all, is its small size. Can we say anything about the possible upper boundary on the market share of small cars? We know, looking at sensitivity to size, that consumers like to have at least one automobile capable of carrying the entire family together. Regardless of the number of special purpose vehicles they may have--a pickup to go hunting and shoot at each other, a tiny little car to transport themselves to work, and so on--they like to have one car which is suitable for the whole family. What does this imply in terms of the market share available to small cars? A few years ago Phil Patterson, sitting in the audience, coughed up a few thousand dollars to support two Irvine anthropologists, Gladwin and Murtaugh, in a study of auto purchase behavior. So instead of doing field work in South America or Africa, they chose to study the fierce tribe of Southern California auto buyers.

These anthropologists began with detailed interviews, and tried to figure out how it was that people chose automobiles: how did they decide what size car to buy? The end result was a series of decision-tree models. They're nice; anyone can look at the models and follow what's going on; you don't have to be a statistician. They show the process by which people progressively narrow down to pick a given car size. Then, last year, the model was applied to known U.S. demographics to produce market share projections, for 1990, of the share of large family cars. What they found is that, essentially irrespective of fuel prices and all kinds of other factors, 30 percent of the market is going to be these large cars in 1990. Well, in one respect that's good news for American manufacturers. It means they can sell to at least 30 percent of the market. But, on the other hand, that other 70 percent is all a potential Japanese share (which is a pretty big piece of the "blanket").

Somebody in the audience mentioned the importance of demographic trends, so let's also look at market shares from a demographic point of view. A few years back, Joan Bradley and I did a model of imported car shares: a simple multiple regression model, not terribly difficult to make sense of. We used both state-average data and household data, and modeled the demographic factors which influence people's willingness to buy imported cars and small cars. Three demographic factors emerged as overwhelmingly important in that decision. The first was family education levels. The second was whether or not it was a multiple-car household, and the third was the age of the head of the household. The education level variable was far and away the most important. It turned out that the more educated the household, the more likely it was to buy a foreign car or a small car. The multiple-car variable embodies the portfolio notion--the family has a variety of cars to meet a variety of needs. If the family can have only one car, then it must be big enough to meet any conceivable need. But a multiple-car household can "afford" to have a lot of small cars; and, in fact, as cars per household increase, so do small cars per household. Finally, the age variable: we found that 42 years old was a dividing point. Above that, people didn't buy small cars; below that, they did. With some further work, we decided this wasn't simply a senility factor (I'm on the wrong side of the dividing line, after all), but rather it was a kind of historical, cultural factor. People above that age had grown up with big cars and had certain preconceptions of the size car they needed. People below that age had grown up in an era when there were small cars around, and they had different conceptions. The important distinction I'm making here is that it is a value-dimension rather than an age-dimension: hence as that cohort--the people who were over 42 in our sample--moved through the population, then that age shift-point also moves upward. So, in fact, all three major demographic factors are going in the wrong direction for U.S. manufacturers: people are becoming more educated, multiple-car households are increasing, and that pro-domestic cohort is aging itself out of existence.

Now, knowing that I did that research, and distrusting fancy statistics, as you should, you may wonder about the value of those demographic conclusions. So it's worth pointing out that recently Rich Kusmiak did a number of simple cross-tab analyses on the latest National Personal Transportation Survey. No fancy regressions, no multilogit anything; just simple cross tabs. And he confirmed all three of those demographic factors as being important and in roughly the order I gave them to you.

Well, so far we've gotten no comfort from either the upper-bound analysis or from looking at demographic factors; so it's time to bite the bullet and look at multilogit models of auto choice. What do they tell us about consumer sensitivity to various factors? In particular, we know that this mini-car has lower operating costs and lower purchase cost. Let's take these factors one at a time. What will be the effect of lower operating costs (higher miles per gallon) on market share? The particular model I used for this projection is another one of Phil Patterson's bargain basement models. This one was done by Kenneth Train and me; it's a ten-class auto model with about a million variables in it, which purports to explain why people buy the size automobile they buy. The model has three advantages for our current purposes. First, some people actually used it successfully to project 1980 market shares. Remember, this was a 1975 model. They applied it to recent data to predict 1980 market shares and pretty well got them right on the nose. You can see the model was unusually lucky; I won't say it was correct. The second reason is that this particular model has been taken over by Ison, Adler, and Ford, and simplified greatly: they got it down to five car classes: subcompacts, compacts, intermediates, etc.; and they reduced the 25 or 30 odd variables down to just three. So it's an easy model to calculate with. And finally, since it is after all my own model, I know what kinds of secrets are hidden in its bowels, and I know what fudging was in there; so I know how to compensate, I hope.

What I did was the following. I assumed that the five classes of cars had essentially the same characteristics as in 1980, except that the subcompact class was given the 45 miles per gallon efficiency of the Honda City Car. I then ran through the model and reprojected market shares. That one change, the increase in efficiency, produces an 8 percentage point increase in the market share of subcompact automobiles. It says the increase in operating efficiency, alone, will increase subcompact share by 8 points. The other important characteristic of the Honda City is its very low price. What can we say about consumer sensitivity to up-front purchase costs? We know from analyses of the housing market and the appliance market that consumers are extremely sensitive to purchase price, that they will choose the less expensive model of something even when doing so involves much higher operating costs later on.

To project the effect of the City's low price, I reran the simplified Lave/Train model keeping all class characteristics at 1980 values, except that the price of the subcompact class is decreased by 25 percent. This one change, the 25 percent price decrease for subcompacts, increases their market share by a full 14 points. If we both make them 25 percent cheaper and give them 45 miles per gallon, the combined effect is an increase in total market share of 22 points. And finally, if we use that $3,500 price estimate and combine it with 45 mpg efficiency, we get an increase in market share for subcompacts of a full 30 points. That mini-car is going to be a really serious competitor.

Since I don't want to go on record as saying that they will actually take that hunk of the market, I ought to cover my tracks a bit and qualify the forecast. First, there are all the usual methodological problems. First, we are making a projection which is well outside the calibrated limits of the model. Second, we are basing the whole auto choice decision on just two factors, operating efficiency and purchase price, when we know that there are other factors involved as well; though in this case, since the performance, comfort, noise, and passenger capacity of the City are all equal to or better than existing subcompacts, this is probably an acceptable simplification.

What about the safety issue? One of the things you know, if you were reading the Washington newspapers last week, is that small cars are more dangerous than big cars. To what extent, then, is the safety influence going to limit the market share on this particular automobile? Are people sensitive to safety considerations, and will they be willing to drive a more dangerous car just to save a few thousand dollars?

Well, there are two kinds of evidence that seem relevant. First, we can look at seat belt usage; we know that only 11-14 percent of drivers use them. This suggests that consumers are not terribly concerned with safety. It can be objected that people are not using seat belts because their "operating cost" is too high--the time to put them on and the discomfort of wearing them.

So maybe seat belt evidence isn't relevant. Perhaps, if we gave consumers a chance to purchase a once-and-for-all increase in operating safety, they'd take it. That is to say, even though the daily cost of seat belts is too high, maybe they would be willing to pay an extra two thousand dollars, initially, in order to have a safer car to begin with. Well, I think that's unlikely, if we recall the general proposition that people avoid up-front cost. There is also some specific evidence which is relevant. You may recall that roughly five years ago, General Motors offered consumers exactly that tradeoff: to spend some extra money and buy an air bag for extra safety. This option was available on the big, luxurious GM cars; and it was very cheap compared to the kind of price differences we have been discussing. Approximately a million cars could have been purchased with that option over the years GM offered it; but, in fact, only ten thousand air bags were sold. That is, only 1 percent of the buyers were willing to spend a little bit more up front in order to purchase extra safety. So I'd conclude that there's no reason, whatsoever, to believe that safety considerations are going to rescue US manufacturers when price and efficiency considerations are not on their side.

Okay, let me sum up and quit. Looking at sensitivity to overall car size, looking at sensitivity to operating costs, looking at sensitivity to purchase costs, looking at demographics, and looking at safety, there's no reason to believe that a mini-car like the Honda City could not substantially enlarge and dominate the small car market. Using the most likely combination of characteristics for the car, I would project a total market share of 60 percent for subcompacts and minis, with minis taking about 40 percent all by themselves. Thus the U.S. industry has plenty to worry about. In terms of the original metaphor, the Honda may not get all the blanket, but it's sure going to leave the rest of us feeling pretty cold.

DISCUSSION

UNIDENTIFIED: I'm wondering if you're using the correct model. From the things I have been reading, the Japanese seem to be more interested in the Third World Market.

DR. CHARLES LAVE: That may or may not be true, but I certainly wouldn't want to be an American manufacturer with that particular car hanging over my head. It is true, as Dan Roos pointed out, that under current import limitations where Japan is limited by number of cars, then there's no reason to export that car--they would rather use up their quota on expensive cars. But we don't know whether that quota will persist. Also, the subject this morning is the possible future of mini-cars; so you can either regard my calculations as being the extent of a particular threat, or as being the potential for a small car in our market.

JIM PLINE: I would assume, Charles, that your prediction is comparable to what happened with the Volkswagen Beetle. It came in and fairly well took over the market.

DR. CHARLES LAVE: Yes, that's exactly the way I see it. The car is sporty, youth-oriented, cheap, and efficient. As far as I can see, it appeals to exactly the class of people who produced the import boom in the first place.

UNIDENTIFIED: You may be correct on the initial sales appeal of that car, but remember that the BMC Mini and the Lada once looked that way in Canada; but then their sales plateaued out at some point, and they did not go on to take over everything.

DR. CHARLES LAVE: My guess about the Canadian experience is that the reputation of those cars eventually caught up with their sales, just as happened with the Renault Dauphine in the U.S. twenty years ago. But my assumption, here, is that the Honda City is a high quality car, unlike the Mini and the Lada; and remember its comfort, performance, capacity, and features do not mark it out as inferior either.

UNIDENTIFIED: You're right about the quality issue. Also, those cars simply did not hold up to Canadian winters, and they tended to rust out very quickly because of road salt.

DR. CHARLES LAVE: I remember, when I was a kid, we were told that the way to catch a pigeon was to put salt on its tail. Apparently, the Canadians discovered that solution for catching up to these foreign pigeons.

UNIDENTIFIED: The numbers you quoted and the prices, is this before or after the car has been put through the Federal mill here to meet our safety and emission standards?

DR. CHARLES LAVE: Well, what I was told was that the $3,500 would be the price for a "Federalized" car. Remember, the Japanese have pretty strict smog standards, too.

POTENTIAL USAGE

Kenneth Orski, President, Corporation for Urban Mobility

PAT WALLER: You make it sound depressingly good. All right, our next speaker is C. Kenneth Orski, who's president of the Corporation for Urban Mobility. It's a public purpose venture to promote public/private cooperation in urban transportation. He's formerly associate administrator of the Urban Mass Transportation Administration, and spent the last four years with the Marshall Fund, where he participated with Dan Roos in the development of the MIT Future of the Automobile program. And he's going to talk to us about the potential use for this small vehicle that we're discussing.

KENNETH ORSKI: As Pat said, my assignment is to talk about the future potential use for minis, and I confess that I run immediately into some problems of definition, because frankly, I'm not sure I know what a mini or a micro is. Certainly the kind of car that Chuck Lave described, the Honda City Car, doesn't sound like a micro car or a mini car. It sounds pretty much like a conventional car, perhaps somewhat smaller in size and certainly cheaper to operate. I don't think that any of us really reached a consensus on what a mini exactly is. Thus, rather than talk about what the potential uses for the minis are, I would like to rephrase the question and ask what are the acceptable minimum performance and design standards for cars that would make them significantly different from the cars that we know today. I have another reason for rephrasing the question. It seems to me it brings up the old philosophical question that we all had to address in our high school essays, and that is, should we let technology dictate our needs, or should we, on the contrary, make our needs influence the technology? In other words, are we to accept the technology of the mini as a given and try to adapt our requirements to it, or should we, on the contrary, define our minimum requirements and then tell the engineers to design a car that we need. Well, from the rhetoric that I've just given to you, I think it is clear that I'm in favor of the latter approach: to ask ourselves what is it indeed that we are looking for in a so-called mini car. I'm not sure whether we are ready to reach a consensus on a set of minimum acceptable performance standards for a mini car. I think our answers would depend on the context in which we live. Do we live in the city, or in the country, or in a suburb? Do we do a lot of city driving or freeway driving? Do we live in hilly or flat country, and so on and so forth? If I were pressed to provide my own set of acceptable minimum standards, and I think that all of us could go through that kind of exercise, I would provide you with the following. Don't forget that I live in Washington, D.C. in a rather dense urban area, and therefore my travel behavior and my travel needs may be very different from your travel needs. My minimum requirements would be as follows: I'd like my car to have minimum cruising speed of, say, 50 miles an hour. Now the speed limit in the District of Columbia is 25 miles an hour, but obviously I want more than just the minimum legal speed limit as my minimum speed requirement. I don't care much for high acceleration, I think I would go along with, say, 0 to 40 miles in 10 or 12 seconds, because the kind of driving I do does not require much acceleration performance. I am interested in good fuel economy. I still hope that I will someday own a car that does 50 or 60 miles to a gallon. I want to accommodate two passengers in comfort, but I wouldn't mind if my car accommodated more than two people. I want some space for luggage, but again, I'm willing to compromise on trunk space, as well as on cruising range. I probably wouldn't need more than, say, 100 miles cruising range so that I could fill up, let's say, once a week and pay no more than $10 for a fillup. And finally, I want a low sticker price. I am a romantic who harks back to the days when a car could be bought for three or four thousand dollars fully equipped, heater, radio, and so on. My requirements, in other words, are essentially for a city car, a low cost, low performance vehicle intended for short distance, non-freeway commuting and for local urban and suburban travel on weekends. It would serve, basically, my day-to-day transportation needs that I calculate represent roughly 80 percent of my automobile travel. Now those happen to be my requirements, but even there I have to ask myself, what about the remaining 20 percent of my travel needs? After all, I don't use my car simply for commuting. I do go out of town occasionally, my mother-in-law does visit us occasionally, which means that we have an additional passenger or two. I do have to haul bags of peat moss every spring, so I do have some trunk requirements, and so forth. How do I handle the other 20 or 30 percent of trip requirements? Now, here I must let my imagination roam, for given the way the auto system functions today, I see no solution for people such as myself, let alone for people who do a lot of freeway driving or who have large families and need larger cars. I would have to imagine, in order to make the mini, the real mini car, possible, a vastly different automobile system, a system that would include a vastly expanded and greatly more accessible system of renting and leasing vehicles. No matter how city-oriented you may be, sooner or later you will need that larger car. Can we envision a society which, in addition to having automobiles owned by individuals, also provides an extensive system of leasing and renting automobiles? The conventional wisdom and our instinct would say no, because from the very beginning of the automobile age, we have regarded the car as an article of personal possession. In some cases, such as farmers cooperatives, owning agricultural implements in common, the notion of sharing vehicles has been accepted. When it comes to sharing passenger cars, however, I think we are in virgin territory. However, there are some tentative signs that attitudes may be changing. The practice of time sharing various types of equipment, from sailboats to lawnmowers and power tools is spreading. Informal cooperatives are being formed to spread the cost of high-cost equipment and, in theory, this principle could be extended to automobiles. We have looked at some examples overseas, where the practice of sharing cars is beginning to take hold, especially in Sweden. Of course, Sweden is a very special country, with a long tradition of cooperatives -- food, housing and other kinds of cooperatives. So Sweden may not be our typical model, but still, if you look at Sweden, if you take Sweden as a harbinger of things to come, automobile sharing, the common possession of automobiles is a possibility. There are some examples of Swedish communities where neighbors banded together to own special purpose vehicles such as RV's or station wagons, as community property. Likewise, in the Netherlands and in France, there have been some tentative attempts to look into joint use of cars. We don't have to adopt that kind of an advanced notion, although that notion ... I see Bob Whitford here in the audience ... the notion of automobile cooperatives will be tested in the United States, as well. Bob Whitford and Tom Sparrow from Purdue University are now working on a demonstration project which would test the feasibility of an automobile cooperative in a residential neighborhood. But I'm more drawn toward the concept of using the conventional private rental firms, and have them expand their vision to include the widespread rental of automobilies on a decentralized neighborhood basis. So far, the automobile leasing and rental agencies have looked primarily to the business market. It is no accident that they are usually located at airports and in downtown locations. They are after the business market. However, there's no reason why, if the firms saw a market for short term automobile rental among residents of urban neighborhoods, why these agencies could not expand, and perhaps even make a killing, by renting automobiles in residential areas. Here again, there are some vague signs that this is beginning to happen. Right here in Washington, D. C., Budget Car has launched a few neighborhood-based auto rental agencies, and I'm told that they are booming. If that kind of a system could be universalized, if it could be widely adopted, then I think it might begin to make sense to think about specialized mini cars that would satisfy the city travel needs, but still give you the freedom and flexibility that comes from owning a standard automobile. Unless and until we are able to divorce the notion of automobile ownership from automobile possession, I will remain skeptical about the widespread feasibility or acceptance of a micro car. On the other hand, if we did revise our notions rather drastically, there might be a very promising market for them.

DISCUSSION:

BOB WHITFORD: I'd like to add a footnote to your statement. We are in the process of forming an agreement with Avis now in terms of jointly looking at some experiments with the Rent-A-Car. Our experimental effort as reported in the papers will be presented in Session 249 for this Transportation Research Board Meeting.

CARL CLARK: NHTSA. I noticed that you do not include safety at all in any of your minimal requirements. If you think about this at all, the small car seems to be less safe at the present time or could be more safe. Why didn't you include any aspect of safety, or do you think that's totally outside consideration?

KENNETH ORSKI: Well, I confess that my personal ... in my personal calculus I put safety rather low, much to the displeasure of my wife. I don't "buckle up." I am probably not your typical consumer or automobile owner. I think most people would probably rank safety much higher and elevate the minimum standards much higher than I would. I've driven a Fiat 500, for years but never felt any less safe than I do now, driving a larger Toyota. But it's a matter of perceptions, and I readily admit that opinions of people will differ on where to place safety in your rank of priorities. I personally would trade off safety for sticker cost, because I don't see how I or a large number of other people can afford $10,000 cars in the future. If there were a way of producing a $3,500 car enabling both my wife and I to each have a car, I would be willing to sacrifice quite a bit of built-in safety. Now that may sound radical to my NHTSA friends, but so be it.

UNIDENTIFIED: How close would a car like the Honda City come to meeting all of your requirements?

KENNETH ORSKI: Oh, I think it would meet them and exceed them. I would be willing to compromise much more in terms of interior space, for example. As I understand it, the Honda City Car is a four seater. Now, personally, I don't need a four seater 80 percent of the time, so I would be satisfied with something smaller, lighter, and cheaper.

UNIDENTIFIED: I realize that it would meet your minimum requirements for a mini or a micro, that is, 80 percent of your requirements, but would it, the Honda City Car, perhaps come close to meeting 100 percent of your requirements?

KENNETH ORSKI: Well, never having seen it I really can't answer. I wonder whether the car is comfortable enough to use on a 3,000 mile trip to the Rockies, or whether it is large enough to haul a lot of camping gear. Maybe it would satisfy my needs 90 or 95 percent of the time. I do drive out West, say, once every two years, but I'm perfectly willing to rent a car for that purpose, so we're talking about marginal utility.

FRED REEVES: Berkeley, California. I'm particularly interested in your leasing concept, and I was wondering if someone could act as a central point for rallying people who have found these access points. For example, in my proposals, I found that one of the things that people need to know is that it's happening, that it has a marketing potential, it has experience. I was wondering if you could collect opportunities from people in the audience, so we have some examples.

KENNETH ORSKI: I think that's an excellent idea. There is really no clearing house and no source of information about this, and one finds out about it almost by accident, by talking to people. I would suggest that the MIT project on the Future of the Automobile, and Bob Whitford's project at Purdue are two logical places to which this kind of information could flow, and from which in turn it could be disseminated to others. I would certainly applaud and second the notion that there should be more communication on that subject.

The question was whether the proposed leasing and renting arrangements might not be more typical of suburban behavior than city behavior. Yes, and no; it seems to me that it was not an accident that Budget Car began to experiment in central city, because that's where you have the concentration of demand and also the highest percentage of noncar owning people. In Manhattan, that kind of lifestyle is also very prevalent. Now, lots of people don't own cars in Manhattan, and rely on car rental agencies for their automobile travel needs. So, in many ways I think the renting and leasing approach lends itself best to inner city living. On the other hand, the need for cars and for additional cars is probably greater in the suburbs, where there is no public transit alternative, and where one is literally prisoner in one's own home unless you have a car. But I think one would probably have to ask the car rental agencies, all of which are now undertaking market studies, to find out where they feel the market really lies. I suspect you will get different answers from different people.

UNIDENTIFIED: Do you feel that manufacturers give any implied warranty say to sell these small cars even if there are no regulations?

KENNETH ORSKI: Maybe I should invite some of my colleagues to comment on this. I have no opinion on this, but I think Dan does.

DAN ROOS: The only comment I would make is it is ironical if one looks at the Japanese/US situation that the only area where unquestionably US productivity is superior is with respect to safety. And yet, US auto manufacturers have chosen never to utilize that with respect to their advertising and trying to gain greater market share. Certainly we respected their perception to take the issue as not important. Now I suspect the reason for that is an underlying fear that if one raises nasty issues about accident death and safety, it will have an overall negative impact on people's desire to buy an automobile, and therefore that can offset any competitive advantage that they might have with respect to the Japanese car. Although there are some people who will argue that and will say that if one looks back at some of the experiences that have been widely reported, the most significant of which was Ford's attempt during MacNamara's administration at Ford to market safety, but the conclusions were nowhere near as negative as currently perceived.

THE MARKET POTENTIAL FOR MICRO-MINI CARS IN THE UNITED STATES

John Hemphill, Executive Vice President
J.D. Power and Associates

PAT WALLER: Thank you. I believe, Ken, that your views on safety are not at all atypical but rather would be very typical of the average automobile purchaser. And, in regard to your views on sticker price, I grew up with the belief that anything you paid more than $5,000 for had to have a fireplace.

I have tremendous difficulty adjusting to the changing prices in automobiles. Our last speaker this morning is Dr. John Hemphill. He is the Executive Vice President of J.D. Power and Associates which is a marketing research company that specializes in automotive consumer research. The company was founded in 1968 and is located in West Lake Village in California. Prior to joining J.D. Power, he was Associate Dean of the School of Business and Economics at California State University in Los Angeles and has been a consultant to the U.S. Department of Transportation, Department of Energy and the Environmental Protection Administration. He has authored a number of transportation-related publications and he is going to speak to us today about the next wave of downsizing: The market potential for micro-mini cars in the United States.

JOHN HEMPHILL: I might just quickly add that in our national survey which I will be referring to later on, the average expected price the consumers will pay has risen 21 percent in just the past 12 months to about $8200.

The objective of my presentation is to describe the marketing research on micro-mini cars that J.D. Power and Associates has conducted during the past two years, and review some pertinent trends in automotive consumer preferences to put into perspective the potential demand for micro-minis in the US market. Unlike Charles who did not venture either a number or a date in his forecast, I will do both towards the end of this presentation.

The U.S. automobile market has been drastically and permanently altered by OPEC 1 and 2 and the resulting increase in the price of gasoline. The fundamental shifts in demand among consumers during the decade of the '70's were abrupt and long lasting and as you well know have affected almost every aspect of the automobile industry. The effects of these market changes I'll present are related to the market potential for micro-minis, as well as findings from significant, I think, original research we have conducted on the receptivity of American consumers to cars smaller than the Honda Civic. Events surrounding the oil embargo of '73/'74 and the Iranian crisis of '79 have left an indelible mark on the buying behavior and preferences of the American automotive consumer. Barely noticeable in the 1970's, but now the most pervasive force in the US market, is the continued growth and demand for smaller, more fuel efficient automobiles.

From sales in 1970 that accounted for 17 percent of all cars sold, domestic sub-compacts and import makes had captured 42 percent of the U.S. new car market by the end of 1980. All indications are that this trend will continue. Fuel economy became and remains the key to automotive marketing and design. As a consequence, domestic manufacturers have engaged in massive programs to downsize their fleets and sales of smaller import models, especially those from Japan which have resulted in an unprecedented penetration in market share. But still the demand is unfulfilled. In the Automotive Consumer Profile (ACP), a national representative survey of 5,000 American drivers, conducted by our company on a tri-annual basis, respondents who plan to buy a car within the next 12 months are asked how that car would compare in size and fuel efficiency to their current primary vehicle. In the latest wave of ACP, more than half of these consumers indicated a desire for a car that's very much or somewhat more fuel efficient than their current primary vehicle. Further, only slightly less than half indicated their next car will be very much or somewhat smaller than their current vehicle. The picture is clear; the American automotive consumer wants fuel economy and sees downsizing as the means to that end. In rating the importance of various factors in the next vehicle purchase decision, 95 percent of American drivers say that fuel economy will be very or somewhat important in their consideration.

Another important factor in the changing character of the automotive market is the emergence of the multiple-vehicle household referred to by two of our speakers. The traditional family automobile beset with changes in lifestyle and demographics is fast disappearing. More than half of all American households own two or more vehicles and more than one in five have three or more vehicles. The growth of multiple-vehicle households on the one side and declining family size on the other are factors often overlooked when the phenomenon of vehicle downsizing is examined in relation to escalating fuel and operating costs. The trend is toward increasing demand for personal transportation as opposed to family transportation. This situation has seemingly opened the door for smaller more specialized vehicles such as the micro-mini car.

Currently the car market is severely depressed and this condition is likely to last until about mid-this year. However, a look beyond the short term reveals a very healthy automobile market during this decade. We anticipate that average annual unit sales will exceed 11 million but it is important to keep in mind that inflation has and will continue to affect the new car market. A sizeable proportion of the market will be seeking reasonably priced, dependable and economical personal transportation.

By 1985, we anticipate a fundamental restructuring of size class segmentation. Our view is that the current X-body and K-car class will be the standard size passenger car of 1985. Each class below the standard size would be proportionally smaller than the traditional definitions applied during the last two decades. It will become more difficult for the American consumer to perceive the subtle product differences in moving from one class to another. But in time, the American consumer will, much like the European and Japanese consumers already are, become attuned to slight changes in car sizes and nuances in design.

We are certain that a newly defined mini class will emerge in the US automobile market. The class will consist of passenger cars having a wheel base under 90 inches going as small as perhaps 75, and having an overall length of under 140 inches. This important development will evolve more easily than anticipated as the energy situation continues to drive up the cost of personal transportation. Wheel base and overall length alone are not clear arbiters of market class or product class competition. Thus, we expect a great deal of confusion in the industry concerning the issue of appropriate class size definitions. What appears to be a lack of consensus now will surely become more serious as downsized models proliferate and a "mini" class emerges. Actually there are two discernible categories within the micro-mini class, based on such factors as overall length, weight, and engine displacement. There are several vehicles currently being produced for non-US markets that qualify as micro-mini cars with the Japanese leading in the number and variety of models being offered. Each has four-passenger capacity. Specifications for those models that fit our definition of micro-mini cars range from 76 inches to 90 inches in wheel base, 123 to 139 inches in overall length, and from 1200 to 1650 pounds in curb weight and finally with 550 to 1250 cc in engine displacement.

The central question is the U.S. consumer's receptivity to vehicles with these specifications. As noted, if given a choice, demand exists for vehicles that are smaller and furnish more fuel economy than is now available in the U.S. market. In fact, our Automotive Consumer Profile survey research shows that even in the subcompact car class, 50 percent of the owners say they want a somewhat more fuel-efficient vehicle the next time they purchase. These owners anticipate that further downsizing means not only will they receive improved MPG but also they will have to pay less for the car that delivers it. They should not be interpreted to mean they do not want the options and accessories they have grown accustomed to on larger cars. The potential demand for micro-mini should be considered in the context of downsizing that has occurred particularly during the last two years. For example, the number of passenger vehicles driven by the 4-cylinder engine has increased by nearly 50 percent during this period. This is a dramatic shift in such a short period of time. When new car intenders are examined, comparing engine type currently owned to engine type preferred in the next car, the results are even more striking. Currently 23 percent of the new car intenders have a 4-cylinder engine in their car but almost 40 percent want one in their next car, 1/2 have 8-cylinder engines but only 1/5 want one in their next vehicle. As we've said, fuel efficiency is the key to automobile design and marketability and the demand for improved fuel economy is limited only by available product and technology.

Consumers' demand for fuel efficiency is closely tied to their expectations regarding the price of gasoline. The median price expected by the driving age population 12 months from now is around $1.60 per gallon, down from the $2.00 per gallon they expected earlier this year. Although the consumer reacts to current fuel market conditions in their forecasting of fuel prices, they see prices remaining high and continuing to increase modestly. Those surveyed did not expect the days of "fill-'er-up" for $10.00 to ever return and their car size preferences reflect this.

During the past two years J.D. Power and Associates has been studying the question of consumer receptivity to micro-minis specifically, and on a national scale. One of the questions we posed to consumers representative of the driving age population was as follows: "There's a possibility that in the next few years both import and domestic car makers may introduce micro-mini cars which are smaller than the current Honda Civic and Volkswagen Rabbit. Please indicate how likely you would be to purchase a new micro-mini car if they were available the next time you purchased a car." Note that we did not bias the respondent by indicating, for example, that the micro-minis would be cheaper or give better gas mileage. More than 20 percent of the driving age population say they would consider a micro-mini the next time they buy a car. This percentage represents about 27 million American drivers.

From December 1980 to March 1981, the percentage of those who would consider a micro-mini increased from 20 to 23 percent; a statistically significant change, no doubt influenced by expected increases in fuel prices as deregulation took effect.

The micro-mini car is viewed primarily as a multi-use vehicle and this is seen in the proportion who would buy it to replace their current vehicle. Over half of those considering a micro-mini would use it as a replacement.

The multi-use purposes that consumers perceive are also indicated by their preference for a four passenger configuration over the two passenger design. The margin of preference as we've measured it is about 5 to 1.

Our Automotive Consumer Profile and other syndicated research we have conducted on the market for micro-minis indicates that about 1/3 of the market for them will come from current owners of subcompact or compact domestic models and owners of intermediates or full size models. About 2/3 will come from current owners of economy imports.

A significant proportion of buyers would be those who would have purchased a used car. We expect 1/4 of the buyers to be diversions from the used car market.

While males, Californians and those under 50 years of age are more likely to consider micro-minis, there are few variations in the micro-mini interest level by any other demographic or geographic variable.

When consumers can actually view and drive the micro-minis under test conditions, as we have recently done in Los Angeles and in Cleveland, there are no significant differences in consumer interest levels.

Acceptability of the use of the cars in all normal driving situations was slightly higher in Cleveland than in Los Angeles. Average ratings for the 12 models evaluated showed them to be reasonably acceptable for the more common types of driving, somewhat less acceptable for freeway driving and other special uses such as very long trips. As part of our field tests in Cleveland, and in Los Angeles, we asked respondents at the end of both the static and the test drive evaluations how likely they would be to purchase one of the micro-minis. In both cities, the likelihood of purchasing rose from the static to the test drive phase. For example, the percentage who would definitely/probably purchase any of the models evaluated in Cleveland rose after the static from 86 percent before to 89 percent after the test drive. There were important differences among the various models we tested, according to consumers, but the only car feature that did vary significantly overall between Los Angeles and Cleveland was higher preference among Clevelanders for an automatic transmission. None of the cars we had in the test were so equipped.

We have concluded there are four basic attributes or product capabilities that consumers perceive to be important in their consideration of micro-mini cars. They must have greater fuel economy than existing subcompacts at a somewhat lower price. Second, the in-use feeling that the car is fun to drive or convenient or easy to drive. Third, the performance that matches car size and available options must be there, such as air conditioning and automatic transmission. And, finally, there must be provisions for four seat passenger capacity. We expect the initial market for micro-minis would be for that "sub-mini" classification we saw before with an overall length of from 130 inches to about 140 inches, since the models in this size category will be perceived as only slightly smaller than existing models, and the cars can be equipped with an engine--say one with 1000 to 1200 cc displacement--that can accommodate automatic transmission and air conditioning while furnishing the necessary performance. However, we must add that more model-specific research will be required to pinpoint initial entry product positioning, market strategy and option packages.

There is a great deal of talk in the industry about consumers' concerns about safety and some believe that this will be a major issue in the acceptance of still smaller vehicles.

Consistently, we find safety to be a relatively unimportant issue to automotive consumers, regardless of the size of car owned. And demographically, safety is an important purchase consideration only to buyers over 55 years of age. In this age group, fuel economy wins out over safety, however. It should also be noted that the over 55 age group that is the most concerned with safety is the same group that is least likely to use seatbelts.

Safety is not a marketable feature to automotive consumers and will not be an important constraint on consumers' acceptance of micro-mini cars. In fact, restrictions of space and related factors in micro-minis are the primary reasons for car owners not considering them, outweighing safety considerations by over a 3 to 1 margin.

The high proportion of prospects for micro-minis that would purchase the car as a replacement vehicle, about 40 percent, suggested it would be used by a principal driver much more than by multiple household members and not for specialized driving applications.

The micro-mini car will be used much like existing compact and subcompacts are used by their respective owner groups. Again, the strong preference for the four seat configuration reinforces this important finding.

All indications are that while commuting and use for errands will be the primary uses for micro-minis, as they are for other cars, they are not perceived as single or specialized use vehicles and must be able to perform or fulfill normal usage expectations of about 250 to 300 miles per tankful of gasoline.

Based upon our national survey research, our product clinic research, and our focus group research, we estimate that by 1985 the micro-mini car market segment could easily account for 6 to 9 percent of passenger car sales. With two or three manufacturers in the market, then, and assuming one of them is a domestic manufacturer, unit sales of micro-minis in a 12 million car year could easily exceed 800,000 units. It is also assumed that gasoline fuel prices will continue to increase by a couple percentage points faster than the Consumer Price Index. We are also assuming that whatever fuel efficient technology that may be incorporated in the subcompact models can also be passed on to the new micro-mini models, so they would have the same relative fuel efficiency advantage they have now. While demographic, geographic and economic conditions vary from region to region, the fundamental nature of the automotive consumer remains fairly common throughout. Sales of micro-mini cars will undoubtedly be greater on the west and east coasts, but viable demand exists in all regions of the country, especially in the more congested urban areas. The prime prospects for micro-mini cars are those whose economic situations require exceptional fuel economy in a low cost package. Compared with the total new car market, they are younger, more likely to be single, and less affluent. Many of these prospects are currently being held out of the new car market by high prices and interest rates.

Some of the implications. There is a great deal of work and research yet to be done on the strategic and tactical aspects of market entry for micro-minis. It is clear though that the potential market exists and is of sufficient size to meet financial production and distribution criteria. The implications of the next wave of downsizing are many. For the American car makers find themselves, again, playing catch-up with the imports in this new segment of the market. This appears to be a likely contingency should domestic manufacturers choose a wait-and-see posture. I might add that even though there's been the recent tie-up between General Motors and Suzuki, Suzuki which manufacturers one of the near state-of-the-art micro-mini cars, there is some doubt whether that car will be brought into the country by GM within the next few years. Will electric vehicles find a niche soon? We think not. Unless there is a major fuel supply interruption or technological breakthrough that significantly increases the range of EV's and reduces their price in battery replacement cost, we do not see a market potential in the consumer market until well after 1990. Will micro-minis help reduce U.S. dependence on foreign oil? Already the average vehicle fleet fuel economy is improving as more downsized vehicles are replacing the larger vehicle. Micro-minis will contribute to further fleet fuel economy during the decade, and as fuel prices escalate beyond conservative projections, penetration and resulting fuel savings will be significantly higher. Can the micro-minis meet safety standards? Will fuel economy standards be necessary? It will no doubt require some engineering and product adaptation, but it appears that already existing micro-minis can be equipped with the features and the protection requirements to meet existing safety standards at a cost that will allow them a competitive price advantage. But whether fuel economy standards will be necessary after 1985 depends on fuel prices, supply, available product and the fuel efficient technologies they incorporate and their effects on consumer preferences and perceptions. The level at which the standards may be set, of course, depends on political, economic and other considerations at the national level. J.D. Power and Associates is currently examining these issues from the consumer's viewpoint in relation to the automotive market of the future. It certainly appears that current consumer interest is strong enough so that if effective marketing is accomplished with micro-minis, probably by the Japanese first, fuel economy standards could be set at higher levels than would otherwise be the case. This would force domestic car makers to produce and market cars in the micro-mini class. In conclusion, consumers, reacting to existing conditions and their expectations, will certainly reveal their transportation preferences. And the demand for low cost, fuel efficient, personal transportation that the micro-mini furnishes will certainly stimulate their availability in the very near future.

DISCUSSION:

QUESTION: Have you considered the light truck, micro light truck, that comes out of these same places? In Japan, we have these vehicles starting at prices of about $2000 rather than $2700 that the micro cars are. It works in the same way to save fuel economy while it seeks to serve a different sphere of marketing than the four passenger car. It seems like a very attractive possibility for a lot of our needs including Mr. Orski's fertilizer . . .

HEMPHILL: Henry was asking about whether we'd looked at the consumer receptivity to the small, very small two passenger trucks on the market. We have not specifically looked at that except in the same way that we have looked at the micro-mini cars. We've presented micro-minis to consumers in both static and drive evaluations, as well as had consumers indicate their receptivity to them in two national surveys. The small fuel-efficient trucks you refer to we have not looked at except in our mail surveys. Receptivity is quite high; the niche in the market is for the younger age group as you might imagine and for some rural uses, but there could well be a market for that in the nature of the micro-mini down the line as well.

ROBERT CONNELLEY: Your view of the industry is that 11 million cars would be bought each year this decade. What if that doesn't turn out to be the case and it's only 7 million considering the type of people who would buy those vehicles and their characteristics? How does that affect the market for minis?

HEMPHILL: It's a good question. And the question was what happens if our projections for an average annual, it'll be up and down, but an average annual of about 11 million units doesn't transpire and it's somewhere around 7, perhaps 8 million unit level? In answer to that, I think one has to weave in a number of things and I am not going to take a long time to do it, but someone asked about the demographics. Well, there are some demographics at work here that are important. The health of the US automobile industry, market I should say, perhaps not industry, will be very much tied to the increase of the number of licensed drivers coming into the population during the decade. And we will see about a 14 percent increase in licensed drivers. This is about half of the increase we saw in the 1970's but still a fairly healthy growth in that segment. The ratio of cars in this country to licensed drivers is nearly 1 to 1. It seems that when a licensed driver comes into the market they certainly want access to a vehicle, a primary vehicle for their almost exclusive use. The micro-mini fits that bill. Someone referred earlier to the Volkswagen experience. The Volkswagen success was built upon parents turning away from the used car market to purchase a car for a son or daughter, and buying a VW. This will be the case with the micro-mini cars. I was told by the president of one of the major Japanese manufacturers not two weeks ago, he said, "I could bring in our micro-mini car for a third under the lowest priced car that I now have on the US market out the door at retail, with fuel economy that may be 10 to 15 percent greater than the best fuel economy that I achieve on my product line." Our projections would certainly be lower if demand is down. But not that much lower, because the demand for these will be at the younger age groups coming in as first time buyers.

QUESTION: I noticed that we don't discuss and you apparently don't see a market for essentially an enclosed motorcycle. Something on the order of a Morgan/Bright, the freeway or commuter type or would you say two passenger vehicle. As a related point, it sure bothers me that everybody thinks that they are assuming the fuel consumption and fuel costs approximate the ownership costs. My own case with a teenage son, I find my insurance costs are higher than my gas costs and that's driving a fullsize station wagon. There are penalties associated with high accident level vehicles and high accident level vehicles tend to be the smallest vehicles. If these vehicles cannot meet present insurance or present safety standards they may well have very much higher insurance costs as well as threats to my life.

HEMPHILL: Let me rephrase, as there were a lot of statements in that question. The question might be, are we overemphasizing the role of fuel economy in the purchase decision at the expense of other considerations that the consumer has to weigh? I would offer this, and our survey data came in a little bit too late in order to incorporate it into the paper, but consumer preferences have clearly shifted in just a year. We regularly take a look at the top 12 factors considered as important in the purchase decision. In some cases we aid the respondents, in some cases we don't. Now a year ago, fuel economy led the list in purchase considerations by a wide margin. Second came low purchase price, third came dependability, minimal repairs. Just a month and a half ago, the top rated factor was dependability, maintainability of the car, dependability and quality, I should say. Second was low purchase price, and third was fuel economy. So we've seen a rapid turnabout in purchase considerations. At the same time, in that same year, the interest level in the micro-mini car has changed not one bit, in fact it's edged up somewhat. So I think that consumers are looking at the package that the micro-mini offers rather than just its fuel economy and certainly, as Charles pointed out, the first-time cost of the vehicle is as important to consumers as is the fuel economy that it furnishes.

We don't see very much of a market for an enclosed motorcycle. There's a niche in the market somewhere on a low volume basis for that kind of a vehicle. The overwhelming preference for four passenger configuration of the car suggests the people, if they have a choice, will prefer one that has multi-use capabilities. That's what four passenger seating does.

QUESTION: What were the first-time prices you used in today's surveys for your 1985 projections and did you have the basis for the ratio of personal incomes to inflation?

HEMPHILL: No to the second, the first I can comment on. In terms of the prices that we presented to consumers for these cars, we had, as I say, 12 presented to them. The prices for them ranged from \$3600 to about \$4900 in today's, this year's dollars. We expect that the prices for these will go up no faster by 1985 than for any of the other car models that the Japanese are producing. I think one of the things that is overlooked as far as the Japanese strategy is concerned, is certainly that they have no incentive to bring the cars in now and probably not next year. At the same time the Japanese are very much geared to becoming full-line car manufacturers from low-priced cars to very expensive cars; in today's dollars, cars in price from \$16,000 down to \$3800/\$3900. The micro-mini is coming in at the bottom. They will be very shortly introducing cars in the sporty car class priced from \$14,000 to \$16,000. We currently have a test underway for those kinds of vehicles and I can tell you the interest level is very high.

QUESTION: I'm interested in pursuing the insurance thing a little further. The insurance industry has recently said that smaller cars were unsafe and, based on studies of fatalities and insurance claims, I expect there will be a lot more of this close rate adjustment, so that a two-part force exists. You have a higher insurance cost plus greater information on difficulties with safety. Is this factored into your projections?

HEMPHILL: It is to the extent that we still believe it to be important.

QUESTION: To what extent do you see the importance of it?

HEMPHILL: The question is to what extent will safety over the next few years play a role in the purchase decision. And more information being supplied to the public on the safety of vehicles. I am not sure more will, by the way. I'm not sure we are going to get better information to the consumer about safety issues. I think that the publicity certainly does raise the sensitivity of consumers to this sort of thing. But if you look at where their preferences are and the margin of preference, safety rates down that list of 12 factors between 8 to 11. And, never above 8th place in their mind. The first time cost, the expected fuel economy of the vehicle, the expected durability, dependability of the car, the seating capacity, its range—a number of other things are very important as well, much more important than the safety issue. We still don't see safety becoming a marketable feature to consumers, meaning one they will respond to in their car purchase decision. If the insurance costs are significantly higher over the next few years, this is not presented to consumers in the focus group work. They are certainly aware of it, but they are apparently willing to amortize the cost of the vehicle and insurance premiums over the life of the vehicle as opposed to the trade-off with the first-time cost of the vehicle itself. After all, you are talking about a car that may be $2000 to $3000 lower in price than what a comparable but upscale larger model might cost them. That's what turns them off.

QUESTION: Yes, along these lines the loss of life is expensive.

HEMPHILL: Oh, absolutely. But the single individual consumer believes (a) it's not going to happen to me; and (b) if it is about to happen, I can avoid it and well, it's a very difficult thing, it's first a very difficult thing to measure. We try to do it directly and indirectly. The direct way I refer to is by asking a question. A few months back, we said large trucks are becoming an increasing hazard on streets and highways. Strongly agree to strongly disagree in the response. We were expecting that larger car owners would feel safer on streets and highways than smaller car owners—at least that. It did not vary one bit by car size owned. It only varied by the over 55 group feeling that they were less safe on streets and highways because of the trucks.

QUESTION: Mine's not a question, but is a hypothesis. I think that the small micro-minis will be driven less miles specifically in terms of the vehicle miles per year than will this car we have today. Particularly in terms of what Ken has to say about 20 percent of the drivers will get some other kind of car. I think that that cuts down the potential of accidents with smaller vehicles.

HEMPHILL: It increases the calendar life of the car, too.

QUESTION: I note that it is possible to build a 1100-pound car which I call a hack. I will be showing films of that in the session this afternoon. I have an instinctive response to this sociology of our lack of concern for safety. The city was disrupted by an airplane crash last week and a number of people were killed similar to those killed on the highways every day. We just ignore it. My question to you is should we go on ignoring as we are or what should be done about it? How can we get legislation on safety features even if the people don't want them? Don't want to pay for them, don't want to pay attention to it? Should we just ignore it, or should we do something?

HEMPHILL: Well the question is, I'm asked for a judgment call about whether we should or should not be giving attention to safety, whether consumers desire it or not. I can respond on a personal level and say we certainly should, in terms of the social costs involved with the injury and death that occurs. The professional side of me says the consumer really doesn't care and would rather have a cheaper car that's sporty and fun to drive and can carry four people.

PAT WALLER: Well actually this is just getting to a question I just wanted to ask the whole group here. I think all of you have made it very clear that safety is not a big issue in the decision making of the car purchaser. Furthermore, we have the information that you presented, Dr. Hemphill, that these smaller cars are going to be purchased particularly for younger drivers, their first car just starting out. We have a much higher crash rate and much higher death rate in that age group already. Since it is fairly clear, and I think there have been some serious efforts made to inform the public and get them concerned about safety and safety just does not sell for a lot of reasons that I am sure we're familiar with. Given that that's the case, where should the responsibility lie for safety standards or some insurance that safety measures are addressed? Where should that responsibility lie? How should that be handled or should we indeed ignore it?

DAN ROOS: I am going to use your question as an opportunity to raise some and maybe play the part of the devil's advocate. I suppose I am a little bit concerned with the session this morning. I won't quite say it sounds like advocacy, but everybody comes across so strongly in terms of the mini-micro that it seems worthwhile to raise maybe the other side and in doing so I will touch some on that safety issue as well. As I listen to the discussion there are two arguments for the mini-micro. One is fuel economy and one is cost. And it seems to me that when we talk about something that could be conceived as fundamentally new, there it's important we recognize whether we are talking about incremental change or dramatic change and it strikes me, based on everything that we have heard this morning, we are talking about incremental change and I would argue, small incremental change. Let me be more specific on that. With respect to the questions of cost, the only figure that has been thrown out was Charlie's figure which he would be the first to agree is a speculative figure and as I recall, Charlie, that was about $3500. I happen to be looking for a new car, so I have been looking over the pages of the automotive section. In Boston there was an ad this weekend for a Renault car, which certainly comes pretty close to being a micro-mini, that was down to about $4500.

Granted that's $1000 more but still they were considerably less than $10,000 that's being bandied about and there were several other cars in the $4000 to $5000 range. There were also several ads for 1980 Citations, and other reasonably fuel efficient cars with a one year guarantee selling for about $3500. I must say I'm not sure if a consumer was given a choice of having a fairly nice, larger, reasonably new Citation as opposed to buying a very very small micro-mini car as to what that decision would be. As I said in my talk, if one looks at current figures, the subcompacts are doing very, very badly right now. And, if the subcompacts are doing badly, it is unclear whether a sub-subcompact is going to do much better.

From a fuel economy point of view, I think we all recognize the fact that we have gone from a situation in the 1970's of an average fuel economy on the order of 12 or 13 miles per gallon and we will have gone at least to 27.5 by '85, a hundred percent improvement. The figures being thrown around today are 40, 50 miles per gallon. You can go out and buy a VW Rabbit right now and get 40, 50 miles per gallon. I mean, one is not talking about huge differences, quite unclear as to whether the American consumer is going to pay for small incremental improvements of fuel economy. One other point in that regard which hasn't been mentioned at all: Clearly if cost of operation is important, an obvious tradeoff is ridesharing. To what extent does it make more sense for two, three people to carpool, or to enter into a vanpool with respect to the commutation trip as opposed to going out and buying a micro-mini car. Also, with respect to the cost issue, everybody talks about $10,000 and how awful that is. I would simply point out that if one looks at data, the car payment as a percent of disposable income, this year is exactly the same as it was in 1976 and 77, which was a boom year in car sales and in fact, if one tracks the cost of buying a car over the last 10 or 20 years, it certainly has not been out of line with inflation.

I think the gentleman in the back raised a very interesting point which hasn't really been addressed at all and it gets back to my point on incremental versus dramatic change, because if one does not look so much at the downsized car but looks at an upgraded Moped from the point of view of enclosing it, making it far more comfortable, then one potentially is talking about dramatic change. One is talking about a significant increase, with respect to fuel economy, a significant decrease with respect to cost. But, that does raise many of the questions with respect to guideway, with respect to safety, because you are talking about such a fundamentally different vehicle. But it is quite conceivable if, in fact, cost is such an important consideration and if fuel economy is such an important consideration, then that ought to be far more of a focus than the class of vehicles we're talking about. I am not sure we should necessarily take as a given what everybody has. That the consumer will not pay attention to safety. I say that from a couple of points of view. Because certainly four or five years ago, we could have said that the American consumer and the U.S. auto manufacturers would have said that the U.S. consumer would not pay attention to fuel economy. And, to cost considerations in terms of buying a vehicle, that it was much more a possession, that it had images to it, and I think it's fairly clear that in the last several years the consumers' viewpoint towards the vehicle has changed rather dramatically. Not that it is a particular issue being addressed, but I've been fascinated the last three or four weeks by the focus that the media has directed toward drunk driving. A focus that I have never seen in the last decade and highlighting what several states have been doing which is clearly related to the safety problem. If one looks at European experiences, certainly there are countries where safety is far more of an important characteristic and one could argue that Europe to a large extent leads the United States with respect to concern over overall economy of automobiles. The small cars, I think by and large, are less safe cars. It strikes me we are now entering a period where we are yet once again above the 50,000 deaths per year. If that figure starts to increase significantly, my sense is that there will be a response and safety will emerge. Safety will either emerge in a new way with respect to increased consumerism and increased concern or once again the government will be playing the more significant role in terms of requiring certain characteristics in terms of the design of vehicles. I'm sorry that was a long response but I really felt it important that we not just take for granted the fact that this micro-mini is going to descend on us and it's going to be terrific and everybody is going to buy them. It is not at all clear to me that's going to happen.

PAT WALLER: Thank you. Could I ask our speakers if there are any final comments that you would like to present? I know better than to ask a professor.

CHARLES LAVE: No, it'll even be quick. Two people in here have been sort of expecting the insurance industry to ride to the rescue of the American car industry because somehow we all know small cars are less safe, therefore, they'd be charged higher premiums. So we'll add the premium cost to the gasoline cost and all of a sudden we can sell big cars. I must admit to thinking about this for just about 10, 15 seconds, the last insurance bill I have on my automobile has three quarters of the cost in two components. Collision payments, and liability for what I do to other people. If the small car costs less, collision has got to be less, and obviously the small car is going to do less damage when it hits other people. So in fact, in a properly adjusted insurance market the damn things may even have a cost advantage on you and you're not going to get rescued.

PAT WALLER: I think the main concern was the potential for injury where you would have the medical problems that cost.

KEN ORSKI: I have just one quick final thought and that is I think the whole session could be summarized in one question. Can, will we be able to afford in the future an all-purpose car? If the answer is yes, then I see no future for mini cars because almost by definition, an all-purpose car for city and highway driving cannot be a micro car. The question is can we afford both in terms of fuel efficiency and sticker price of that kind of a car in the future.

PAT WALLER: How about the question can we afford two all-purpose cars? I think of this much more as a second vehicle, you know, if indeed it has a use.

INTRODUCTION

James L. Pline, Group 3 Council TRB, and Concept Review Supervisor, Idaho Transportation Department.

This morning we heard that there was some potential for a smaller vehicle, primarily because of buyer first cost and fuel economy. Safety did not appear to be a major item of buyer concern. It appears that we can expect a greater number of smaller vehicles in the traffic stream, particularly in and around some of the urban areas as a second vehicle, maybe for some of the younger drivers. If this occurs, what kind of problems can we expect? Our speakers this afternoon will point out some of these problems and maybe raise some additional questions relative to vehicle design. What features should we expect in this vehicle? What features would there be that might improve the safety? Are there some vehicle design features that would improve the compatibility between the vehicle, the driver and the roadway? What are the vehicle problems and how should they be resolved? The roadway, because of its cost, of course is slow to make transitions to accommodate vehicle changes. What are the roadway features that could be a problem with smaller vehicles? Can some of these problems be offset in cheap retrofit of roadway appurtenances? Is there a need for vehicle design and driver education to offset some of the problems? What is the scope of the costs when we talk about roadway revisions? The safety of smaller vehicles has recently been highlighted in the news, pointing out the problem. It appears to be quite a problem when we mix the smaller vehicles with the larger ones. Are there some items that could be taken care of to gear the driver for his operation of the smaller vehicle in the traffic stream? What has been the impact of these smaller vehicles as far as safety? Interwoven into these considerations, of course, are the existing laws, federal requirements, vehicle standards and liability considerations of smaller vehicles. Will there be a change in the vehicle safety standards? Can we expect some changes as far as liability? What approach is the insurance industry taking in this regard? Our speakers this afternoon will address these questions and raise some additional questions that we hope will generate research and answer some of these problems.

DESIGN NOTES FOR A SAFER HALF MEGAGRAM AUTOMOBILE

Dr. Carl Clark, Office of Passenger Vehicle Research, National Highway Traffic Safety Administration

JIM PLINE: Dr. Clark, our first speaker, is a biophysicist. He has taught at the University of Illinois and the University of Pennsylvania. He has also worked for the Library of Congress, has had some involvement in aeromedical research for the X-15 pilots and Mercury astronauts. He is currently working for the National Highway Traffic Safety Administration.

DR. CARL CLARK: May I note that I am speaking as an individual and not necessarily representing the National Highway Traffic Safety Administration policy.

In looking at the various ways of describing the small cars one recognizes that smallness finally gets down to the size of the human body. The dimension of the car, in order to have any crash survivability, gets down to the physics of the deceleration event. The engine power is related more to the attitude on acceleration that is desired than the actual efficiency in going across the road. We're hearing the advertisement for the new Chevrolet, that 12 horsepower will keep you at 50 miles an hour. Many of our cars are still over 100 horsepower. So I am urging that we indeed think of smaller sizes in terms of curb weight. Can we make a half megagram or the 1100 pound car safe. It can be made safer if some attention to these basic physics and biophysics principles are observed.

The Suzuki Alto at about 1100 pounds is near a half megagram. It's a four passenger car not yet available in the United States. The problem of the safety of an automobile falls into two categories; crash avoidance and crash protection. The small automobile crash avoidance aspects depend upon handling properties and braking particularly, and in both of those we can make improvements. It is very significant to note the discussions on the passive restraint standard. And so, these cars indeed, according to the very minimum federal standards, do not have to observe the crash requirements for dummy survivable loads. To be sold in this country they would still have to observe that 30 mph barrier crash loads will not cause the tearing out of the windshield or leaking of fuel. There are a few standards that still require a crash test. This may change, as a matter of fact, and we are concerned about how the death numbers will increase as very small cars get on the road. The Alto looks as if it complies with all the present standards.

The Dihatsu Cuore is also a half megagram car. It has some problems. The gas tank is in back of the rear wheels and you want to avoid that design today. The steering apparatus is not good. You want to look particularly at the rearward displacement of the steering wheel. These vehicles have the wheels near the front and the steering apparatus gets involved early in a collision. Therefore, I think we need to take a hard look at going to non-mechanical steering control, either hydraulic controls or electronic controls like in the aircraft industry. Why do we need that rod that is a spear coming back at the person?

In the discussion this morning, we didn't really touch on the smaller vehicles. I do want to talk a little bit about the earlier version of the Sebring City Car, a two-passenger electric. It didn't get much over 30-35 miles an hour and it did very poorly in crash tests. The modern version is called the Commut-a-Car. It is handled by a new company, and has a much better bumper system. The front wheel is the first collision contact and it has a rigid steering wheel with no crash protection. A fluke in our standards is that all three-wheeled vehicles are classed by the National Highway Traffic Safety Administration as motorcycles. That isn't in the standard itself, it was a legal decision and, at present, that decision is firm enough that to change it will require a regulation. So, these cars have never had to meet a crash survival test, and, indeed, that's one of the attractions to build three-wheeled cars in the United States. We do have the ability in the National Highway Traffic Safety Administration to do defect investigation and require recall if we see a car that is totally unreasonably unsafe even if no standard is involved. The manufacturer has to certify standard compliance and we can subsequently test for compliance.

The HM vehicle is an enclosed motorcycle weighing about 600 pounds. It is basically a one place vehicle, a three wheeler. We have done quite a study of three wheeled vehicle dynamic safety and you'll see a film of that in a moment. This does have room for another passenger in back of the front passenger, and gets something like 78 miles to the gallon. It meets the legal requirements at the present time to be on the road.

This is Jim Beatty's enclosed motorcycle. Jim Beatty is an aerodynamicist and was particularly interested in making the 0.25 drag coefficient vehicle. This is actually a rear-drive motorcycle engine and a strengthened frame with a roll bar. He has paid attention to crash protection. He has beverage cans packaged in plastic in the nose and probably has quite significant crash protection. The two outrigger wheels do not both touch at once, but they give stability.

We have these smaller vehicles coming along and I think they'll just be in a niche of the market. I think they can probably comply with our standards. We are concerned as to whether our standards are really adequate and yet this is a period in which we probably will not have very many new regulations to strengthen the standards. The standard car in either a barrier or a crash test was not so good a few years ago. It is now a lot better. It is interesting that Jim Ryan in 1957 proposed that bumpers don't have to meet 5, 10 or 1-1/2 miles per hour test as the industry is now arguing, but indeed could stop us at 30 or 40 miles per hour without significant injury. That concept was developed in the old safety car designs. The AMF Safety Car looks horrendous with the early version of the air bag flying out the windows and all that stuff. With hydraulic bumpers the load can be attenuated so that the frame and the interior passenger compartment in a 50 mile an hour crash will receive only 40 G's. In crash protection, what you need first is a structure. Both AMF and Fairchild Safety Cars were over-designed but the message is that bumper attenuation can protect us. We haven't adequately dealt with the compatibility issue at all in American regulations. The heavier cars with load attenuation can take up a greater proportion of the load and thereby provide protection for the smaller car. This is something in front of us that we need to think about. So far, we're having trouble specifying sufficient safety requirements for the individual car but eventually the mix and the possibilities of load attenuation for the bigger car must be considered. If we would begin to deal with the compatibility issue we could do a lot in this area.

The first message that comes out of this is that the small car should not just be small; it can be lightweight but it also should have a crush capability. Because of the three-wheeled vehicle exemption from our dummy crash tests, a number of three-wheeled vehicles have been built. We have been concerned and have tested the dynamic stability of these, which is more a crash avoidance feature. You bring them up to increasing speed in a constant radius turn and determine the speed at which they either skid out or begin to lift a wheel. The three-wheel design can be less stable than a four-wheel design of the same weight, but a three-wheeled car that is well designed can be more stable than some of the four-wheeled cars that we now have.

There is an 1100 or 1200 pound car put together by the University of Washington, mainly constructed by the students, but using crush protection concepts. The front end has foam-filled material and honeycombed material. It provides passenger survivability at 40 miles per hour with not more than 30 or 40 G.

The potential of a good belt system begins to fade out at around 30 miles an hour or 30 G. You begin to overload the chest. An air bag can distribute the load so that you do have the possibility to make design speed, that is 55 mile per hour crashes, survivable by allowing the right amount of crush distance. I would settle for 30 miles an hour barrier crash survivability without injury today. At thirty miles an hour, you can design a controlled collapse of the front end so objects do not penetrate the passenger compartment. With the combination of perhaps two feet of crush area and no more than 30 G in the passenger compartment and a good restraint in the passenger area, you should live, in fact emerge without injury from a 30 mile an hour crash. My own research design is that we should emerge, without injury, from 55-mile per hour crashes. My conclusion in looking at the data is that we have the technical know-how today to perhaps get rid of some

80 percent of the deaths on the highway by the information we now have. We know how to build these cars. The questions have been, "Are they too expensive? Are they too different from what the public expects?" The National Highway Traffic Safety Administration is hoping to convince the public to fasten up their belts. Certainly if they would do so their chance of death would be cut in half. I still feel that car design is where we must also look; doing something about the design to provide protection in spite of the public.

The 30G "squarewave" crush distance to stop from 30 miles an hour is a foot, but in a typical oscillating pulse car crash the used crush is nearly two feet. So even little cars should have something like two feet of crushable material if they're going to be made by a reasonable manufacturer today. To a significant extent the fuel economy is a function to a significant extent of the engine horsepower. My own recommendation is that we pay much more attention to being patient on the highway and not using the greater horsepower. We should not expect high acceleration, and design the roads accordingly. Certainly, we ought to make more one way streets to reduce the chance of head-on accidents. The feeling that you have to get there so quickly is a social ill within our country. We can begin to pay attention to not having to hurry quite so much and use a mere 20 to 15 horsepower for our motor vehicles. They can, indeed, be big enough to survive the crash loads and yet not so heavy that we get at least 40 miles to the gallon. I do stress, again, that the present motor vehicle safety standards will not make these micro-mini cars, the half megagram cars, as safe as the present large cars. I hope we will pay attention to requiring a dynamic test at some future date.

I do see the communications to the car being very significant in crash avoidance. Micro electronics are now appearing. We have computers taking care of the engine. They could begin to interactively tell us where our next turnoff is and all kinds of other things that we want to know about where we're headed that contribute so significantly to accidents. In the same way, once you have the computer on board the functions of the radar detection of an impending impact can be put in that same computer thus eliminating a major part of the cost of a radar system. One of the estimates is that automobile radar, if you didn't have to pay for the computer, might be as little as $25.00, molded into the front grille of the automobile. The radar brake is certainly a feasible device. My own expectation is that we can begin to design cars that just plain cannot crash. That should be our goal. People will say, "That's much too expensive", and what I'm saying is let's do the research to cut the expense. These little cars are coming, and let's make them safer than they will be if we don't pay attention to these basic principles.

DISCUSSION:

QUESTION: How does the small car respond to crosswinds?

DR. CLARK: We did pay attention to the crosswind sensitivity in the tests of these three-wheeled vehicles. NHTSA has large fans that can create significant winds of 30 miles per hour. What you want to make is the center of pressure for the side load very close to the center of gravity. Mr. Walter Korff is one of the experts on how to make the little cars so that they're not sensitive to crosswinds by putting the center of aerodynamic pressure at the center of gravity. He also was involved in one of the high speed Bonneville Salt Flat designs that got aerodynamic drag down below .2. My view of reasonable safety is that we have the technology to save 80 percent of the 150 people we're killing every day. Eighty percent, and we're not using it, so somebody's not doing a reasonable job. We should examine dollar trade-offs. The societal cost of accidents, which we estimate at about 50 billion dollars a year approximate each year the cost of new cars. The average societal costs due to accidents equal the cost of the car. If we take a significant chunk of that cost of accidents and put it into safety so that we didn't have the accidents, we'd come out ahead. The problem is that the manufacturers at present, in product liability settlements, pay probably less than one percent and maybe as low as 0.1 percent of the societal cost of accidents. They see the cost of safety but they don't see the benefits of it. I've suggested, actually, within the agency that we might be better off to abolish all of our standards and simply require that the manufacturers pay for all the costs of injury. You would then have no insurance, injury insurance, on your car, so you probably, over the life of the car wouldn't pay too much more than you're now paying, and yet all the money to pay for safety would be in the same pocket that is paying for the car design. I think you would see that the numbers of deaths would go down at least half, and probably 80 percent is what I surmise.

QUESTION: How good is the air bag restraint system?

DR. CLARK: I thought I invented the air bag restraint when I was at the Martin Aircraft Company in 1962. I was developing an air bag design for astronauts landing on the moon. I had the first government contract on air bags, and worked on air bag restraint for airplanes, and then finally did the initial public work on air bag restraint for automobiles. We don't know the acceleration level that is survivable or that which would produce what I call a "soft death". In fact, I wrote in the book, "Human Factors in Technology" a chapter on "Acceleration and Body Distortion", and I said that it is not the force but the distortion due to the force that is lethal. If you examine the effect of acceleration, if it's indeed a uniform acceleration over the entire body, it's a uniform load and is not distortion. If there are differential compression capabilities, the lungs for example, you can have differential compression and can get distortion there, but basically, if you have a uniform loading such as an air bag provides you can, probably, as a healthy person, stand up to 200 G. In fact, there are reports on the survivability of people who fell out of 15-story buildings and got up and walked away. They survive by hitting soft dirt and sinking in five inches with a well-distributed load. There are also people who hit the tops of cars flat and dent the car and survive. These are very high G levels, but they're well distributed, so there's little distortion. By no means is 30 G the limit. The real problem is the distribution of the load. This is the problem with the one and seven-eighths inch wide seat belt. At 30 miles per hour, in a barrier crash, the 30 year old male begins to break his ribs; the 50 year old male at 30 miles per hour is perhaps breaking 10 or 12 ribs. The 30 mph barrier crash load is not something you walk away from if you are an older person wearing safety belts. In an air bag there is a broadly distributed load and no problem.

POTENTIAL IMPACT OF THE MICROVEHICLE ON ROADWAY FACILITIES

Donald L. Woods and Hayes E. Ross, Research Engineers, Texas Transportation Institute, Texas A&M University

Paul Dexler, in a July 1981 Motor Trend Magazine article (1), says, "The Micros Are Coming." For those of us in the highway research field, this means we are already behind. To have the information necessary to guide designers when the micros are in wide use, several years and millions of dollars of research will be needed.

This paper explores the potential impact of micros on highway design. An attempt has been made to present logical and reasonable projections for changes in design which can be expected should the microvehicle become a significant part of the traffic stream.

Before evaluating the potential impact of microvehicles, it was necessary to define the basic design characteristics of a microvehicle. Based on the data provided by Dexler, the following summary statistics are given for minivehicles and microvehicles. These data form a basis for selecting a design microvehicle.

For the purposes of this paper, the values listed in Table 1 for the microvehicle will be used as the design microvehicle. It probably represents the low side of the microsize vehicles that can be expected in the next decade and therefore may well be the logical microcar design vehicle.

Driver eye height for the design microvehicle can be estimated from the vehicle height. The Society of Automotive Engineers (2) suggests that a driver's eyes will typically be approximately 10 in. (25.4 cm) below the roof of the vehicle. From Table 1, microvehicle height is approximately 53 in. (134.6 cm). The eye height then would be approximately 43 in. (109.2 cm), or 3.58 ft. (1.1 m). This eye height is remarkably similar to the eye height of minivehicles and the design eye height that has been tentatively adopted for the new AASHTO highways and street design policy. Therefore, the problem of driver visibility from the microvehicle would not be expected to be any different than for the present minivehicles.

The design microvehicle is 6 in. (15.2 cm) narrower and approximately 2 ft. (0.61 m) shorter than the present minisize vehicles. The doors on the microvehicle will probably need to be essentially the same size of those on the minisize vehicles. A recent study (3) indicated that the partially open position of minivehicles is about 47 in. (119.4 cm) wider than the closed door width, and the fully open position is about 83 in. (210.8 cm) wider. Thus the two-door open design microvehicle dimensions are 102 in. (259.1 cm) or 8.5 ft. (2.6 m) partially open and 138 in. (350.5 cm) or 11.5 ft. (3.5 m) fully open.

These basic dimensions permit an evaluation of the future needs of highway design features to accommodate the microvehicle.

Geometric Design

Stopping Sight Distance

The basic microvehicle design characteristics previously summarized suggest that a 3.5 ft. (1.1 m) eye height would be appropriate, since AASHTO has already adopted an eye height of 3.5 ft. (1.1 m) as the basic design eye height for the future. General application of this criterion would appear to satisfy the stopping sight distance needs of microvehicle drivers.

Passing Sight Distance

An eye height and object height of 3.5 ft. (1.1 m) previously adopted by AASHTO would appear to provide a relatively safe passing sight distance for the microvehicle driver. The lack of adequate visibility of restrictive pavement markings and the changes in acceleration characteristics of the smaller vehicles will probably be far more significant. No additional changes in the passing sight distance criteria are seen to be necessary to accommodate the microvehicle.

Lane Widths

Lane width requirements for the microvehicle for low-speed operation could be as narrow as 7 ft. (2.1 m) -- a vehicle 5 ft. (1.5 m) wide plus 1 ft. (.31 m) clearance on each side. It is, however, very doubtful that microvehicles will ever make up a majority of the traffic stream. The compact will probably be the least size of vehicle on which lane width will be predicated. Thus an 8 ft. (2.4 m) lane in the absence of trucks or buses is the least probable lane width that can be effectively operated. For high-speed operation (i.e., over 35 mph (56.3 km/h)) a 2 ft. (0.61 m) clearance on each side of the vehicle is needed for normal tracking. Thus 10 ft. (3.1 m) as a minimum should be used. Where trucks or buses are present in substantial percentages, the lane width would be dictated by the maximum 8 ft. (2.4 m) truck width. For low-speed operations (i.e., 30 mph (48.3 km/h) or under) a width of 10 ft. (3.1 m) is acceptable. For high-speed operations 11 or 12 ft. (3.4 or 3.7 m) will need to be provided.

TABLE 1. TYPICAL DIMENSIONS FOR MINI AND MICROVEHICLES (after Dexler (1))

VEHICLE TYPE	VEHICLE LENGTH (in.)	VEHICLE WIDTH (in.)	VEHICLE HEIGHT (in.)	VEHICLE WHEEL BASE (in.)	VEHICLE WEIGHT (in.)	WHEEL TRACK (in.)
MINI	148	61	53.6	89.5	1630	52.5
MICRO	126	55	53.0	81.5	1200	48.0
DIFFERENCE	22	6	.6	8.0	430	4.5

Metric Conversions: 1 in. = 2.54 cm
1 lb_m = .454 kg

Parking Stall Dimensions

The basic microvehicle parking stall dimensions would be 8 ft. by 10 ft. (2.4 m by 3.1 m). It is very doubtful if the microvehicle would ever be dominant enough in the traffic stream to justify these dimensions for design. Rather, it is likely that the subcompact vehicle dimensions of 8 ft. by 15 ft. (2.4 m by 4.6 m) will prevail for the foreseeable future.

Changes in Geometric Standards

In summary, geometric design standards are not expected to change significantly as a result of the presence of the microvehicle in the traffic stream. In the urban environment and when speeds are low it may be possible to reduce the lane width down to 8 ft. (2.4 m) in the absence of trucks or buses.

Highway Appurtenances

Sign and Luminaire Supports

According to AASHTO (4), "Satisfactory dynamic performance is indicated when the maximum change in momentum for a standard 2250 lb. (1020 kg) vehicle, or its equivalent, striking a breakaway support at speeds from 20 mph to 60 mph (32 km/h to 97 km/h) does not exceed 1100 pound-seconds (4893 N-sec), but desirably does not exceed 750 pound-seconds (3336 N-sec)."

As used in the Specifications, "breakaway supports" is a generic term meant to include all types of sign supports whether the release mechanism is a slip plane, plastic hinges, fracture elements, or a combination of these. The Specification states that "Breakaway structures should also be designed to prevent the structure or its parts from penetrating the vehicle occupant compartment." The Specification also alludes to the unacceptability of vehicle rollover following impact with the test article.

The AASHTO criterion implies that the change in velocity of an impacting vehicle should not exceed 10.7 mph (17.2 km/h), but preferably not exceed 7.3 mph (11.7 km/h). Recent test guidelines published by NCHRP (5) recommend change in velocity limits similar to AASHTO for sign and luminaire supports.

The question is then: What velocity change can be expected if a microvehicle impacts a support designed to the current AASHTO criteria? To make an estimate of this change an assumption must be made with regard to the kinetics of the support (in the absence of an actual vehicle and full-scale crash tests). It is assumed that the impulse (change in momentum) during impact is a function of the support design and independent of the impacting vehicle, i.e., it is not a function of the size or shape of the vehicle. This assumption is believed to be valid for most breakaway type supports. Its validity for "yielding" or "base bending" supports is less certain. Based on this assumption, velocity change was computed for three vehicle sizes using the formula

change in momentum = impulse = $m\,(\Delta V) = M$

or $$\Delta V = \frac{\Delta M}{m} = \frac{\Delta M(g)}{W}$$

where g = gravitational acceleration
W = vehicle weight

Computed values are given in Table 2.

TABLE 2. VELOCITY CHANGE AS RELATED TO VEHICLE WEIGHT

VEHICLE WT. (lb)	VELOCITY CHANGE (mph) Based on M = 750 lb-sec [1]	Based on M = 1100 lb-sec [2]
4500	3.7	5.4
2250	7.3	10.7
1200	13.7	20.1

[1] Preferable according to AASHTO (4)

[2] Limit according to AASHTO (4)

It can be seen from Table 2 that sign and luminaire supports that were designed to satisfy the "preferable" limits will probably produce microvehicle velocity changes in excess of the upper limit (10.7 mph). In truth, many sign and luminaire supports now in use just barely meet the upper limit criterion. For those designs, velocity changes for the microvehicle can be expected to be approximately twice the recommended limit.

In addition to the hazard of increased velocity change, microvehicles will have a greater propensity for rollover following impact with sign and luminaire supports. Recent tests have shown that smaller vehicles upon impact with sign supports tend to spin out, and in some cases roll over violently if the impact is off center (6).

Longitudinal Barriers

Lateral and longitudinal vehicle decelerations are primary measures of impact severity for longitudinal barrier collisions. Of these, lateral decelerations are usually more critical. The following discussion therefore focuses on variations in lateral decelerations which may be expected as a function of vehicle size.

As a general rule lateral vehicle deceleration depends on the velocity, weight, and encroachment angle of the vehicle and the lateral deflection of the barrier. Estimates of barrier lateral deflection will be made by use of the following approximate formula:

$$\frac{1/2\, M_k (V_k \sin \theta_k)^2}{D_k} = \frac{1/2\, M_u (V_u \sin \theta_u)^2}{D_u}$$

where V = impact velocity
θ = impact angle
D = lateral barrier deflection
M = mass of impacting vehicle
K = subscript to denote known data
U = subscript of variables

The strong post W-beam barrier with wood posts, known as the G4(1W), is a widely used longitudinal barrier system. It will therefore be used to make the following comparisons.

The 1977 AASHTO "Guide for Selecting, Locating and Designing Traffic Barriers" provides the following information for a particular crash test of a G4(1W) barrier:

M = 4123 lb
V = 88.1 ft/sec
D = 2.8 ft
θ = 22.2 degrees

Solving the equation for Du and substituting the above data into the equation results in the following equation:

$$D_u = 6.128 \times 10^{-7} \ W_u \ (V_u \sin \theta_u)^2$$

where D_u = deflection in feet of G4(1W) barrier
W_u = weight of impacting vehicle in pounds
V_u = velocity of impacting vehicles in feet per sec
θ_u = angle of impact in degrees

The estimated deflections for a W-beam barrier of the G4(1W) type impacted at 15°, 60 mph by vehicles weighing 1200, 2250 and 4500 lb. (545, 1022 and 2250 kg) are presented in Table 3.

TABLE 3. EXPECTED DEFLECTION OF A G4(1W) BARRIER ON IMPACT AT 15° AND 60 MPH

VEHICLE WT. (lb)	EXPECTED DEFLECTION OF W-BEAM BARRIER (ft)
450	1.4
2250	0.7
1200	0.4

The AASHTO Barrier Guide also presents an equation for estimating the average lateral acceleration on impact with a W-beam barrier of the G4(1W) type.

$$G_{lat} = \frac{V^2_f \ \sin^2 \theta}{2g \ ((A \sin \theta - 0.5B \ (1 - \cos \theta) + D))}$$

where G_{lat} = lateral acceleration on vehicle in G's
A = distance in feet from front of vehicle to 6.6 (0.45 x (length)
B = vehicle width in feet
D = expected lateral barrier deflection in feet
V_f = velocity of impacting vehicle in feet per second
θ = impact angle with barrier

For the G4(1W) guardrail system the lateral accelerations for a 60 mph impact at 15° and various vehicle weights were computed and are given in Table 4.

TABLE 4. EXPECTED AVERAGE LATERAL ACCELERATION ON IMPACT WITH A (G4(1W)) BARRIER AT 15° AND 60 MPH

VEHICLE WEIGHT (lb)	A (ft)	B (ft)	D (ft)	G_{lat} (g's)
4500	8.0	6.5	1.4	2.4
2250	5.5	5.1	0.7	4.0
1200	4.7	4.6	0.4	5.3

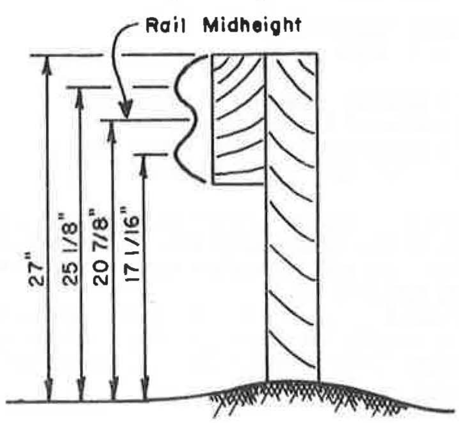
Similar data for rigid barrier impacts (i.e., D=0.0) are presented in Table 5.

TABLE 5. EXPECTED LATERAL ACCELERATION ON IMPACT WITH A RIGID BARRIER-SAFETY SHAPE OR VERTICAL WALL

VEHICLE WT. (lb)	A (ft)	B (ft)	G_{lat} (g's)
4500	8.0	6.5	4.1
2250	5.5	5.1	6.1
1200	4.7	4.6	7.1

When compared with recommended lateral deceleration limits of 5 g's (7), the values for the microvehicle are what may be termed "marginal". It can be seen that severity of impact increases as the vehicle size decreases and as the stiffness of the barrier increases. Predicted lateral deceleration of the microvehicle upon impact with a rigid barrier (such as the concrete safety shape) is considerably higher than recommended limits. Stability of the microvehicle upon impact with the concrete safety shape barrier will also be of critical concern. It is well known that the propensity for rollover of vehicles striking the concrete safety shape barrier increases as the vehicle size decreases.

The geometry of the barrier is also of major concern. Figure 1 shows the typical W-beam installation and the distribution of midheight of the



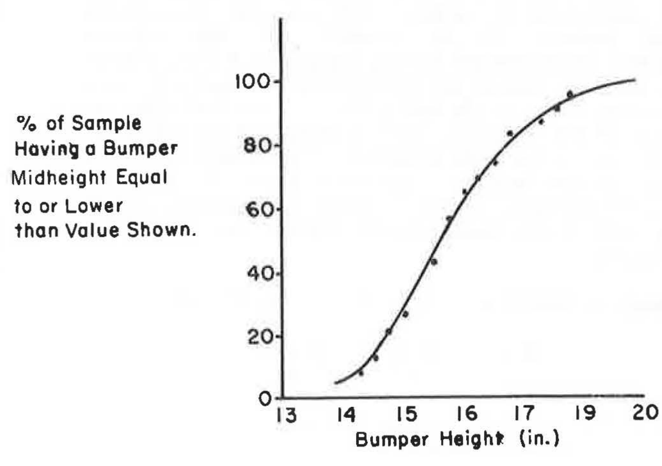


FIGURE 1. CUMULATIVE DISTRIBUTION OF BUMPER HEIGHT OF MINIVEHICLES

bumper on cars between 1100 and 2250 lbs. (545 and 1022 kg) (small cars). Note that the bumper mid-height of a full 80 percent of the vehicles in this weight range is lower than the center of the lower bulb of the W-beam barrier.

This suggests that the smaller cars including the microvehicles may have an increased potential to submarine under the barrier and snag on the posts. Indeed, testing has demonstrated this behavior on a Honda Civic for an opening of only 13 in. (33 cm) from the bottom of a rigid concrete rail to the bridge deck. This suggests that most W-beam barriers and W-beam transition sections may be too tall for many small cars. The microvehicles will only add to the severity of the existing problem.

Strong-post W-beam barriers (e.g., the G4(1W) and the G4(1S) roadside barriers) can possibly be modified by the addition of a rub rail to accommodate the microvehicle should the underride or submarine problem materialize. The same modification may also be necessary on weak-post systems (e.g., the G2 and G3 roadside barriers). Use of the thrie-beam in lieu of the W-beam will undoubtedly reduce and may eliminate this problem. It may also be necessary to adjust the cable spacing of the G1 system for the microvehicle. Need for the above modifications will also depend to a large extent on the profile of the microvehicle. If the hood and fender heights are similar to present subcompact models the problem will probably be minimal. Answers to these questions must come from analysis, including appropriate computer simulations and ultimately full-scale tests.

Crash Cushions

Most of the commercially available crash cushions can be adapted to accommodate a 1200 lb. (545 kg) design vehicle. This process is, however, expensive as a retrofit but will probably be practical if the unit must be replaced. A typical crash cushion provides 7 to 10 g's of longitudinal deceleration on frontal impact. Assuming the 10 g level to be typical for a 2250 lb. (1022 kg) design vehicle, the resisting force can be calculated.

$$F = ma$$

where F = resisting force in pounds
m = mass of impacting vehicle
a = acceleration

For a 2250 lb. (1022 kg) design vehicle, the resisting force is:

$$F = \frac{2250}{32.2}(10)32.2 = 22{,}500 \text{ lbs.}$$

The acceleration on a 1200 lb. (545 kg) vehicle is:

$$a = \frac{(22{,}500)32.2}{1200(32.2)} = 18.8 \text{ g's}$$

A crash cushion that is safe for the 2250 lb. (1022 kg) vehicle is decidedly unsafe for the 1200 lb. (545 kg) microvehicle. The problem is not, however, that difficult to solve. For example, an inertia barrier designed for a maximum 10 g deceleration to accommodate a 2250 lb. (1022 kg) and 4500 lb. (2043 kg) design vehicle impacting at 60 mph results in the Figure 2 designs.

A design to accommodate the 1200 lb. (1022 kg) microvehicle results in the Figure 3 design.

While the number of modules involved is only changed by one, the design to accommodate the 1200 lb. (545 kg) vehicle is 27 ft. (8.2 m) long as compared to 21 ft. (6.4 m) for the subcompact vehicle

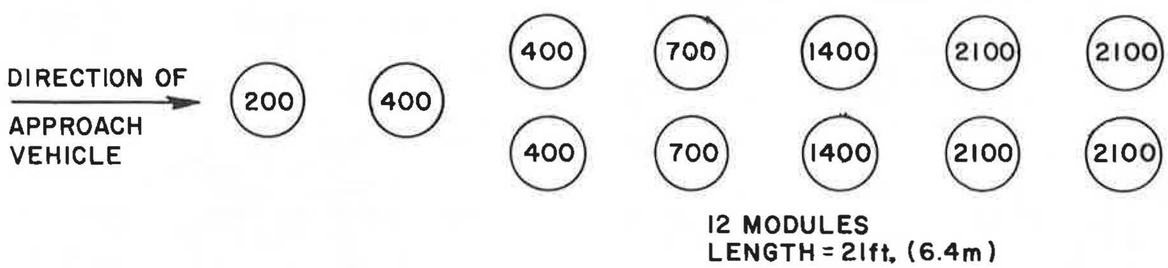


FIGURE 2. INERTIA BARRIER DESIGN FOR 2250 lb. (1022 kg) DESIGN VEHICLE

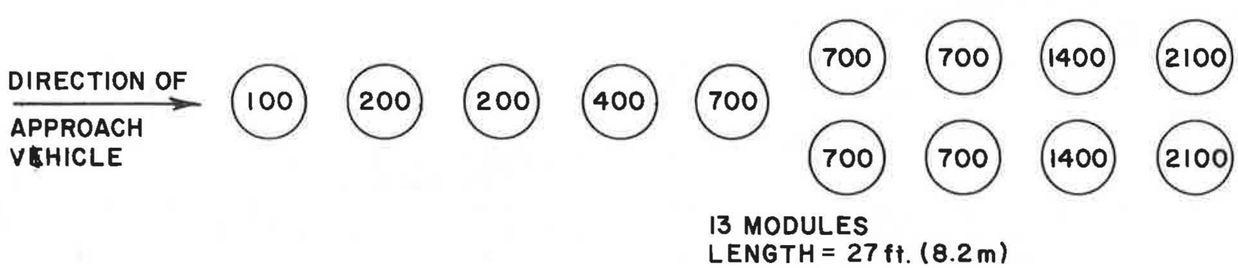


FIGURE 3. INERTIA BARRIER DESIGN FOR 1200 lb (545 kg)DESIGN VEHICLE

design. This example illustrates that for inertial barriers, at least, the retrofit to accommodate the 1200 lb. (545 kg) microvehicle will be rather easy to accomplish.

Driver Visibility

Driver eye height for microvehicles is essentially the same as for minivehicles. For this reason, driver visibility problems above and beyond those created by the minivehicles can only be created by blockage of the line of sight by elements of the vehicle. This will probably not require any significant changes in the traffic control device location. Nor is it expected to appreciably alter visibility of the roadway features.

The reader should recall that the standards for sight distance, marking no-passing zones, and stopping sight distance will be changed by the new eye height and object height criteria to be published by AASHTO in the near future. The advent of significant numbers of microvehicles in the traffic stream will probably not create any appreciable difference in the geometric design and operational standards required to satisfy the needs of the minivechicle.

Restricted Use of Microvehicles

Many have suggested that microvehicles should be restricted from the highway system and limited to low-speed urban roadways. Several types of restrictions have been discussed.

1) Restriction by highway type.
2) Restriction to the urban limits.
3) Restriction by operating speed

All three of these restrictions seem to be predicated on the concept that the differential in weight between the microvehicle and other vehicles in the traffic stream results in a serious safety problem if high-speed operation is allowed. The three restrictive methods mentioned above are all attempts to keep the microvehicle out of high-speed situations.

The concept of restriction has many social implications. For example, the microvehicle as the second vehicle in the household would not present a serious problem if such restrictions were implemented. History has taught us that the first to adopt new technology (i.e., new car sizes) are the young. This is for two reasons: First, they have limited funds, thus lower vehicle cost and greater fuel economy are of prime importance to them. Second, these young people do not consider the smaller vehicle to be a second vehicle but rather simply a source of transportation. Restrictions to a particular area or particular type of highway would be perceived as a restriction on their right of choice of which vehicle to purchase.

Another factor that will tend to limit restriction of the microvehicle is low probability of being involved in an accident. There is only a three percent chance of any given vehicle being involved in an accident of any type in any given year. The combination of these factors will make it very difficult, if not impossible, to implement restrictions of any type. The enforcement problem would also be a most challenging one.

Summary

Based on a tentative review, it appears that no major changes in geometric design standards will be required as a result of the microvehicle. Some highway appurtenances will likely need to be modified if current performance standards are to be maintained. Many sign and luminaire supports will likely have serious deficiencies. W-beam barriers will be adequate for microvehicle impacts but a rub rail may be necessary for the strong post guardrail systems to ensure safe impacts. The thrie-beam will likely be used more in lieu of the W-beam due to its increased height and reduced ground clearance. High decelerations and an increased rollover potential will be a major concern for microvehicle impacts with the concrete safety shape barrier. Adjustments may be necessary in the relative heights of the cables used in the cable roadside barrier.

Crash cushions will need to be redesigned to accommodate the microvehicle. In the case of the inertia barriers at least, this change is more one of length than the provision for additional elements.

Driver visibility requirements for the microvehicles are not expected to be greater than with the minivehicles that are presently in the traffic stream. The limited changes needed on the highway system to adapt to the microvehicle, combined with the social and enforcement problems of restricting their use to a particular area or a particular part of the road system, make restriction a highly questionable practice. Overall, the impacts of the microvehicle on design standards should be fairly minor and might actually allow the use of lanes as narrow as 8 ft. (2.4 m) to increase the capacity of low-speed urban streets in the absence of trucks and buses.

References

1. Dexler, P., "The Micros Are Coming - The Micros are Coming", Motor Trend Magazine, July 1981.
2. "SAE Standard Practice No. 1139", 1978.
3. Holbrook, M.E., et al, "Width of Small Cars with the Doors Open", an unpublished research paper, Civil Engineering 617, Texas A&M University, Fall 1981.
4. "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals", AASHTO, 1975.
5. Michie, Jarvis D., "Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances", NCHRP Report 230, March 1981.
6. Ross, Hayes E. Jr., Walker, Kenneth C., and Effenberger, Michael J., "Crash Tests of Small Highway Sign Supports", FHWA Report No. FHWA/RD-80/502, May 1980.
7. "Guide for Selecting, Locating, and Designing Traffic Barriers", AASHTO, 1977.

DISCUSSION:

QUESTION: Isn't there a problem with the smaller vehicles being subject to more rollovers?

MR. WOODS: It does roll over more frequently. California data supports that. All the other states have reported a significant number of rollovers after impact with safety devices or other vehicles. All of what we projected is based on the vehicle remaining stable. That is not necessarily a valid assumption when you start getting into these very low weights and off-center hits. That is correct and is a very valid point. The problem that you get into with trying to detect the stability problems is very complicated, however, and well beyond the scope of what we were trying to address in this session. It is certainly a fundamental problem. We will have to weaken the devices; they probably will have to be weaker than what we have projected in the paper; that is, taking the 1,100 and 750 second criteria. But that was, and the question came up earlier, what was the survivable deceleration. The criteria that we now have, as much as anything, is based on the stability of the vehicle after impact. Therefore, we have incorporated some of that thinking into the criteria.

QUESTION: What has or can be done to make utility poles breakaway design?

MR. WOODS: The utility pole area has some real built-in problems. It's obvious we can treat them, we know how to do that, that's not the problem. The problem is, people that work on utility poles have union rules that don't allow them to climb them if they are weakened and that creates a very basic problem. If you put in a weakening mechanism to make it safe, what do you do with the lineman when he goes out for repairs? This is not significant in every state, it is very significant in some states. We do not have a satisfactory mechanism at the present time for these very light vehicles in that respect. We're probably exceeding the mass of the pole--the mass of the pole probably exceeds what we can reasonably hope to be safe for a vehicle of 1,000 or 1,200 pounds which means scaling down the size of the elements drastically, but more practically, get it away from the highway. That's where we're going to push, I think, in the future. We forget sometimes that we give the utilities the privilege of being on our right of way but we don't have to give it. We can take it back and force them to do things or lose their utilities, to make them safe, especially under certain circumstances.

QUESTION: What effect would there be on sign post design?

MR. WOODS: They do have to be substantially weaker, there's no question about that. Probably we're talking about changing the material property in order to achieve the fracture at relatively low energy levels and at the same time resist bending satisfactorily. Probably, also we're going to have to cut the weight down even further. Where we now talk about 3 pounds per foot being the basic single post that's safe, we may have to think in terms of 2 pounds or less. This means we have more vibration problems and several other of the normal installation problems becoming very difficult. The other thing that looks very shaky is the fracture type, the wood supports. Four by six is marginal for a 2,250 pound vehicle, now we pull it down to 1,200 or 1,700 even, and it becomes at best survivable. The injury rate is going up drastically with the smaller vehicles.

In terms of making them more survivable for a 15 degree hit? The logic of the system says you have to yield a little bit in order to get these lateral decelerations down below 5 G's. Maybe the criteria are bad, that's a possibility. Assuming the criteria are good, then it probably would mean adding on to it to allow the vehicle to penetrate slightly, which increases our maintenance costs. We're going exactly the opposite way at the present time. Increased use of concrete to reduce the maintenance costs. Those of you who haven't heard the message yet, the national average metal beam barrier maintenance cost is 50 cents per linear foot per year. The national average concrete barrier maintenance is a penny per foot per year. If you have any reasonable idea what the highway agencies' problems are now money-wise, you understand very quickly why concrete is becoming terribly popular. It's economically feasible.

OPERATOR AND SAFETY PROBLEMS

James O'Day
Highway Safety Research Institute
The University of Michigan

JIM PLINE: Our next speaker is James O'Day, with the Highway Safety Research Institute at the University of Michigan. He's head of the Systems Analysis Division at that agency. He's been involved over the years in accident investigation, processing and analyzing accident data, has frequently written and presented papers on safety of large and small cars, and had a short tour down in Australia as a consultant to them on safety matters.

JIM O'DAY: As Don Woods said, one of the hardest things to do with this kind of problem is to describe distributions out of data that do not exist and that's what I'm going to try to do, too. The only joy in this is by the time the real data exist to prove that I'm wrong, most of you will have forgotten who said it. Listening to this morning's speakers, I'm not sure that safety matters much to anybody anyhow. We'll proceed from there.

Thousand pound cars just don't exist in the United States in quantities large enough to measure anything (in the present accident data) about their safety performance. Let's start with some data on vehicles that do exist and use some sort of a physical model to proceed from that into the future. I want to start by describing two relationships, one a sort of an empirically-derived relationship from accident data, and the other just a physical model that I think you'll all believe. First the empirical data.

Injury or fatality to occupants of a crashed car results from a variety of things that happen. Carl mentioned the 30G level as an important severity you don't want to exceed, but, many fatalities occur because of an interaction with some part of the body with some part of the vehicle at much less than 30G's. There are lots of things that happen to cause serious injuries and accidents. There have been a lot of crash severity measures tried over the years in accident investigation and in vehicle testing, vehicle design. Many of these correlate more or less well with the probability of occupant injury. Years ago, we used traveling speed because that was what police reported on their accident reports--we'd look at accidents and find out how many people survived or didn't survive for crashes that happened at a 30 mile an hour traveling speed or whatever. A severity estimate closely associated with traveling speed which was used in analysis was the barrier equivalent velocity or BEV. The barrier equivalent velocity would be the equivalent speed of hitting a barrier with the car in a frontal direction. We have also used measurements of the vehicle damage extent and developed a relationship between inches of crush and speed of impact. All of these quantities have been used to estimate crash severity.

Over the past several years, the use of this quantity that Carl mentioned, called Delta-V, has come into prominence. Delta-V is essentially the change in velocity during the crash or crunch phase of an accident. Again, you can think of it pretty much as the same thing as a barrier equivalent velocity for a vehicle that's going into a solid barrier, i.e., it's about equal to the traveling speed in that case. If you hit something hard at 30 miles an hour, your Delta-V will be 30 miles an hour, since in a hundred milliseconds or so, you will be at zero miles an hour. All of these measures are roughly equivalent, although some predict injury better than others.

The Delta-V turns out to be moderately easy to estimate from damage measurements. There are some questions about the precision of Delta-V, but we'll not worry about that for the moment. There are now quite a lot of accident data available for which a value of Delta-V has been estimated for each crash-involved vehicle. One of the most useful results of NHTSA's National Crash Severity Study (NCSS) program was the determination of a relationship between fatality rate for car occupants and Delta-V. Figure 1 shows the approximate relationship. At zero miles an hour, nobody is killed. At Delta-V of 20 miles per hour, about one percent of the occupants of frontally crashed passenger cars die. At 30 miles per hour, the fatality rate is about eight percent (everybody does not die given a 30 mile an hour crash). At about 40 miles an hour the fatality rate is around 17 percent and at 50 miles an hour it's close to 50 percent. It is curved upward rather than linear.

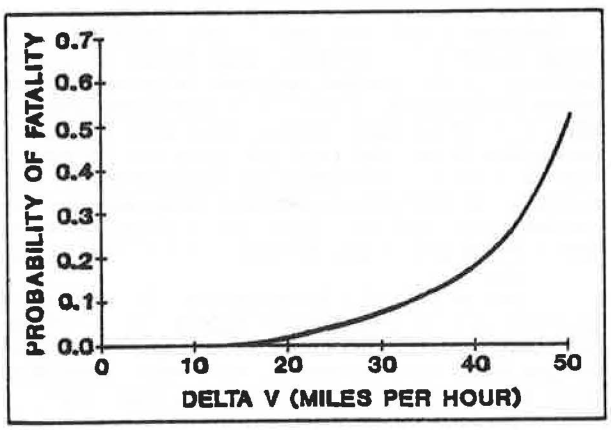


FIGURE 1
Probability of Fatality for Occupants of Towed Passenger Cars Versus Delta-V
SOURCE: NCSS Statistics

Keep that curve in mind for just a moment, and let me go on to the physical model. Let's consider two vehicles of exactly the same weight and structure which run head-on into each other, each traveling at 20 miles an hour. When they hit, given that they're the same weight and structure, they're going to both stop over whatever this crush phase happens to be. The length of the crush phase depends on the structure of the car, but in some short period of time they're going to go from 20 miles an hour to zero. Looking at the curve of Figure 1 and looking at 20 miles an hour, on the average in each of those cars one person out of a hundred would sustain a fatal injury; I would then expect two fatal injuries in a hundred such (two-vehicle) crashes. Now let us assume that the two vehicles are of very different masses--say a 3,000 pound passenger car and a Michigan Special--we have a truck in Michigan that legally operates at 165,000 pounds--each going 20 miles an hour. When they hit each other head-on momentum will be conserved as you saw in the movie that Carl showed. The heavier vehicle is going to continue to go forward, and the lighter vehicle is going to back up. Now, the Delta-V for the lighter car is going to be the 20 miles an hour that he would have had if he would have stopped plus about 18.5 miles an hour that he gets from the truck. The Delta-V that the truck sees is only 1.5 miles an hour. Now, I look on the curve at 38.5 miles an hour and I find that in that car I'm up very close to 0.16 probability of fatality in the car, so that in a hundred such accidents--16 people will die.

Now, we won't usually be running into 165,000 pound vehicles. Let's go back to something that is more reasonable, like a 1,000 pound car (which is the one we are talking about today) running into a car that is the average of the passenger car weight of the present population--about 3,200 pounds. When those two cars run into each other, the bigger car is going to see a Delta-V of about 8 miles an hour. Now that's only about a three to one ratio, and yet the smaller car (with Delta-V = 32 mph) is getting close to the Delta-V it would see when hitting a tractor-trailer. When the disparity between the vehicle weights gets up to three to one you're not going to be much worse off by hitting something larger.

Now, for a long time in the United States, the passenger car population looked like kind of a normal distribution that centered somewhere around 3,300 pounds and dropped off to about 2,500 and up to about 4,500 with a little bump or the Volkswagen Beetles at 1,700 or 1,800 pounds. But most of the vehicles were in this relatively narrow weight range (2,500-3,500 pounds) so that when they ran at each other they did not have a two to one ratio to worry about. As we began to get smaller cars into the population and began to look at two to one ratios (from about 4,000 to 2,000 pounds), a car in this population which weighs 2,000 pounds is about twice as likely to have a fatality (given that it will hit a variety of larger cars) than will a car that weighs 4,000 pounds. If we go now to a group of 1,000 pound cars, these 1,000 pound cars will be competing with a very large group of cars that weigh between 2,000 and 4,000 pounds plus a group of larger vehicles (pickup trucks and vans) in the more than 4,000 pound class. Incidentally, about 20 percent of the total vehicle miles in the United States are put on by those pickup trucks and vans, so that they are not a small proportion. The chance of one of these 1,000 pound cars running into a truck is substantial.

If other things are equal, and we bring in a group of these 1,000 pound cars and put them into the normal population and have them do the things that everybody else wants to do, go on all the roads that they would like to travel on, etc., they'll probably be in about as many accidents per vehicle mile as the larger cars. We should expect to see a substantial increase in the fatality rate for these vehicles.

Things are not likely to be equal, for a number of reasons. Very light cars could be restricted by operator choice to primarily urban travel. The worst place that these cars could go is out on two-lane rural roads where there will be head-on traffic and high-speed intersections. If the operators of small cars choose to stay on lower speed roads, the estimate of increased fatalities would be too high. I looked several years ago at the possibility of a small electric car coming into the population and tried to estimate the safety consequences. We concluded that it was probably going to be a safer car per mile traveled than larger cars because it would be operated entirely in urban areas. It was a restricted range vehicle that just was not going to get out on high-speed roads as frequently as normal cars do.

It's quite possible that the micro-mini car or the very small car could be so much improved in its interior protection that it would overcome at least part of this momentum imbalance. Carl has talked about ways of doing this. The best estimates for the current car population and improvements from belting or air bags, I think are not in the 80 percent range (reduction in the chance of fatality), but more probably in the 30 percent range. That is my judgment from the current designs and the current price structures; the addition of air bags or full usage of belts would probably result in something like a 30 percent reduction in the probability of fatality. That's probably not enough to overcome the weight disadvantage.

If Charles Lave was correct this morning, in estimating that young people are going to buy these cars, there is a slight positive advantage because young people are substantially less susceptible to injury, and, when injured, they recover more quickly. If the population of these micro-mini cars turned out to be primarily young people, things would not be as bad as if they were all 55 year olds who would be more easily injured.

Well, where do we go from here? Safety wise, it seems to me that bringing a 1,000 pound car into the current United States population and road systems is inviting a kind of safety disaster. We seem to have three approaches to countermeasures for avoiding such disasters, and they operate kind of at three succeedingly difficult levels. The first one that everybody thinks about is education. Let's tell everybody to watch out for the little cars, let's put it in the drivers' education courses, we'll educate and tell Sonny when he goes out at night, "Take the big car if you're going to drink." We know the little car will be more dangerous to its occupants, and education and informing people may do some good. The second kind of countermeasure is to change the vehicle system to reduce the chance of an accident. This morning Pat Waller mentioned the possibility of painting all the micro-mini cars day-glo orange or red, and that is not a bad suggestion. We've done some work that shows that day-glo colored motorcycles are much more visible and less likely to be struck by a passenger car.

Finally, when things get bad enough, and we've decided neither one of these solutions is adequate, we had better think about the possibility of separating vehicles on the highway when they are not physically compatible with each other. I know Don said this is going to be a very difficult thing to do and the society is not going to accept it. But there is some acceptance of such a countermeasure now, and there may be more in the future. The New Jersey turnpike has separated lanes for trucks and cars over much of its length now. Although cars are permitted in the truck lane, there are car lanes that trucks are not allowed to enter. If you travel on the New Jersey turnpike in a car, you can choose to avoid the trucks. Better yet, if you go to New Jersey, take the Garden State Parkway which allows only cars and let the trucks take the turnpike. They go almost the same place and you can travel much more comfortably and safely in an environment with only cars. Another example of positive separation is that we've put sidewalks into almost all of our cities for pedestrians. Years ago people walked in the street, but when the frequency of interaction between cars and pedestrians or maybe even between horses and pedestrians got so big that it was a problem, we put the pedestrians in a separate place. We have pedestrian overpasses and underpasses; we've physically separated most of the pedestrians from the vehicles. We have railroad rights-of-way; we put railroad trains on tracks and have grade-separated crossings that preclude the possibility of cars from getting into the way of railroad trains and vice versa. We have bicycle paths in lots of cities, and bicycle lanes on the streets marked to tell cars to stay out of these lanes. There are many Moped lanes in Europe serving the same purpose. I suggest that the highway engineering fraternity ought to think long and hard about what is going to happen when and if a substantial proportion of the United States car population is in this 1,000 pound class and has to survive in traffic with an average weight of 3,000 pounds or more. Otherwise, the little guy is going to be in trouble. Traffic engineers believe that this will be a bigger social and political problem than an engineering problem. The prospect of such changes deserves thought at this point because, if the micro-mini cars are as susceptible to damage as the physical model suggests, the public will demand such changes sooner or later. They're going to say "Get the big cars off my road, because I drive a little car. Do something to make me safer." It has been done for the bicycles, the pedestrians, and the Mopeds, and it may have to be done for the micro-minis. I think as a last piece of advice, we had some talk this morning about safety matter and insurance and how the economics of insurance is related to it. If the environment does not change, perhaps you should take the money that you save in buying and operating a micro-mini and buy term insurance on your life.

DISCUSSION:

JIM PLINE: I've got one. As a traffic engineer, we can hardly afford to build and maintain what we've got; we can't build separate facilities, so I guess we'll have to kind of check that out won't we?

JAMES O'DAY: I'm sure you will.

LAWS, STANDARDS AND LIABILITY

Andrew Hricko, General Counsel
Insurance Institute for Highway Safety

JIM PLINE: Our cleanup hitter this afternoon is Andrew Hricko from the Insurance Institute for Highway Safety. He is the General Counsel and Secretary Treasurer for the Insurance Institute in Washington, D.C. He has been with that organization since 1964. Prior to working for them, he was Senior Attorney in the Legal Division of the Board of Governors for the Federal Reserve System and has also served as Assistant Attorney General for Pennsylvania.

ANDREW HRICKO: The case law relating to the mini and micro type vehicles is quite new and quite limited. However, using the principles of law applicable to products in general, I've come to some basic conclusions. Decisions have been limited to findings of responsibility of the micro-mini vehicle manufacturer. Now down the pike, we'll be able to see cases coming that involve the potential liability of traffic engineers and governmental agencies for the maintenance of such roadside appurtenances as signposts, guardrails, and the other objects that were designed to breakaway with the regular size cars, but do not function well with mini vehicles. Future cases will face some basic questions. Is it the responsibility of government to change the driving environment to accommodate a rapid change in motor vehicles or is it the responsibility of the manufacturer to produce products which can safely operate in the existing environment? Now these questions have not been answered, but they are going to be the ones that will be coming up in the not too distant future.

We do have some answers to the question "What duty does a car manufacturer owe to the purchaser of a small car who has knowledge that if he is involved in collision with a larger car he is going to come out second best?" Does such knowledge preclude recovery? The case decided on appeal early last year, Dorsey versus Honda Motor Company, provides some insight into the possible line of reasoning which will follow in future cases involving mini or micro cars. Mr. Dorsey purchased a Honda AN 600 which complied with Federal standards as it relates to seat belts, belt anchorages, and steering wheel displacement. However, it was built prior to the effective date of the Federal Motor Vehicle Standard 208 and was not held to a crash worthiness standard. Dorsey testified that he understood that his car could be seriously damaged in a collision with a larger car, but he did not know any specific crash characteristics of the Honda. Dorsey was involved in a crash with a standard size car weighing about 3600 pounds. The car was traveling about 3 to 5 miles per hour. Dorsey's car weighed a little over 1300 pounds and the impact was about 30 miles per hour. They estimated that it was equal to a 20 mile per hour barrier crash. The Honda failed specifically in three areas. The A pillar deformed, rearward, about 10 inches; the seat latch broke, pushing Mr. Dorsey to the left and towards the pillar; the seatbelt failed to adequately restrain him, it being too elastic. He wore the regular shoulder belt. Mr. Dorsey's legs were fractured and he suffered severe permanent brain damage. Dorsey and his wife sued on the grounds of negligent design; negligent failure to warn of design defects; strict liability and breach of warranty. He won on every theory. The jury awarded him $750,000 for his injuries, his wife got $75,000, and they also took a look at Honda's design and slapped them with a $5,000,000 punitive damage award. The trial court judge went along with the compensatory damage but denied the punitive damages. Mr. Dorsey appealed. And Honda cross-appealed for whatever damages were assessed against them. The Plaintiff proved that Honda's own test, performed by a wholly owned subsidiary, showed that the "A" pillar would deform, and that the restraints would not prevent an adult male dummy from impacting the interior of the car in a 30 mile per hour crash. The subsidiary advised Honda not to put the vehicle on the market without enlarging either the front of the vehicle or redesigning the inside to provide a little more room. Honda ignored the advice and exported the vehicle to the United States without changing it or warning prospective purchasers of its crash characteristics. Plaintiff's experts proposed numerous safer alternatives to the Honda's design; lengthening the hood and enlarging the passenger compartment; using the heavier engine and heavier metals in construction; using metal reinforcements for the passenger compartment and the "A" pillar; redesigning the seatbelt to prevent submarining; and using a less elastic fabric for their seatbelts.

These items are the keys relating to a case involving a micro-mini car. Not those specific ones, but the fact that you have to show that there's something besides the size of the car that could have been improved in order to increase the chance of survivability. Honda's defense was that the sole approximate cause of Dorsey's injuries was the relative size of the two vehicles. The crash worthy cases up to that point had indicated that if one buys a small car, one can't complain if he is injured because everyone knows that you get injured in a small car. Supporting this premise was a case back several years ago, involving a Volkswagen. It's Dreisinstok versus Volkswagen, a Virginia case. In that case the plaintiff purchased a microbus. The manufacturer put the seats as far forward as it could to enlarge the cargo space. The court looked at that case and ruled in favor of the manufacturer basically on the grounds, "what you see is what you get". You could see that that car wasn't going to have much room for your knees. You could see the dangers of a frontal collision, and it was, in a sense, an acceptance of the risk. There was no offer of evidence in that case that perhaps there could have been a stronger bumper, that perhaps the frame could have been built a little bit better. It was just a question of you could see the deficiency and no evidence was offered that those deficiencies could be corrected.

In the Honda case, the lower court held that size alone is not a bar to recovery, if you can prove that the manufacturer can make improvements which would have protected you from the injuries received. This theory was also upheld by the Appeals Court. The Appeals Court stated that you could have improved that vehicle without making one change, literally, in the size of the vehicle. And that's what Mr. Dorsey wanted. He wanted a small car and the changes that could have been made would have been very simple. The Court said there was no relationship between the "A" pillar, the design of the seat track, or the seat assembly, the choice of webbing and vehicle size. Specifically, and I'll quote, "Dorsey's willingness to buy a car with a small passenger compartment is not a willingness to be supplied with a passenger compartment that is negligently designed or defectively constructed." The court distinguished the microbus case on the grounds that there was no evidence that any improvement could be made.

Downsizing vehicles may impose a higher duty on manufacturers to compensate for the small size by using improved safety technology. Dorsey's case is a very strong recent authority for this. Although Honda met the specific Federal standards, its crashworthiness could have been improved by using known safety devices and better materials. The court cited, for example, that nothing would happen with the size of the car if they had made the webbing and the safety belt less elastic. One could argue that the $5,000,000 punitive damage was for failure to surpass existing safety standards. The plaintiff was able to prove that Honda was aware that the safety standards were inadequate to protect passengers in a collision, and that it knew ways of improving the vehicle's crashworthiness, but never implemented them.

In a recent series of crash tests, done by NHTSA, both the Honda and the Volvo failed the 35 mile an hour crash test the first time around. The second time around all they had to do was move the latch back on the safety belt a little bit and make them a little bit stiffer to pass the test. They were able just by those minor changes to make a difference to the occupant between being dead or alive.

The Dorsey case is not revolutionary and is fully within the mainstream of traditional tort law. To determine whether liability would be found, courts inquire as to whether the defendent has violated a safety standard or acted in a manner inconsistent with industry custom and usage. However, to say that mere compliance with a standard and customary practices should absolve a manufacturer of liability tends to defer the implementation of new technology and allows industry to set its own standards. This result is particularly intolerable when there is a widening technology gap between what actually is being used to protect people and what could be used. There are many improvements in the motor vehicle that could be inaugurated. You've seen some of them on the screen previously concerning the RSV's.

The courts have looked upon this subject for many years. There is a 50 year old case that Judge Learned Hand wrote in a landmark decision, a decision that is still being cited in some cases: "A whole calling may have unduly lagged in the adopting of new and available devices." And, in that case they failed to adopt a safety device and were found wanting. Even in the basic law book of torts that you read when you are starting law school it says, "where common knowledge and ordinary judgment will recognize unreasonable danger, what everyone does may be found to be negligent." There have been some accusations that the automobile manufacturers are not using available safety devices on the grounds nobody else is doing it. There are sufficient court decisions to show that the responsibility is there and, if you don't exercise it, you can get burned.

Those who come into contact with a product may reasonably expect its supplier to provide feasible safety devices in order to protect them from dangers created by its design. The existence and feasibility of excellent automotive safety technology that can protect people in small fuel-efficient cars is common knowledge throughout the auto industry. Increasingly, courts will be called on, as in the Honda case, to decide to what extent the industry will be held accountable for disregarding that technology and to what extent conservative safety standards will protect manufacturers. Now NHTSA itself has refused to hold small cars to a lesser standard because of the availability of superior safety technology. In February, a year ago, NHTSA denied a petition to reclassify cars weighing less than 1400 pounds to reduce the number of standards applicable to them. The agency stated, (as a matter of fact they are talking about one of the cars that you'd seen on the screen) and I'm quoting NHTSA, "the technology is available to build relatively light passenger cars that achieve high fuel economy while also complying with the Federal safety standards. Further, research and tests have shown that substantial levels of safety protection can be designed into small cars." For example, Western Washington University has built an experimental vehicle, the Viking 6, that is lightweight, 1200 pounds, yet will protect its occupants in a 41 mile per hour frontal barrier crash test. Current safety standards specify tests of 30 miles per hour.

The proposed Federal Product Liability Act would create a presumption that if you have an existing safety standard and comply with it, your vehicle is automatically not defective. Now, if this Act is enacted, every effort should be made to ensure that safety standards are reasonably consistent with available technology. This is especially critical in the microcar area. Standards written in the '60's and '70's which protect occupants of full size cars will not, in many cases, protect the occupants in the microcars. An example is the seatbelt assemblies. The belts installed in Dorsey's Honda were inadequate and yet they met the standard. The standard is not related to the size of the vehicle passenger compartment. Thus, the webbing that would restrain a man before he struck a hard surface in a larger car would be ineffective in a much smaller vehicle.

Now, of course, one would assume that the manufacturers of the microcars would make every effort to incorporate the latest safety devices in their vehicles. An article in Fortune magazine in November of last year noted that Honda had just introduced a new City car, sold with a companion motor bike that collapses and fits neatly into the trunk. The microcar has a 1200 cc engine and is jammed with features meant to appeal to younger drivers, including a refrigerated drawer in the dashboard that holds a quart of beverage cans. Now we may have seen the beginning of a new product, the four pack to replace the six pack. It's easy to understand why auto manufacturers are getting increased auto product liability cases with that kind of design planning. I wouldn't want to be the attorney trying to explain to a jury why we have the refrigerator with the beer in it right where we used to put the air bag. That, quite frankly, is what is going to happen. NHTSA rightly refused to hold small cars to a lesser standard than other passenger cars. However, as mini and microcars become more popular, NHTSA should carefully scrutinize all its standards to assure that they will afford protection to occupants in all passenger cars, regardless of size. If NHTSA doesn't do its duty, some other portion of the government is going to. As Judge Learned Hand put it, back 50 years ago, "courts must in the end say what is required; there are precautions so imperative that even their universal disregard will not excuse their omission."

DISCUSSION:

QUESTION: The precedent caused by the general manufacturer of an automobile can create a situation of establishing a standard for others to meet, can it not?

ANDREW HRICKO: That's correct. As a matter of fact, there was an interview given by, I think, Mr. Peck out in Los Angeles and he made the point that the RSV vehicles, for example, if brought to a stage where they are mass produced or at least made in some numbers, that would become the standard for the industry and every manufacturer could then be potentially liable for not going to that standard. Yes, very definitely, there are some that predict that is going to come about.

QUESTION: I understand there is experience with the small cars where they are involved in fewer accidents because they are driven slower and just locally. So that the insurance rates are less with the little cars which is why it is an interesting crossover. What do you think is the likelihood of passage of the Product Liability Act? Can you tell me the number of that legislative action? Do you think it will pass?

ANDREW HRICKO: I don't know. It's been around, I think this is the third time its been around in various forms. I really haven't been following it that closely. I do know what provisions are called for, but I don't know what the prospects are.

QUESTION: Changing the universe to accommodate the micro is to suggest the other course of action is to make the micro fit. If the micro is required to fit the world as it is and is required to meet and adopt the available technology, if this was required through technology, is it still going to be economically attractive?

ANDREW HRICKO: I don't know because I don't know how much you have to mass produce to determine the exact cost of things. But when you start talking whether it is economically profitable to produce a car that should have certain standards, you should also consider the cost of having to go to every guardrail in the United States and put a rub bar on the thing to accommodate this vehicle. How much does that cost, should that cost be considered into it? I mean I am paying it and you're going to pay for it in the gas tax. It's going to come out of our pocket. One could argue why should someone be able to put a product on the market and then everybody else has to accommodate his profitmaking, rather than the other way around.

UNIDENTIFIED: I particularly wish to compliment everyone on their excellent presentations of materials covered and it was delightful to be here. I have a question for my good friend Donald with regard to having to soften various appurtenances along the highways. We should worry about these small sign supports that you folks discovered can't even take care of the 1500 pound car instead of why we have to take care of them now when industry didn't. The 1100 pound car compounds the problem since there are so many signs. There should also be some thought given to vehicle side panel design (you apparently were aiming at the head-on collisions there) I am also wondering about why you illustrated the design for 1200 pound cars when you may get into 700, 1400 and 2100 pound vehicle side hits 15 or 20 degrees on that particular type of attenuator, whether the problem really is the first one-time accident.

DON WOODS: In both cases you are correct, we have made estimates of what the reduction and the momentum change that would have to be to accommodate the 1200 pound car. It looks like (I am having to recall this number), I think it was about 235 pound-seconds, I guess it would be about the kind of change that would be compatible in a 1200 pound design. That's considerably weaker than all base bending type, all the fracture type supports, that we have. So what we are literally saying is the U-post and woodpost are obsolete in this kind of thinking. The slip base designs, the small post slip base design are marginal. They are in the 250 range, 275 range, so they still would be compatible but then we get into the "max" problem with the big signs so that's going to be fundamental. With respect to the crash cushions, I did not try to go through a detailed design and decide if approximately 2/3 of the hits were with the crash cushion, so they are very significant parts. I did predicate all the thinking on the head-on hits. The primary reason for that was that I thought they will be what the design people would be most interested in. The number of modules was related. We would certainly have to consider the side hits later when getting into those larger modules and to think about adjusting for excessively high deceleration. It certainly does exist, even with the systems we have out there now.

ANDREW HRICKO: I'm sorry, I am confused, and always have been I might add, with regard to the "G" force consideration by the municipals, the Federal highway, and industry people who are out there designing the appurtenances. The Federal highway used the 12 G's based on the high estimate of 50 milliseconds. You know the NCHRP is 30 milliseconds, but I am wondering how that 30 and 40 G's Dr. Clark mentioned here is tied down. I wonder if you two could try to resolve the meaning or interpretation?

DR. CLARK: The National Highway Traffic Safety Administration has, as I read it, assumed that the safety designs are utilized and its standards based on using good criteria. So, if indeed you have a full belt system on or an effective air bag system for riding through the 30 mile per hour crash, the question is not damage to the passenger compartment, but is survivability. It's marginal with belts. You begin to break ribs and so on. You should walk away from it with air bags. We've shown we've got good air bags to over 50 miles an hour. Unbelted, you begin to hurt yourself after being in a crash at 5 or 6 miles an hour. I think the LD-50 for dropping a person onto a hard surface killed about half the people, in something like 15 feet. It's a lethal event for half the people that drop in the main squatting position. So, indeed, if you are unrestrained, the levels are a lot lower. We're beginning to recognize at last that 90 percent of us are riding around without restraints. And, we're going to do more research now on what happens in the unrestrained condition. I used to say the manufacturer president of the company ought to be asked to bang his head at full velocity on anything on the surfaces of the car and have it not hurt him. We know that won't happen and yet we know how to design for that. So, typically, in the belted crash, your face is going to hit the steering wheel, you're going to break your facial bones. Well, that isn't a very serious injury, but we can do a lot better than that. So it is time to use the knowledge that we have, not just in restraints, but in every other feature of the car design: on better visibility, better protection for pedestrians, and so on. It's on that basis that I say, if we use the knowledge we've got now, we could cut that 150, 140 deaths per day by perhaps 80 percent. It's tragic that we don't think hard about this. We ignore it and walk away from it.

It used to be said of sports car drivers that they could always duck out of the way of a collision--having a mentality for this and continuing to examine the escape routes and having vehicle characteristics so the car can do a lot in ducking out of the way. Americans generally do not use anywhere near the full handling capabilities of their vehicles. The problem is we get our licenses without having to examine the emergency driving situation. We should have more practice. As we get to the smaller cars, this characteristic isn't better, it's worse, as you are saying. Particularly the three wheelers. It is being recognized by the responsible designers such as Walter Korff that we should stay with the larger tires and not have skid out. We should sacrifice a little bit of gas mileage for handling characteristics. He does make a point for having a low center of gravity nearer the two wheels in front so on a skid out there is understeer rather than the spin of oversteer.

DON WOODS: There is certainly an instability problem and there are people in the audience that know a great deal more about it than I do. Let me just comment about the two cars I have. I have Toyota frontwheel drive and I have Dodge Colt rearwheel drive. Both of them have roughly the same size engine. The Colt is very unstable under any condition. It has far more power than you can accommodate on any kind of friction or surface that is not absolutely dry. If you accelerate hard, it can come around in just a split second. The Toyota, on the other hand, is as stable as any vehicle I have ever driven. The front wheel drive on ice and snow and slick surfaces is very hard with the accelerator. What it does in braking, I don't know. I brake cautiously on snow and ice because I don't see much of it. I stay way back and I brake gently on it. What it would do under that condition I do not know. But we do have some problems with wheel size and, those that have heard me before, we have one bridge test in which there was a 13 inch opening from the bottom of the beam down to the deck. A car went under it, snagged on the post, and that's a whole lot lower than all the barriers we have out here. That's kind of a repetitive message, but we're going to have to do something drastic. There are ways they are doing it right now--to try and adapt to the smaller cars.

QUESTION: DOT some years ago had a research safety vehicle program and they were pursuing two designs primarily; the engine in front and one with the engine in the rear. I'd just like to know the outcome and final recommendation of DOT on the research safety vehicle?

DR. CLARK: Guess I need to answer that. The research safety vehicle program has been very successful. It has shown possibilities for control deformation in crash worthiness and improved restraints to live through 50 miles an hour crash. It has also shown how close we are to the crash prevention devices, such as the radar brakes. They are beginning to be used in Europe. The periscope design visibility systems were used for a while. We've thrown them out. Unfortunately, the major rear accident I note is someone coming out of an almost blind spot. We know how to deal with that problem and yet we don't have the solution presented to us. The engine in the front versus the engine in the rear has not been an issue in the safety vehicle design. It really is a mass distribution and spring loading problem. You can design a good car to be either case or you can design a bad car. I really don't know enough about it to give you the trade-offs. It is quite possible, though, to have a prevention car that is safer than the ones we've just reviewed. The message is that we know how to stop collisions, severe crashes and the killing of people. Notice that in 1957 Jim O'Brien said, "Let's put a hydraulic rear bumper on the car". In fact, he said, "I have trouble getting into my parking spaces so I'll have it pulled back when I'm driving slow and as I get up to speed I'll extend it." That design was used in the Fairchild experimental safety vehicle. The design was heavy and expensive even as hydraulic retrofits. They know how to make hydraulic designs in much lower weights. The trade-off that we've experimented with was a foam filled box beam product and the auto industry has not picked that up. The Viking 6 used it on a 1200 pound car without injuring the people if they were restrained.

COMMENT: Just two quick comments on the safety vehicles themselves. Some of the interior design that has been used is not being used on American cars. They are being tested and used elsewhere. The windshield in which they put the flexible material on the inside is being used by a number of firms in Europe, but it still hasn't been approved for use in the United States. Putting this all in perspective the air brake on trains took 40 years for adoption. So, perhaps we should look upon some of these things in the proper time frame when we get around to it in another 40 years maybe.

QUESTION: You all seem to be in agreement that there will be forthcoming problems with the introduction of microcars in the United States. Have you thought about the onset of a political campaign to prevent their introduction?

DR. CLARK: The politics of stopping free enterprise is not in good shape in the United States today. I don't think that is likely to happen, the leverage we have in our democracy is through the interest of people. It has indeed proved very difficult to involve the people in their own safety in bills, and to involve them in saying somebody else should not ride around in a little car. I think it would not be feasible. I think, in fairness, I should say NHTSA will watch the numbers that develop, we'll count the bodies, and if things do get too bad, there can be a vote for the defect action which does not require a standard, but simply saying, this vehicle is too unsafe and requires that it be removed or taken from the road. Or, action to improve the standards. There is quite a feeling in the agency that the three wheel car should not be called a motorcycle.

ANDREW HRICKO: There is just one bit and that's with the NHTSA doing away with passenger restraints standards which would have been involved with these vehicles also. They would have to come up with certain requirements, at least at 30 miles an hour. Although not required, it is not dead. It is in the courts at this time. So it may be turned around there whenever a decision is reached.

JAMES O'DAY: I think there is sort of a parallel to the microcar in the introduction of Moped in the United States. Something like four or five years ago there was quite a flurry of activity in the thought that Mopeds were going to come in and destroy the world, or at least cause or come in such numbers that there were going to be enormous increases in injury and so on. I think the public is going to tend not to go with Mopeds, as clear as I can tell. In spite of all the good words this morning, it wouldn't surprise me to see the public choice that they really don't want microcars. Something in the order of 1500 or 1800 pound cars is as low as they want to go.

DR. CLARK: Unless a safe microcar is made which can be done.

JAMES O'DAY: I'm not sure the choice is just on safety. I think there would be other things that would control it. Mopeds must not be doing the things that they thought they were going to do. And they haven't done it.

DON WOODS: Another problem that we still face is that the accident is a relatively rare event in any given automobile. They go into court and argue that they cannot sell a vehicle because it is unsafe. Until you have a very strong track record, that's a weak argument. It is in fact a rare event still.

One of the sections that we took out of a report after review was the probability of having an accident with signs. The reason this was taken out is the thinking that it would lead too many people into believing it was not really a problem. Because the fact that only a 3 percent chance exists that any vehicle will hit a sign support in any given year, and then you have one of the probabilities of injury, and all these things combined give you extremely small numbers, .001 or .002 probability of severe injury. Those are all meaningless to people when you try to talk to them. We're finding we screen that out completely. It is a problem only in the sense that there are so very many of them out there and therefore a number of them are going to be hit. I don't foresee that the microvehicle is going to be 50 percent of the traffic stream. I think the speakers this morning guessed it as considerably lower than that. If you have a 7 percent switch to the microvehicle, the change in fatality would be barely measureable. General downsizing may mean its going to happen across the whole board. It is when you aggregate them across the whole country that the numbers then become very significant. I've got to say that that's a unique problem. Almost all of our safety problems are very low probability events. And we still have to treat them all to make them as survivable as they can possibly be.