EATON YALE & TOWNE INC.

24275 NORTHWESTERN HIGHWAY
SOUTHFIELD, MICHIGAN 48075

LOUIS A. SELIN
Vice President-Marketing and Engineering
Automotive Products Group

July 12, 1968

Dr. William Haddon, Director
National Highway Safety Bureau
Federal Highway Administration
Washington, D. C. 20591

Dear Dr. Haddon:

With regard to the meeting that has been set up in your office on Friday, July 19, at 2:00 PM, I am writing to let you know who from the industry will be in attendance:

AMERICAN MOTORS CORPORATION
Elmer W. Bernitt - Vice President, Automotive Safety & Quality Assurance
Jack E. Martens - Chief Automotive Safety Engineer

CHRYSLER CORPORATION
R. C. Haeusler - Chief Engineer-Automotive Safety
W. M. Swan - Assistant Chief Engineer-Advanced Chassis Engineering
Robert O. Sorenson - Federal Safety Coordinator

FORD MOTOR COMPANY
John C. Eckhold - Automotive Safety Director-Product Development Group
~~Robert E. Schrock—Assistant Chief Engineer-Body Systems & Advanced Engineering~~
Dr. John Versace - Executive Engineer-Safety Research
Richard Edwards - Exec. Engr. - Advanced Product Design

GENERAL MOTORS CORPORATION
Robert F. McLean - Executive Engineer-Development Engineering

EATON YALE & TOWNE INC.
R. G. Brown - Director of Research & Development
D. P. Hass - Chief Engineer-Product Commercialization
Hal H. Newell - Washington Representative
L. A. Selin - Vice President-Marketing & Engineering

I am enclosing a sheet titled "HUMAN FACTOR ELEMENTS REQUIRING ADDITIONAL TESTING" which, as I explained when we met with you on May 28, are the items of concern to us and I would hope could be part of the discussion in our forthcoming meeting.

Sincerely,

L. A. Selin

LAS/yjm
encl.

AUTO-CEPTOR SYSTEM

HUMAN FACTOR ELEMENTS REQUIRING ADDITIONAL TESTING

1. EFFECT OF NOISE ON HUMAN EAR

The noise level of the inflating bag is close to the acceptable limits as shown on a curve originated by the Human Engineering Laboratory and qualified by Messrs. Coles, Garinther, Hodge, and Rice in an article titled "Hazardous Exposure to Impulse Noise" in the February, 1968, Acoustical Society of America Journal. Because the rate of pressure rise and frequency content of the impulse noise generated by the inflating air bag may be different than that of the noise sources used to establish the above criterion, it is highly desirable to run a test with human volunteers, conducted by some agreed upon expert, using accepted methods for measuring the effect on the ear due to the inflating bag.

2. EFFECT OF PRESSURE IMPACT

It is necessary to find the magnitude and effect of the pressure due to the impacting air bag on the occupant seated in the worst position. Primates or human volunteers may be used to evaluate this effect.

3. CORRELATION OF DUMMY AND HUMAN RESPONSE

Most of our testing to date, either on a sled or a car barrier test (except for a series of nine primates at Holloman Air Force Base last June, 1967), has been with instrumented dummies. While these results were favorable, it is recommended that a number of primates and possibly human volunteers be tested to verify our results.

4. DRIVER REACTION TO INADVERTENT FIRING

Several of our engineers have run tests, sitting behind a wheel mounted bag deployed at a vehicle speed of 40 mph, with no loss of control or other problems. A broader range of subjects experiencing this phenomena may be required for a complete story on vehicle controllability in the event of inadvertent actuation.

DPH/sb
6/12/68

U. S. DEPARTMENT OF TRANSPORTATION

NATIONAL HIGHWAY SAFETY BUREAU

- - -

Room 4-A
400 D Street, Southwest
Washington, D. C.

Friday, July 19, 1968

The meeting convened, pursuant to notice, at 2:05 p.m., Dr. William Haddon, presiding.

PRESENT:

AMERICAN MOTORS CORPORATION:

Elmer W. Bernitt, Vice President, Automotive Safety & Quality Assurance
Jack E. Martens,
Chief Automotive Safety Engineer

CHRYSLER CORPORATION:

R. C. Haeusler,
Chief Engineer-Automotive Safety
W. M. Swan,
Assistant Chief Engineer-Advanced Chassis Engineering
Robert O. Sorenson,
Federal Safety Coordinator

FORD MOTOR COMPANY:

John C. Eckhold, Automotive Safety Director-Product Development Group
Dr. John Versace,
Executive Engineer-Safety Research
Richard Edwards,
Executive Engineer-Advanced Product Design
W. R. Smith,
Washington Office

GENERAL MOTORS CORPORATION:

Robert F. McLean, Executive Engineer-Development Engineering

PRESENT (CONTINUED):

EATON YALE & TOWNE INC.:

R. G. Brown,
Director of Research & Development
D. P. Hass,
Chief Engineer-Product Commercialization
Hal H. Newell,
Washington Representative
L. A. Selin,
Vice President-Marketing & Engineering

BUREAU STAFF:

Dr. Haddon
Mr. Niedernhofer
Mr. Jacklin
Mr. O'Mahoney
Mr. Smeltzer
Mr. Carter
Colonel Stapp
Dr. Holloway
Mr. Ferguson
Miss Claybrook

OTHERS:

Mr. L. Patrick

P R O C E E D I N G S

DR. HADDON: I just want to welcome you on behalf of the Bureau and to recite a little bit of the past history of the meeting.

As some of you know, Eaton Yale & Towne, Incorporated came to us because it wanted us to see, and we were interested in seeing, the developments that it had been pushing. At the end of that meeting, we asked if there were any ways in which we could be of assistance in pushing the further developments of this device, not specifically Eaton Yale accounts of this, but rather of the approach in general.

Consequently, the Eaton group -- if I can call you that for short -- stated it would like to bring together some of the people that it was working with that might be interested in this so that the kinds of expressions of interest and discussion of technical problems that we had engaged in with them when they first came to us might be known firsthand to the people who they in turn were dealing with.

I would like to point out for the record that this meeting is being recorded. The transcript is being taken so that everything that is said here today will be available to anyone who wants to look at it.

In short, this is not really our meeting as much as our being responsive to a clearly felt need to assist those interested in highway safety. It is really, in a sense, Eaton

Yale & Towne's meeting, with us participating, together with the rest of you.

I would like to say something also by way of preface with respect to our feeling with respect to the general approach. We think that first of all, as I personally put on record in 1961, that any approach which substitutes so-called "passive methods", that is those that require no preparation on the part of anyone other than original release of the vehicle, that a passive approach is, generally speaking, almost invariably far superior to any one that requires cooperation of drivers, or pedestrians, no matter what their competence might be.

I note, for example, that one of the many problems we face with active devices relates to the fact people who have been drinking or who are distressed or otherwise preoccupied or impaired are largely likely, as accident reports make very clear, not to avail themselves even of the devices they normally use. So, in short, we think the general area of passive devices is the way to go whenever possible.

Also, we think with respect to the specific approach -- although not necessarily the specific gadgets being discussed here -- that the general approach of air bag restraint or, I think they perhaps should be referred to as air pillows, which I think is a more meaningful term to be public, this general approach is extremely promising from many, many standpoints,

and is one to be furthered, if at all possible.

In fact, as far as I am personally concerned, after cleaning up the side structure and head area and windshields, this is clearly, in my opinion, the highest priority that the industry and the Government and anyone else concerned with highway safety should have.

From a technical standpoint, as you know, this offers the possibility of maintaining an anatomical relationship in a crash in that there is no jack-knifing, or sudden folding at localized areas on the body. There is also the advantage, of course, that this can be pre-set so that they will respond under given crash conditions, or at least so we hope.

We are quite aware there are tough problems of reliability. They are brought, froma statistical standpoint, the alpha and the beta areas, but we have every confidence that those represented here or elsewhere will be able to solve these.

So with this as a preamble, I would like to merely add that we are not certain that we can or should come out of this meeting with any commitments, but regard it as an exploration of use, we hope, to all of those concerned.

I would like to turn this over to Mr. Selin of Eaton Yale & Towne at this point, for any way you would like to, in effect, run the meeting.

MR. SELIN: I would like to suggest, perhaps, in

launching this discussion today that we perhaps take about ten minutes to get on the same wave length and discuss the state of the art today.

Much of this may be redundant, I appreciate that, but it will be real brief so we can all zero in on the type of a system in general. Because there might be many approaches and I would hope you would look upon this as a general approach and there may be many ways of going.

Then, I think after that brief period, we from Eaton Yale & Towne would like to discuss the areas of concern to us which are primarily in the human factors end of it. I think since most of you gentlemen here have a brief agenda of those four areas, then perhaps we can discuss this, and I would be hopeful that all the rest of you gentlemen may have questions or other suggestions in any area -- reliability, human factors, whatever.

So, with that, if I could call on Pete Hass, who is also at Eaton Yale & Towne, to get us zeroed in on the state.

MR. HASS: Maybe, just to get us all up to date, we ought to go through, hopefully, a general description of the system as it breaks down into components.

(Speaking from prepared charts:)

We are talking about -- since it is a passive system -- we need a crash sensor, which censors a vehicle impact of predetermined crash intensity. That is, we are thinking in

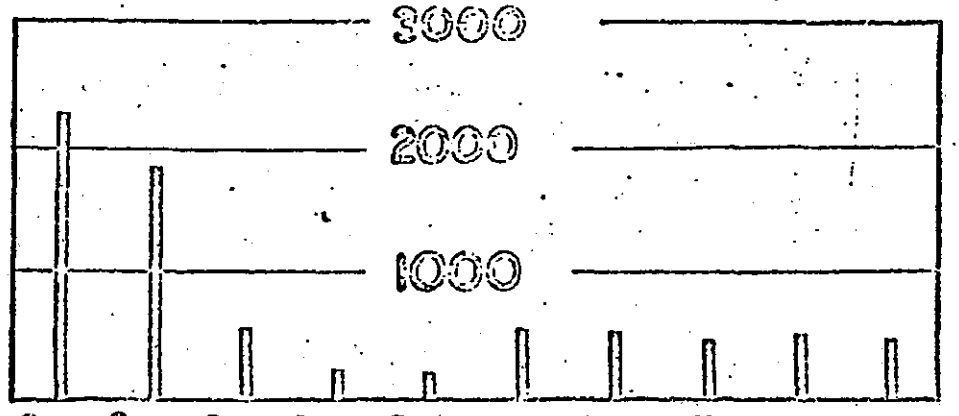
AIR BAG RESTRAINT SYSTEM DESCRIPTION.....

CRASH SENSOR SENSES VEHICLE IMPACT OF PREDETERMINED CRASH INTENSITY-CALLS FOR DEPLOYMENT OF THE INFLATABLE CUSHION

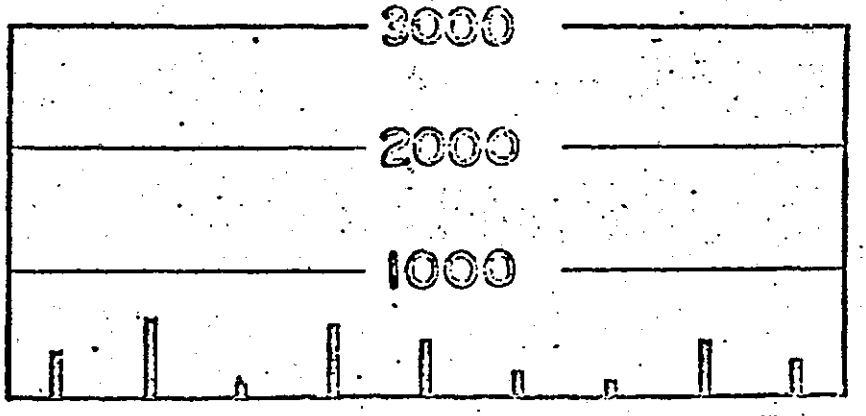
INFLATION ENERGY SOURCE STORED PACKAGE OF SOLID OR FLUID MATERIAL WHICH IS TRANSFORMED TO A GASEOUS STATE TO INFLATE THE.....

RESTRAINT CUSHION A STOWABLE CONTAINER WHICH IS POSITIONED IN FRONT OF THE VEHICLE OCCUPANT IN THE EVENT OF A CRASH INTENSITY IMPACT.

AUTOCEPTOR RESTRAINT PERFORMANCE...30MPH BARRIER IMPACT

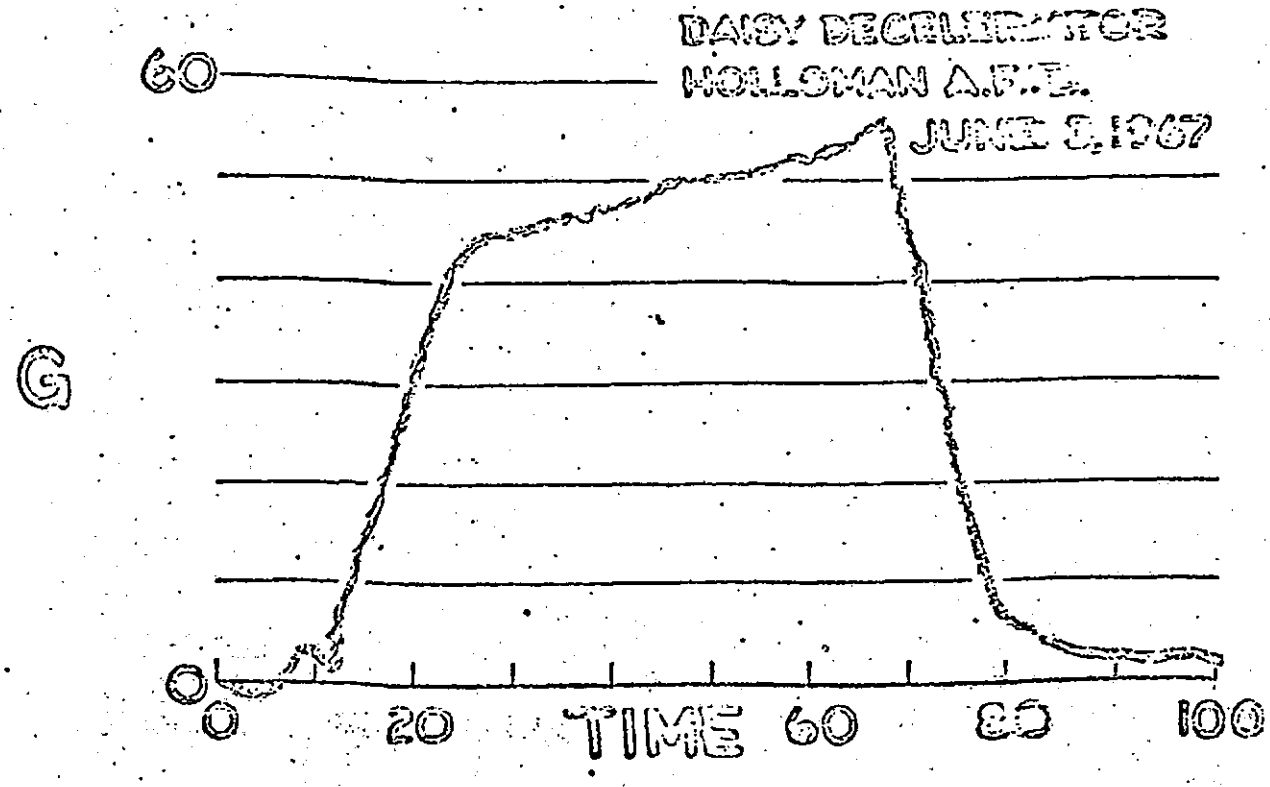


DUMMY	C_{HYD}	C_{HYD}	C_{HYD}	C_{HYD}	C_{HYD}	95M	95M	95M	95M	95M
BELTED	YES	YES	YES	NO	NO	YES	YES	YES	YES	YES
BAG-MATE	95M	95M	–	–	50F	95M	95M	95M	95M	95M
POSITION	CF	CF	RF	RF	CF	CF	CF	CF	RF	RF



DUMMY	95M	95M	95M	95M	95M	95M	95M	95M	50F
BELTED	YES	YES	YES	YES	YES	YES	YES	YES	YES
BAG-MATE	95M	C_{HYD}	C_{HYD}	–	–	–	–	–	–
POSITION	RF	RF	RF	RF	RF	DR	DR	DR	DR

PRIMATE TEST RESULTS. . . .



"40 GS FATAL IN OTHER RESTRAINT SYSTEMS"

"GROSS INJURY AT 57 GS WAS NOT FELT TO BE SIGNIFICANT. . . . . ALL SUBJECTS RECOVERED WITHIN 10-20 SECONDS AFTER IMPACT. . . . NO OTHER SYSTEM RESULTED IN SUCH IMMEDIATE SUBJECT RECOVERY POST-IMPACT"

"IMPACT PROTECTION WITH ADVANCED RESTRAINT SYSTEMS"
J. SNYDER PHD.
11TH ANNUAL STAPP CONF.

RESTRAINT SYSTEM EFFECTIVENESS

TYPE	LIVES SAVED 100% USAGE	UTILIZATION FACTOR	LIVES SAVED PER YEAR
1968 STANDARD			
BA COLUMN	13,000	1.0	13,000
LAP BELTS (6)	3,920	.2	780
SHOULDER BELTS (2)	5,500	.1	550
			14,330
SUBSTITUTING FRONT SEAT AUTO GEPTOR SYSTEM FOR 2 SHOULDER BELTS			
BA COLUMN	13,000	1.0	13,000
LAP BELTS (6)	4,360	.3	1,310
AUTO GEPTOR FRONT SEAT ONLY	7,805	1.0	7,805
			22,115
BA COLUMN, 6 LAP BELTS, 6 POSITION AUTO GEPTOR			
BA COLUMN	13,000	1.0	13,000
AUTO GEPTOR (6)	14,570	1.0	14,570
LAP BELTS	2,870	.3	860
			28,430

INJURIES... "ALTHOUGH MANY OF THESE (FACIAL) INJURIES MAY BE MEDICALLY CLASSED AS "MINOR", THEY MAY BE DISFIGURING AND HAVE SERIOUS PSYCHOLOGICAL EFFECTS ON THE INDIVIDUAL. ALSO SUCH INJURIES MAY INVOLVE IMPAIRMENT OF THE EYES, EARS, NOSE AND MOUTH. THEREFORE IT IS ESSENTIAL THAT AVOIDANCE OR REDUCTION OF FACIAL INJURIES BE CAREFULLY CONSIDERED"

SAE J885A. HUMAN TOLERANCE TO IMPACT CONDITIONS

AIR BAG RESTRAINT SYSTEM. . . .

1. HIGH LEVEL OF OCCUPANT PROTECTION
2. STORES COMPLETELY OUT OF SIGHT
3. AUTOMATICALLY DEPLOYED- NO DECISION REQUIRED BY OCCUPANT
4. PRACTICAL PROTECTION FOR THE UNRESTRAINED CHILD

terms these days of maybe seven or eight miles an hour barrier crash and then we call for the deployment of inflatable cushion.

We think if we are talking about that sort of barrier crash, we are talking about signal to noise ratios; we like to use road noise or anything else that you might use as a noise screening of about 10-to-1. We think this gets up into the realm of high reliability.

Then we need an inflation energy source and, of course, there are several of these and we simply label this as "package of solid or fluid material" which will be transformed to gaseous state to inflate the main feature of the system to restrain the cushion or, maybe, pillow. I would hope today that we could get a better name for this system than "air bag."

At any rate, this would store well out of the way for normal usage in the vehicle and inflate between the impact and the substantial movement of the occupants in the seat.

Now, the reason that we think this is a pretty good idea -- and here we can bring some actual data into it -- is because of this:

This is a system which consists of about a 2-1/2-cubic-foot bag coming out of the steering wheel and about an eight-cubic foot bag on the right passenger side.

We sold this thing based on, hopefully, honest presentation of the data which is why we included the two severity

indexes of about 2200/1800 for a seat-belted child up front here, right front, in the center front position, and alongside of him was a 95 percentile male.

We must apologize for these by saying in this particular bag configuration, the 95 percentile male dummy pulled the cushion askew a little bit, so that the child dummy just saw a corner of the bag and it did not penetrate in the normal manner.

Over here, with him riding along and coupled with a more normal size dummy, the severity indexes were done in good shape. Interestingly enough, he was unbelted in a couple of these cases.

Now, we have got the unusual numbers out of the way. We would point out that driver and right-front-seat passenger, virtually any passenger load combination in a 30-mile area impact similation received severity indexes in the four to seven hundred range. We think this is a significant improvement over the more conventional restraint system.

Our smattering of tests on live tissue, baboons, at the Holloman Air Force Base, reported in last year's staff conference, a 57 peak which solid hit 5g square wave impact left this animal in very good shape. He recovered in less than five seconds and the reason they did not go higher to get the rating level was the limit of the sled.

Dr. Snyder, in his report, reported that 40g's was

fatal in other restraint systems tested and the animal did the recovery in very good shape. So we are encouraged that on human testing the same sort of results should follow. Effectiveness-wise, I think Dr. Haddon has pointed this out, we hope for fairly great improvement.

This is an analysis of accident reports from Cornell and Dr. Hockey, and is an indication, we think, of how much good might be done with the various restraint systems. Here we are talking if the total car population were equipped with the 1968 standard system, we would expect to reduce the fatalities by 14,000.

This would be in front-seat only systems, but if the air bag were included in all passenger positions, when used with the fixed lap belts, and we would talk about using the energy absorb column, also, we would expect we could double the number of savings to 28,000.

This chart, previously we felt moved to talk about injuries, we did not know how much reduction we could get here but we could expect the reduction to be at least as dramatic as those in the fatalities, because we were keeping the occupant off the harder parts of the vehicle and in very good shape with this system.

Finally then, summarizing the advantages of this sort of a restraint, it gives a tremendously high level of protection; has some aesthetic benefits in storing pretty well

out of sight; it is automatically deployed in the passive system; the last obvious advantage, but one we think exists in fact, that may be the answer to handle the unrestrained child, that is to leave him unrestrained and catch him in the bag which is there only in the event that it is needed.

So I think with maybe that standardization of what we are talking about, we can get into the problem areas that we seek.

MR. O'MAHONEY: Can you supply us with a copy of that chart for the record?

MR. HASS: Yes, we can.

DR. HADDON: I would like to point out that there is some question as to your estimates on use of lap and shoulder straps, because these come out of crashes and if, for example, they were 100 percent effective which, of course, we know they are not, you would expect to see none of them in crashes because those cases would not show up as having injuries.

So this is a bias sort of information and understatement of the true state of affairs. I do not question the general point you are making relates the exact numbers in the way you use them.

MR. HASS: Right.

MR. SELIN: Reliability is, of course, of prime concern with a system of this type. Also it is an item that Eaton, in connection with our particular system, is working on

in-house from the standpoint of entire manufacturing process, the sort of controls to assure ourselves that reliability will be at an acceptable level.

But if we could not treat with that, at least, for the moment unless somebody wishes to bring it up later, the thing that concerns us more than anything else is how to qualify a system of this type as outlined here with the title of "human factor elements requiring additional testing."

And, really, we have listed these from the viewpoint, actually, of how might we go about getting qualified acceptance of these particular areas.

Now, as you mentioned earlier, are there some areas within the Government that might be able to help us to qualify any one of these. That is, somebody that would be considered acceptable to the industry. I think you can read this if you want to deal with the first one first, which is entitled, "The effect of noise on the human ear" -- you can read this and maybe we can discuss what sort of tests should be run to get this sort of assurance and established acceptance of the system at this time.

DR. HADDON: It seems to me on a quick look at this, that you have two kinds of situations here. You have a noise question, for example, which may or may not be a necessary characteristic of a particular design. Whereas, you have others that involve things that will always occur. They may

overlap, but they are at least somewhat apart as I read it.

Is that fair?

MR. SELIN: That is fair.

DR. HADDON: Have you any feeling as to whether any particular energy level, noise level, if you will, is necessary?

MR. SELIN: Yes, we had. We conducted some tests of our own in this area, and by the opinions of certain data and certain experts, have led us to feel that perhaps we are in a satisfactory area. But I do not know that this is in fact true.

DR. HADDON: This is the 150 db area that you mentioned.

MR. SELIN: The 158, yes, sir.

Pete, maybe you would like to cover briefly some of the testing we have done.

First of all, perhaps, treat the criteria that we have set up, right or wrong, that we feel the system abides by. Right or wrong -- I emphasize that point. And, secondly, some of the things we have done in-house lately with some of our own people.

MR. HASS: I interpret your question is, perhaps, inquiring whether we had a minimum sound level as you would expect. Is that part of it?

I think we would be of the opinion that it was certainly above the 135 db, that is usually stated as the safe limit. We find that it is a function of the wave front caused

by the inflating bag itself, rather than an explosive opening means for generation of the gas. Therefore, we think it is probably not reducible to below a generally accepted db level.

In this regard, then, we have been monitoring the noise level of the system, finding it to be slightly below the noise limits for impulse noise as set forth in the human engineering lab report, which was based largely on gun fire noise.

Since we found that we were below, or at this limit, we found or decided that we could ask some of our people to volunteer for exposure to this noise, and we have done so.

We have run audiometer tests before and after exposure to this noise. We had one subject, admittedly with a pretty old set of ears, who had no temporary threshold shift after this, and a young fellow who had a shift of 10 db, I believe, at 500 and 1000 cycles, 1-1/2 minutes after the exposure. And he was fully recovered 30 minutes after -- the exact figures are 10 db 1-1/2 minutes after the test at 250 cycles in a second, but recovered the loss in 30 minutes.

We therefore judged the sound to be not comparable to human hearing and would feel that this would be an indication that a greater number of tests were required for statistical significance without much concern as to damage.

Dr. Haddon: I would like to point out that in audiometer tests you can get a 10 db shift with the same individual having

done either way, up or down, having had nothing done to him in the meantime and to properly evaluate this you would need much more sophisticated research design by people who know how to do biological testing and are quite savvy when it comes to statistical methods.

Although this is interesting and indicates you do not blow out everything between his ears, it certainly does not answer the point one way or the other.

MR. HASS: I think that is right.

DR. HADDON: The question I would ask you then, and the rest of you here, is anyone at present evaluating this in terms of that kind of more sophisticated approach?

MR. HASS: Well, we thought this was a requirement to get us into ---

DR. HADDON: I understand the pertinence for your doing it, but for the long-range, obviously, whatever energy levels are involved here, what durations were involved, one would need a thoroughly competent analysis of this.

MR. HASS: That is right.

DR. HADDON: So what I am throwing on the table, has anyone thought about initiating studies of this sort? Is anyone doing it, and what role should we play, if anything?

MR. PATRICK: We are starting our program of this type, in which we are using animals to start with, to determine whether there is any gross damage by measuring the threshold

over a very wide spectrum range, using pure tones, before and after, and also examining the entire ear pathologically.

DR. HADDON: Does this involve animals that are trained to the equivalent of audiometer testing?

MR. PATRICK: Yes.

DR. HADDON: So you condition them first?

MR. PATRICK: Condition them first, and it is quite an involved process, it is one that has been established and used for other studies of threshold shift. We are just applying it to this particular problem.

DR. HADDON: Are you going to be in a position to separate the effects of the bang, so to speak, from the possible deconditioning effects of the experience?

MR. PATRICK: This, we will have to see. I suspect we will. I don't expect any great problems. One thing that we can do is anesthetize the animal so he will not realize or not know he has been subjected to it and run the test before and after.

DR. HADDON: And run a blank group with just the anesthetic?

MR. PATRICK: Yes, but controlled.

DR. HADDON: Are you using primates?

MR. PATRICK: No; cats.

DR. HADDON: So if your results come out negative, it will be important information; if they come out positive

you will have to figure out another way to check it.

MR. PATRICK: We will have to go further, yes.

DR. HADDON: Do you have some idea as to what your timetable is on this?

MR. PATRICK: We should have the program pretty well completed by October.

DR. HADDON: This October?

MR. PATRICK: This October, yes.

DR. HADDON: That includes this initial phase with cats that you are talking about?

MR. PATRICK: That is right.

DR. HADDON: Are you using Monte Carlo or similar methods as a way of knowing how soon you can branch onto the next step, whatever it might be?

MR. PATRICK: We had not really gone that far yet.

DR. HADDON: It seems to me that if you use appropriate research design, you might be in a position to know before October what needs to be done and which way you should go.

MR. PATRICK: I expect we could. We will take that under consideration.

DR. HADDON: Do you have any plans for follow-up beyond this?

MR. PATRICK: Yes, I suspect that after that we will start with some human volunteers.

DR. HADDON: So, Larry, are the numbers of experimental subjects, cats or otherwise, involved here, large enough so you have some confidence that the results will be sufficiently representative to settle the question?

MR. PATRICK: We are planning at that time on using a dozen animals; this will depend on whether there is a marked shift or not, whether we have confidence. If there is only a very minor change, then it is more representative than if we have some very serious injuries.

DR. HADDON: Are you giving the cats the sound wave straight on to the face?

MR. PATRICK: Yes. With the ear in about the same position that the human ear would be.

DR. HADDON: That is what I was getting at. In other words, you are straightening the head so there is no question about having gotten them straight on.

MR. PATRICK: That is right.

DR. HADDON: Are you going to do runs which might correspond to real human world situations where the head would be turned so that they get it straight on?

MR. PATRICK: We had not planned on that. Again, it is just a matter of how many runs it required.

Now, we mignt use the same animals, if there is no major change, and we could go back and use the same animals at different angles. We will do that. But until we find out there

is any injury, we are rather limited.

DR. HADDON: Have you considered excluding one ear so you can get an opportunity to go back with the same animal?

MR. PATRICK: No; actually, what we have done is taken out one ear.

DR. HADDON: As the control for the pathology?

MR. PATRICK: No; destroyed one ear. This is the way the program was set up before and we are following the same procedure.

DR. HADDON: Are you doing this so that you are certain which side is involved?

MR. PATRICK: That is right, which side is involved. We are also removing the external ear so that it minimizes the directional effect.

DR. HADDON: Larry, is other work along similar or related lines needed, or are you going to sufficiently, when this goes to completion, have covered the water front?

MR. PATRICK: Well, I suspect that we will find that probably we ought to have more animals so that sooner or later I would think that better results would be had with much larger series.

DR. HADDON: Is the problem one of your facilities, or personnel, or your money?

MR. PATRICK: Money.

DR. HADDON: I have approached a non-Government group

that is interested in highway safety to see whether they would be willing to contribute to this field and the answer is yes, so we will be willing to talk later to see how much money you might need to push this.

MR. PATRICK: Fine.

DR. VERSACE: The CHABA criterion could be actually a fairly conservative one.

DR. HADDON: Would you identify for the record the CHABA.

DR. VERSACE: This is the National Research Council Committee on Hearing, Acoustics and Biomechanics.

It could be conservative because it is based upon a steeper wave front, which ordinarily is experienced here.

DR. HADDON: You said, which ordinarily is, but you meant which ordinarily is not experienced here.

DR. VERSACE: That is right. In the air bag case, we do not have quite as steep a wave front as the wave fronts which are presumed to apply in the CHABA criterion.

The only problem is that the CHABA criterion is based upon some presumed tolerance with healthy male Military people. What we do not know, have not the slightest idea about, is how this tolerance is distributed in the population -- children, elderly people, females, and so forth. We do not even know if we are in the order of magnitude using the CHABA of being in the right ball park.

DR. HADDON: I am glad you brought that up, John, because we are concerned about the same issue.

How do you see their getting results?

DR. VERSACE: Frankly, I think you are going to need to do experiments with animals which are much more human-like than cats, because I think you are going to have to take it to the level where actual destruction occurs so that you can find the threshold of tolerance.

I do not believe any of us are too concerned about a temporary threshold shift, as such, so much as we are to actual damage.

MR. PATRICK: This is what we are starting on just to find out whether there is any gross damage. We plan to increase the severity by effectively decreasing the volume, so that you have greater pressures and eventually hope to ---

DR. HADDON: Is the damage in explosive situation by air conduction through the canal or is it primarily conduction through the facial bones?

MR. PATRICK: This, we do not know. We hope to find out. We are thinking of trying this by different means -- destroying part of the ear, and if we can continue on then and get other damage. Frankly, we are just getting started. It is rather exploratory at this time.

DR. HADDON: John, did you have anything else?

DR. VERSACE: No. Another obvious perimeter of this

is the magnitude or steepness of wave front which is the critical point. We don't know that either.

DR. HADDON: Larry, will your experiments distinguish between the two?

MR. PATRICK: Not as presently planned. In other words, we will not deliberately vary the wave front, we will take it as it comes. I presume what you are referring to would be to design a method of varying the steepness of the front.

DR. HADDON: I wonder if we could ask Bob Carter or John Stapp if they would care to comment.

MR. STAPP: I was thinking of another approach, one that gets rid of the wave front, or at least omitting it. That is to have two bags, one inside the other, the inner bag half the volume of the outer bag. You start inflating the outer bag somewhat slowly, and then inflate the inner bag abruptly.

It has the advantage of a backup bag.

DR. HADDON: This has been discussed by various people on other occasions also. Another approach that has been mentioned is to have the surplus bleeding, whatever, the gases, change the wave form from that standpoint.

John, did you have anything else?

MR. STAPP: We do need to know the thresholds of injuries and margins of safety, however, regardless.

MR. CARTER: I think the point John Versace made is a

good one. Basically, we have a very limited amount of data here, so we are playing into an area in which the wave front varies, the actual spectrum of the noise varies from our research data.

When you have a very limited amount of data you start seeking counsel on this, experts throughout the country, and you will get a very, very divergence of opinion in here.

But, generally, our experience indicates that if we are not certain of our data, we do not have enough data, then we think we have a problem more often than not, we really do not have a problem. This is just a general thing.

DR. HADDON: You are saying the expert who is not really an expert on the issues, will play a conservative role, rather than reverse.

MR. CARTER: Every time.

MR. PATRICK: In any case, the overall injury to the individual might be far less even though he loses part or all of his hearing than perhaps losing his life in the impact.

DR. HADDON: I think this is essentially the same argument that is being used with respect to birth control pills there being a slight increase in some things like thrombophlebitis, but an increase which is totally trivial to the number of lives which would be lost in child birth. I do not mean to say we should have conceptions in automobiles, but there is an analogy. We tend to the same opinion but it would

be nice to get away with both.

Anyone else?

DR. VERSACE: I just make the comment that we are often beguiled a little bit with the numbers involved. Don't forget the decibels factor is at 10. It is a very important fact.

MR. STAPP: What is the noise term to ratio?

DR. HADDON: 20/30 milliseconds.

MR. HASS: Yes. It is up in the range of 20 or 30 milliseconds. The fundamental frequency is 50 rather than 1000 received from the gunfire data.

We think we have got a different enough animal that has been tested.

DR. HADDON: Another approach, of course, which has been discussed elsewhere would be to have a bag structure which comes part-way back toward the occupants when the car is in motion; which is supplemented by an additionally moving bag or other structure. Does the distance the bag has to move make a difference in the wave form?

MR. HASS: I do not know whether we can differentiate between the distance and the volume. The length the bag extends itself is somewhat a function of its perimeter rather than the designed shape. Because the gas flow is such it tends to fill out the limit of its confines. There is not enough gas to spill into inflating, so it goes out as it were, a circular

bag would go another half.

We have not found a great variation due to bag shapes. We have run but we have not measured the sound level on a porous bag.

DR. HADDON: Have you measured the wave form in relation to the pressure inside the bag?

My point is, I am thinking that the bag could be brought to full inflation with a different -- althouth it would be related at the time -- with a different pressure so that the occupant began to ride into it, rather than by putting this energy in the bag early. In this way you might be able to change at least the performance.

MR. HASS: Yes, I think really here is where we differ from the general conception of how the bag works. I think in a good many cases it is assumed the bag comes out at a sufficient pressure and therefore locks you into your seat. In our system, we are essentially using a large, low-pressure bag, very low, just a few m.m. of water, perhaps at the time it is ready to go to work, and the occupant uses up some of the travel to develop sufficient pressure to stop it.

DR. HADDON: But you could take an intermediate position, again, in which you got it back there with little energy and then continued building up the pressure inside of it as you rode into it, but after it stopped moving.

MR. HASS: Yes. It could be improved by the rate of gas inflow and the total quantity you put into it. But I think it would be worse than this case.

DR. HADDON: Let me ask again, has anyone done a theoretical analysis of relationships between position pressure, time energy level, that sort of thing?

MR. HASS: We have done some work as a function of the -- let us say parameters -- we are interested in: pressure, since this was a cold gas storage arrangement; valve area, which essentially is fill rate and the slower the fill rate, the lower the noise level, but not to unquestionably safe levels, dropping perhaps from 170 to 140 db.

MR. BROWN: I might expand a little bit on what Pete stated. We have done a significant amount of work with different size bags and different inflations. And you can get some reduction in the noise level by going to smaller bags and slower inflation times and, therefore, there is some room for working within this frame.

The thing that must be kept in mind, there is a time by which you must get the bag in front of the occupant, and you cannot really go very far in reducing the size of the bag or

the time of deflation.

DR. HADDON: But as I understand the answer that was given here a minute ago, nobody as far as has been stated so far, has done a basic theoretical analysis of the specifics of this situation to see what the possibilities are.

MR. BROWN: We have measured with instrumentation the pressure rise at various points throughout the bag. It is very difficult and rather questionable. We have set up a computer program of the inflation characteristics of the bag, and the dynamics of the whole thing.

We have learned a significant amount from that. I do not know that I can answer any specific questions at this time but we do have a fair amount of information.

DR. HADDON: To be explicit, since some of us were at the GM show last week, the sort of thing I am talking about, the ride down and things similar, it derives strictly from basic physics.

MR. BROWN: Well, we have done, you might say, the basic dynamics in the bag itself, the entire sequence of slip, impact of the body, and so on, after full inflation. The particular question we are addressing ourselves to with regard to noise is before, really, the occupant strikes the bag. In other words, most of this is finished before the dynamics of the vehicle is involved.

So, therefore, the specific computer programs related

to the inflation of the bag are the most significant to this question.

MR. CARTER: We have the figure of 135 db quoted as being the tolerance or non-injury limit. I would like to point out the Navy and Air Force have a whole number of aircraft in which they launch these things off carriers, many, many of them a day, and there is an area around the back of those aircraft in which the sound pressure level exceeds 165 db. There are personnel in those areas. Now, they do have on muffs, but about the best you can get out of a muff is probably the neighborhood of 15 to 20 db continuation.

And then there is also some question, when you have that sound pressure level, really, how much continuation you get from the muffs ---

DR. HADDON: If you are going to mention it, isn't it fair to mention numbers of those personnel have been injured permanently?

MR. CARTER: Yes, but only because of the multiple exposure. The time duration of exposure is several seconds for every launch, and a number of aircraft are launched for many days, and they are up there many, many days before actually relieved from these exposures.

DR. HADDON: There have been several recent reports of the sound levels in front of rock and roll bands, and so forth, and that these are quite close to the ranges we are

talking about but for exposures that are millions of times longer.

Is there anything else we should discuss on the noise question?

MR. SELIN: Well, I have a question, I guess, on the same subject. I do not know whether anybody can answer it, but I would like to find out how we might get it.

Based on the very limited testing that Pete referred to, human testing with our own people, how is it reasonable or how would we determine if it is reasonable to subscribe to a human volunteer program?

Based on that, is it reasonable to get into that, instead of working with animals and working up that way?

Have we arrived at a point here where it is reasonable to ask for this? And if it is, what is the best way to proceed?

DR. HADDON: Let me ask Larry first.

Larry, you are closer to this experimentally, apparently, than anyone at the present. Do you feel you know enough to be willing to try this out on human volunteers, considering these people have already done this a few times?

MR. PATRICK: We stood pretty close to it, but we have never actually been in the vehicle. I have been right next to the open window, and actually there is momentary pain in the ear, but nothing that I think is real serious.

Frankly, I think we will try some human experiments very soon.

MR. CARTER: I do not see a problem in setting up a live test program on this thing. More specifically, apparently it is a very easy thing to vary pressure in the gas cylinders. In terms of varying the pressure, you can vary the sound pressure level so there is no reason at all why you cannot start up with a thousand and build up to some 500 pounds, and it seems like a very simple straightforward program.

I would like to ask you, it is my understanding that we all were to discuss with someone in the organization close to you, the possibility of starting such tests. Are you in the process of moving out on that?

MR. HASS: We are in the process of making contact.

MR. CARTER: But this is not a problem where you start out and you are very concerned or very anxious about actually causing permanent damage. It is a real simple experimental procedure to set up, because you do have the prerogative of varying the pressure in the gas cylinders, a very, very simple thing.

DR. HADDON: I would like to point out from an experimental design standpoint, you want to be very careful about learning effects. Your subjects should go through the audiometer testing repeatedly in the way experimental psychologists frequently stabilize subjects before they submit them to the experimental procedure. So you should go, at least in my

opinion, to people that are extremely competent in the laboratory experiment area. It is sort of a mixture between the best pharmacalogical testing and the sort of thing that some of the people that test vaccines get into, [illegible] where you should have double blind experiments if at all possible.

In other words, the person doing the audiometry, for example, should not know whether the subject is before, after, or where he is in the Latin Square design, or whatever is used.

Bob, do you agree?

MR. CARTER: Yes, sir.

MR. STAPP: Before undertaking human experimentation, I would strongly recommend consulting with Dr. Henning von Gierke, head of the Biocoustics Branch of the 6570th Aerospace Medical Laboratories at Wright-Patterson Air Force Base. He has a great deal of human experiment data on, roughly, similar topics.

Second, he has a system of human volunteers available to work with if you would like for him to do the experiments.

MR. HASS: Yes, we have had some correspondence with him. We sent some sound traces down and, of course, it was very minimal data for him to commit himself on and he did not do so. He did say that he felt for continuous exposure our people should wear ear muffs and indicated that, in my opinion, as

closely as he could without saying it, that he felt it would be not harmful.

DR. HADDON: It seems to me what we need is extremely careful work by someone who is a recognized authority, whether at Wayne State, or wherever, so that the issue can be settled once and for all for any particular sound level.

DR. VERSACE: I do not know if you are ever going to get direct evidence on this because I do not really think you will sample the population properly until you include the children, infants, elderly, people with heart trouble, high blood pressure, and so forth. After all, they constitute a sizeable segment of the population riding around in automobiles.

There are more ramifications to this than that, though, because the question is, when should a system like this operate. If we are trading off a ruptured ear drum for which might otherwise be a fatality, that is one thing. But if we are going to trade a broken nose for what might be a ruptured ear drum, that is very different. I would, myself, accept a broken nose any day in preference to a broken ear drum.

If a system like this is going to work -- and it will have some level of hazards, but perhaps not too great -- what is the level at which this thing should

operate?

DR. HADDON: This gets down, of course, to the nose and the characteristics of the surface and the contact.

The system might be a success in Japan and not in the United States.

MR. STAPP: I was thinking of the hazard of triggering the safety device accidentally, with no exposure to other hazards. You lose your ear drum for nothing, then.

DR. HADDON: Can we leave the noise area for just a minute. We will be talking with Larry with respect to the possibility of additional support. If there is anyone else here that is pusing that particular aspect of the problem, I would be happy to put them in touch with the people that said they would probably put up some money on this.

Now, I would like to point out, incidentally, in passing, that under the legislation under which we operate, if our own funds were to go into a device, it may be removed from propriety control subsequently.

Personally, I think we are likely to get there fastest, if somebody could make a profit on this, and would like seriously to consider protecting that interest if it comes down to that, and also the interest of more competition.

Bob, is that a correct interpretation of the law?

MR. MAHONEY: Yes, Doctor, I think so. There is a strong patent section, as you know, in our Act. Anything that we finance, pretty much the patent becomes public property.

There is a proprietary interest in our portion of the device. We finance studies that perfect the patent, or potential patent, rights, not patents, against future patent rights.

DR. HADDON: Mr. Selin, shall we go on, off the noise issue? Have we covered the "effect of pressure impact" sufficiently?

MR. SELIN: Well, I think I look upon two or three here (See Agenda) as pretty much one and the same type problem. It just delineates the one from the other. And, briefly, it is the problem of getting more data related to primates and human volunteers, with respect to impact pressure and the correlation of our objectives, let us say, 30-mile-an-hour barrier crash.

The correlation, that is, of dummies to live tissue. And from my standpoint, there is a dandy. We do not know how to go about qualifying this.

DR. HADDON: Is there anyone closer to current dummy construction problems here to comment on that?

Larry, do you see any major problem in that area?

MR. PATRICK: I would hope to run some data tests in the near future. At least we will get some idea of any scalpel damage.

DR. HADDON: Are you going to be able, in those tests to deal with the problem of sliding off of the sides and many facts which are not those for which any particular bag is

designed? Angular impacts, for example?

MR. PATRICK: We had not planned on the angular impacts as yet. As far as hitting the edge of the bag, we have planned on that but not from a brief impact.

DR. HADDON: May I ask those who are close to this if there has been any consideration to constructing bags in such a way that they offer more resistance at the sides, so they would tend to drive people into the middle rather than letting them slide off if there is an angular impact or if the seating position is unusual?

MR. HASS: Yes, I think we have designed such a bag. We also find that, again, on dummies (that we have been equipping with the slipperiest clothing we can find) that the bag tends to hold them very much in place. This would allow them to move again to the extent of this flexible perimeter.

But we think the prognosis is good.

MR. SELIN: Well, we have still got that ahead of us, one way or another..

DR. HADDON: Pardon me. Can I ask you, Larry, is your problem there, money, also?

MR. PATRICK: Yes, at the present time we have just money for so many runs.

DR. HADDON: And your source, presumably, is not touchable for more?

MR. PATRICK: I do not know about that.

DR. HADDON: I suspect you have more source of money than we do.

MR. PATRICK: We suspect if it looks promising, we could at least propose an extension.

DR. VERSACE: With regard to the directions, our observations have been the bag envelops the occupant very quickly I do not think the direction is a real serious consideration.

DR. HADDON: Are you saying, even if he were to be so positioned that he hit at the interface of the inflated bag and, say, the door on the side, right side, for example, that he would not tend to ride it back?

DR. VERSACE: We have not conducted any tests on angular impacts. This is on observation of the pattern of the bag. That if the structure were angular rather than directly toward the instrument panel, it looks like the bag would do a good job of containing.

DR. HADDON: Can we ask another question.

Do those of you who are doing an analysis and working on this, see a possibility of completely eliminating lap belts or are you talking about lap belts, but not shoulder? Just what do you have in mind?

MR. BROWN: Do you want me to take that one?

At the moment, we think it would have the potential of replacing the shoulder harness; that it would have significant advantage in those situations where people had lap belts,

but did not have them fastened.

On the other hand, we would not at this point in time, at least, in the work we have done to date, recommend elimination of the lap belts, because of the restraint that they give in roll-over and collisions other than head on or angular.

DR. HADDON: Any other comments on that one?

I would like to say, from our standpoint, while we were very impressed with the reduction in death and injury you can get in the lap and shoulder harness, we recognize that not everybody cares for the shoulder harness, in particular, and as a result and because of the fact in practical matter, these are not always designed to be particularly comfortable. They have to be designed for people of different heights and weights and so forth, that we would be very, very delighted indeed to see any such a substitute for the shoulder harness, even if we still have to stay with the lap belt.

That would, of course, modify standards accordingly.

MR. PATRICK: In many cases, it would still be very beneficial to have the air bag, even without the lap belt, for those who do not care to wear the lap belts, and the majority of the cases where we don't have roll-over and so forth, it would still be of benefit.

MR. HASS: I second that motion. We have run a limited number of tests without belts and found severity indexes

quite comparable without belts to the occupants. And, in fact, the child dummy, in a normal sitting position, does much better if he is unrestrained. He gets the benefit of being engulfed by the bag.

DR. HADDON: On this point, you might be interested that we have asked the Cornell people, actually a year and a half ago, to give us a simple plot, a diagram, looking forward from the inside of the car, the instrument panel, windshield, head area, doors, plotting the known points of fatal impact involving children.

And from what we have seen so far -- they showed this a few weeks ago -- from a direct head-on situation, children almost never impact fatally on the windshield or the lower end of it, or on the pillars or on the header. It is almost exclusively a band across the instrument panel, which reminds me of the child impact area we were talking about a while back.

For this reason, a bag or, for that matter, substantial improvement in padding in this area should go a long way toward eliminating that particular problem.

One of the interesting findings was on the glove compartment door itself, as opposed to around its periphery. There is almost no case. This suggests that the door was acting as an energy absorber in giving protection. So the new instrument panels ought to pretty much wrap that up. Whatever you can get out of this.

Anything else on the dummy and belt area?

MR. SELIN: The last item here is the inadvertent firing problem, on which we have run a number of tests ourselves with our project engineers and technicians and, of course, this is the case where you would have the steering wheel bag installation.

These have all gone off very well; again, they are with engineering people and they can appreciate the problem a little bit better, and I think we have to get into a wider range of subjects, the expression sometimes used -- you have got to try the little old lady from Pasadena and a few others.

So this, for the record, is something that has to be expanded upon. It is a matter of selecting, working on a program of subject people.

I think, similarly, you might say at the GM Safety Seminar when they put that girl in the spin there, the skid position.

DR. HADDON: You want to be careful about putting girls in skid positions.

MR. SELIN: Yes, but put her under this environment.

DR. HADDON: Are there any general thoughts about redundancy of triggering devices, on their location, on their reliability, anything of this sort?

MR. MC LEAN: I think in the Eaton Yale & Towne presentation, a very important fact was mentioned rather quickly

which I would like to re-emphasize.

As I understand it, their work with what I believe is good instrumentation has indicated that passenger car acceleration environment has stringent operationsl characteristics. For instance, driving down the road 40 miles an hour and into chuck holes, driving over railroad ties at 40 and 45 miles an hour, laying bare on the roadway, slamming the doors and hood so hard they literally fall off, and I guess they can fall off if you slam them hard enough.

DR. HADDON: These are other peoples' products.

MR. MC LEAN: All products will show this characteristic if you slam them hard enough, I am sure. There is a limit.

So these give us, according to the bare data, a band of acceleration experience which, as Mr. Hass indicated, appears to be about one-tenth of the type of seismic accelerator detection that they are using. About one-tenth that of that signal which is designed as a valid crash signal and he mentioned rather quickly the signal of noise ratio of 10-to-1.

I bring this out now because I think it is of vast importance -- a normal acceleration experience of the automobile driving through a deep pothole at 40 miles an hour, which can happen to anyone at any time.

We got an impulse, to car structure, which was near a ratio of 2-to-3, or something like that. Anywhere near the

actual crash that seems to come through, I would say we have an excellent chance of building a system which would be, for practical purposes, highly reliable and reasonably free from inadvertent actuation.

To me, the most important factor that encourages us to go after a practical installation is exactly this fact. We also are encouraged by some of the installation aspects, which indicate that rather practical areas, such as the fire wall, might be used for acceleration crash censor. And this gives us a possibility for a practical situation with short connectors, energy source, air bag and censor reasonably closely connected, which may result in good maintainability and good reliability and what all adds up to operation suitability.

DR. HADDON: I agree from our standpoint with everything that you said.

MR. MC LEAN: I should like to say further that at General Motors, of course, one of our first program objectives was to replicate with a wide range of our own products, the basic findings as to the acceleration characteristics in a crash versus even stringent regular car operation and, hopefully, I think we should not leave the truck out of this. It has not been specifically mentioned, but I think we should consider it for this type of installation, both the passenger cars and trucks.

DR. HADDON: Would it be clear to say the question

should not be crash per se but forces at the sensing location? It is entirely possible in extreme operational situations, you might want such a device to inflate even though a crash, stictly speaking, does not occur.

I think this signal of noise ratio looks like a different ---

MR. SELIN: I think not.

DR. HADDON: Let me rephrase it.

I think it casts the question of whether this only goes off in a crash, in a different light. I did not think that should be the criterion. I think it should be, really, the factor of crises in a particular location.

In other words, for example, if you go into a pothole six feet deep, you might not call it a crash, but you probably need the bag.

MR. SELIN: And you should register.

MR. FERGUSON: Perhaps one way to answer that question would be to note the basic design of their censor is such that while they have a 10-to-1 ratio now, as Mr. McLean pointed out, it would be a very, very simple design to make it 20-to-1, 5-to-1, whatever you want to.

The nature of the design is such it can be adjusted anyway.

DR. HADDON: Is there any thinking that there should be a sensor set at two or more different levels, corresponding

to either inflation rates or different likelihoods of inflation.

For example, if you want to make a quicker and harder ride down in a very high "g" crash, than in the one which was very low, and the trade-off in terms of driver's loss of ears, and so forth, might be different also, you might want to have such a split approach.

MR. MC LEAN: I would say, sir, from what I know of the system installations possibilities, should it appear as developments continue and experience with this type of system is gained, such things as you are mentioning would be possible. All of them, I think, would add more complication and somewhat more cost to the system, but they are certainly in the realm of the state of art as they are now.

DR. HADDON: So you would prefer to go in the simple direction --

MR. MC LEAN: I think in the case of this whole system, we are learning to fly, yes. I think we want to start with the rather basic simple system, very high in reliability, and get actual field experience and then exploit the apparent possibilities for further development of the system as time goes by.

MR. FERGUSON: Perhaps another thing inherent to the design of the sensor is the diagram system where the bag and inflating time should be the same, regardless. However, the

sensor is designed so that the more severe the crash, the quicker it will trigger or, expressed another way, the more severe the crash the quicker the bag will contain the individual even though inflation is sometimes the same.

DR. HADDON: To a practically significant extent, or different?

MR. FERGUSON: I couldn't say.

DR. HADDON: You are talking about a pin moving a very small distance under a given load. It seems to me the timing or difference with that approach, at least, would be pretty trivial.

MR. FERGUSON: It would be a matter of ten milliseconds.

MR. HASS: We want our various customers to develop the necessary criteria to design the sensor, hopefully the barrier crash and also one which involves a pole impact well out in front of the barrier so that the car envelops it and, depending on when you want to start time zero, if that is the impact with either of these, in the pole impact at about 20 miles an hour, there may be a 90, as much as a 90, millisecond delay before the bag is deployed.

The sensor, however, responds to the rate of energy extraction, and is therefore able to deploy the bag prior to the occupants substantially leaving his seat in either case, either kind of crash, with constant bag inflation times.

I think I would say further on tailoring the inflation time or rate of the bag, that we have been pleased with the tolerance that a system using these sensors or bags has given us.

Now, we have run low-speed stuff in which we have used our dummy, and all of our work with customers has been at 30 miles an hour. Within that range of species we have gotten very narrow bands of decelerations on all size dummies. So we think the basic fundamental system has a lot of tolerance for these.

MR. SELIN: I think this sums up the concern and the human factor area that concerns us, and I appreciate the opportunity to have this open discussion on this subject.

At this point, I will leave it wide open and discuss anything in this general area.

DR. HADDON: Who is the first?

MR. SWAN: Perhaps I should have brought this up when we were discussing two or three (See Agenda) but perhaps we have not touched quite enough on the one area that we have been concerned with. I know I cannot answer you as to whether to give you more -- that is, these bags presumably deploy into the unoccupied areas of the car. That is the idea, they go where the passenger is not and then when he moves to that area, they are all set.

What happens if those areas happen to be occupied?

particularly by his arms, for example, which either cause considerable injury to himself or to other passengers?

There are numbers that indicate that these things are working in the range of five or ten thousand horsepower while they are working and they do not work there very long. But that is a lot of power to apply for a five- or ten-pound object and then hurdle it at a human being. I think this is one of the most difficult to get at in terms of correlation with dummies. The averages are not too good for it and perhaps this is one of the most difficult experiments to get volunteers to participate in also.

MR. STAPP: What is the largest number and volume of these bags you have blown up at the same time with the exposed departments of the car, and is there any summation of the noise effect?

MR. HASS: Taking them one at a time, the largest cubic-foot average per car has been probably close to 18 cubic feet in a small size car.

DR. HADDON: That is the seat, is it?

MR. HASS: This would be front and rear.

MR. STAPP: What proportion of the volume of the car is that?

MR. SWAN: It is about 200 cubic feet, in that order.

DR. HADDON: Are you talking about the overall pressure increase in the car?

MR. HASS: Directly, that has been as high as in the range of three-quarters psi and maybe one and a quarter.

MR. STAPP: Less than sonic boom?

MR. HASS: Yes.

MR. SWAN: We have also measured over one psi.

MR. HASS: So if you live next to an airport, this should give no problem.

MR HASS: I think part of this problem has been concerned without sufficient experimental means to measure the impact pressure on the chest. Here your experimental information breaks down. The bag weight is a pound or less and the gas charge perhaps a pound. You can estimate from the film the speed at which this jelly-like gas impinges the chest.

And you can, as a function of whatever you like to call it, develop some pressures for forced consideration. I think these are a matter of concern with the dummies, of course.

MR. STAPP: If the bag is covered with sand, could that blow out fast enough to damage the eyes?

MR. HASS: If it were covered with sand. It is no greater than 90 or 100 miles an hour for a very short time.

DR. HADDON: We are talking about the same range as a baseball coming off the pitcher's mound but not with the same math consideration.

MR. BROWN: I might address myself to the question asked by Mr. Swan. We have done a lot of testing with people

up against the target of inflation, to determine what would happen in that situation. And we find that it is reasonable that it does not throw the object back as drastically as you might think. It has acceleration backward and is something to be concerned with, and does need testing. But it does not appear to be a serious problem.

Another point I would like to make, in the true crash situation this is not anywhere near the same problem because the deceleration of the bag, you might say, is inflating out. The object is applying its forces against the bag, so that in fact it does not get thrown backward, but rather it is decelerated with the vehicle.

So that the deceleration rate then is what you are after, and this is what is accomplished.

The child up against the dash during inflation is in a sense held against the inflation in the ride down.

DR. HADDON: You are talking from the standpoint of instantaneous accidents only.

MR. BROWN: That is right.

DR. HADDON: Let me make another point here that may amuse some of you. I think you could make a strong case that a complement to such devices is something which stops the head as a head restrainer, for example, from extending backward and if certain places are going to be used, the presence of head restraints going up to comparable percentile values as those

recently discussed and covered by standards, is a desirable feature over whatever other problems they might impose because at least in the normal position this will give the person adequate restraint all the way up his back, including his head.

This should be kept in mind.

MR. HASS: We found, actually, even the three-year-old dummy has enough enertia that the bag must billow out around him and by inflation pressure rather than impact pressure. So that "g" forces on that dummy are very small, less than the landing portion in the feet.

MR. MC LEAN: The important aspect here, then, is that the presence of the person, or possibly a significant part of a person's anatomy against the bag at the moment of beginning of the inflation, materially changes the nature and the rate of the inflation process, does it not?

MR. HASS: No.

MR. MC LEAN: Let us eliminate the word "rate." There are changes in the nature of the inflation. You talk about a developing characteristic which we do not see at all when the bag inflates. This appears to be to the advantage of the person or the part of the body which is against it.

MR. HASS: I think it would be possible to hold the bag against the instrument panel.

MR. MC LEAN: I think it has got to change the rate, too, because it is added math, but we won't go into that. It

may not significantly change it.

DR. HADDON: Can we ask if anyone has feelings on what the structure on the bottom should have as characteristics itself presumably under some loading conditions, including perhaps with the person far forward, who might be bottoming out?

MR. MC LEAN: In our work with Eaton Yale & Towne so far, we have postulated a basic condition that we wish the installer of the bag restraint system to not materially alter any other energy absorption characteristic of the automobile structure.

For instance, if it is installed in the right-hand instrument panel area, we would expect that whatever energy absorption characteristic or crush characteristic, if you will, that the panel had basically, let us say based upon 1969 or so standards, that this characteristic would not be essentially altered by the presence of the air cushion or air pillow system.

Our initial configuration studies would indicate that such installations appear to be possible. We have not proved this yet.

Therefore, if you did not have bag inflation, or if you decided to inflate the bag only at rather a high car velocity, you still would have under panic brake conditions or bumper-to-bumper impact, at five miles an hour, at seven miles an hour, the full availability of instrumental panel crush.

DR. HADDON: That is precisely our view of the

requirements.

Any other discussion on that point?

MR. BROWN: I might make one comment and that is, it is very feasible to do this. Our work would suggest this can be accomplished.

DR. HADDON: Are there any other areas anyone would like to cover?

I would live to cover two, if I may.

First of all, we regard this device as so promising, this approach rather, that we would like to have serious consideration given in the development work that is going on, to the possibility of retrofit, if not in all vehicles, at least in some vehicles, and of course we appreciate the problems of installation, the problems of costs, the high variability of the kind of vehicles that they might be installed in, the different configurations of the instrument panel areas, might not lend themselves to this and at the same time it strikes us as quite likely here we have the opportunity for major breakthroughs which otherwise might not be achieved until the phasing out of all older vehicles after introduction on new equipment.

So we hope a good deal of attention will be given to this and we also wonder along several other lines, whether, for example, installations in the glove compartment or thereabouts of existing cars might not be considered since this would be a place to stash the equipment close to the fire wall in all

possibility.

We wonder also whether companies might not review their own past production to see whether such an installation could be made on their own prior products.

Would anyone car to comment on this?

MR. BROWN: I will make one comment only, and that is that we have given this a lot of thought along the way and would want to work in that direction and think a fair amount could be done. But we have not directed at that. Most of our work has been directed at original equipment manufacturers originally.

DR. HADDON: The payoff of an effective system on the short-term is primarily in the old equipment rather than the new; there is potential payoff.

MR. MC LEAN: I would just like to say our present configuration studies allows us to visualize such a stage. We can visualize such a thing. If it goes into the glove compartment area, it probably will cost you other use of your glove compartment.

DR. HADDON: That is understood.

I do not intend this discussion in any way binding or indicative of our attempt. This also raises the question of how one might get these things in actual use sufficiently to determine their real world characteristics after the preliminary testing might have been gone through but before anyone

would feel sufficiently competent to substitute these across the board for other restraint systems.

Does anybody want to take that one?

MR. BROWN: I will make one attempt at that.

Pending the outcome of the sound work, the human factor work with regard to the sound, and the difference between dummies and human volunteers, once you are through that threshold, it would be entirely feasible to put systems on fleets and start to get real world experience.

DR. HADDON: I might add, from our standpoint, this strikes us as a situation and a much more clear situation than any we have had in the past, of where we should pay extremely careful attention to avoiding a forced introduction of an approach before it has been completely evaluated. Yet the fleet opportunity you mentioned is one possible approach and there are a number of others.

MR. ECKHOLD: Dr. Haddon, the fleet may be an answer. Because before all of the testing is completed and the reliability is thoroughly established, making these available, of course, presents tremendous legal implications, product liability, among others.

You know, this is part of the problem that I think all of the manufacturers who have been working with this have, of thoroughly established reliability as well as solving human factors.

DR. HADDON: Well, there are plenty of precedents in pharmaceutical, food and drug areas, perhaps some others, new devices being introduced strictly on the experimental basis with the understanding by the parties on all sides that this was the case.

MR. ECKHOLD: I think that is why the fleet approach might be the answer to this.

DR. HADDON: I would like to ask Bob O'Mahoney from the Federal Highway Administration Legal Staff -- and I have not tried this out on you previously, Bob -- what do you see the legal problems in terms of our authority to be either permissive or otherwise, in connection with an experimental introduction, for example, on fleets, the problems including those related to allowing other standards to be relaxed, for this purpose?

MR. O'MAHONEY: Well, there would be problems. I do not think they are insurmountable legal problems. I think you would want to allow deviation from existing standards for this purpose only if it is absolutely essential.

I suppose that the legal standing on that, if that became necessary, would be set up in the category of "Vehicles" and call them "Experimental Vehicles", and have a different type of vehicle. We have talked about that anyway. Have a little different set of rules for them and there wouldn't be any problems. I don't think any of them would be insurmountable.

DR. HADDON: You do not see any need for any change in present statutory authority in order to be able to accomplish something of this sort?

MR. O'MAHONEY: Not in the general way you have outlined it, Bill. I think if we got the specifics, we would probably discover problems that do not occur to us right now. One of those problems might be this permissiveness Mr. Eckhold spoke of, product liability. There is also the problem of Government liability, for claims against the Government, so situations might create problems.

I wouldn't say none exists.

I would like to mention another problem that occurs to me, and ask a question after I have stated the problem.

I notice that in the list of people who are invited to attend this seminar, which I will call it for want of a better word, we have no manufacturers from outside of the United States. And, of course, we have a transcript of this and a record and I think we will want to inform foreign representatives of those companies. They may want, and perhaps in fairness they should have, the same opportunity American manufacturers have had to discuss these problems with the Eaton Yale & Towne people.

But I wonder, has there been any work in the area of small cars, the principal product of those manufacturers, with this sort of device?

DR. HADDON: Before that is answered, I do not know when you came into the meeting, but I believe I made it clear earlier that the purpose of the transcript of this hearing, which we regard directly as solicited by Eaton Yale & Towne, was to make the record available to anyone who was interested and perhaps we should go out of our way to give equal treatment everywhere.

MR. O'MAHONEY: I understand that. But I just think for one thing, if we tell these people what happened before they read it in "Automotive News", that would help them some.

DR. HADDON: I think your suggestion is well taken and I think there would be no objection from anyone here.

MR. O'MAHONEY: As I say, they might want to discuss it. In fact, I am sure you want to discuss it with them.

But the second question is still there.

MR. BROWN: Your question is with regard to, have we done any work with cars, say, maybe in Europe?

MR. O'MAHONEY: Smaller cars.

MR. BROWN: Yes, we have. We have made installation we have crashed small cars, and it is our intention to communicate this throughout, just as you suggested.

MR. ECKHOLD: There are two other aspects to that. One, there has been some work done in Japan and there are some Japanese and American patents of certain devices. I do not know to what extent it is actully translated to hardware. Of

course, some of our testing is done on Mustang-size cars with the interior which approximates many of the smaller cars.

DR. HADDON: You do not have insurmountable pressure problems, I take it?

MR. ECKHOLD: Of course, we blew windows out. Of course, we still do not know what effect it has on actual living human beings.

DR. HADDON: The legal comment a moment ago reminded me of the Secretary's comment of a few weeks ago, stated in some exasperation, that he needed a one-handed lawyer because he kept hearing that on the one hand, you could do this and on the other hand, you could do that.

MR. O'MAHONEY: I have got one head.

DR. HADDON: You are singular at both ends.

MR. ECKHOLD: Of course, going back to that discussion, Mr. O'Mahoney, one side of the Government, to some extent the Government side, and we, of course, -- the other side -- face litigation in case of malfunction, and we are as I said, deeply concerned over the malfunction aspect.

DR. HADDON: But to some extent, it seems to us that the definition of malfunction should be covered in any event, including standards in this area, in that the sensor device to some extent is the operational definer of whether appropriate forces had reached the location. I suppose what I am implying is that we would far rather, from our standpoint, in terms of

lives saved, so to speak, see a situation in which we got 95-percent effective use out of this, as compared with belts at 35 percent, and at a much better payoff.

So it seems to me as practical people we ought to get the best of all possible worlds, whatever that might be.

MR. ECKHOLD: I completely agree with that. It implies there is a more serious problem that we have to get around.

DR. HADDON: I think, incidentally, the malfunction problem, if I read this area correctly, is likely to be more of a problem with the borderline impact than with the massive impact; is that fair?

And you have more of a problem with reliability because of the scattering of the triggering of your device, just about at the range at which you have set it for, rather than at a much higher impact.

MR. HASS: Yes, at 4.99 impact.

MR. HADDON: Or maybe 5.1, because of the production.

MR. BROWN: Whereas, there is a band within which there might be some question whether the sensing would trigger it. You have a tolerance on that. But you have probably an even greater tolerance on what is an accident. You have a post-accident, a quartering accident, andeach has a different characteristic curve. So, therefore, stating miles per hour at impact would not be very meaningful.

DR. HADDON: No; we would like to see an eventual definition of this in terms of the device and with the trigonometry of the situation taken into account where it was not head-on.

MR. FERGUSON: I have one question that keeps bothering me here. You stated that you are learning to fly, and you talked reliability. What does the temperature environment do to this thing?

For instance, you have a possible environment to probably 120 mf. What does this do to you? Does it have any basic effect on the reliability? Does it have any basic effect on the inflation?

MR. HASS: We are designing for storage minus 42 plus 220. Operation minus 20 to 200. In a storage system, naturally, you have the pressure effects, but these are not out of the range of feasibility. In other words, the inflation time is not affected. Reliability-wise, we are currently running tests at the temperature extreme.

MR. FERGUSON: Does it have any apparent effect?

DR. HADDON: Nylon doesn't get brittle at minus 40.

MR. HASS: No, sir. Minus 20.

DR. HADDON: Let me ask you another one.

I am thinking of the experience with nylon hose some years ago where air pollution -- I have not heard of it lately -- where there was a sudden running of stockings if the

air pollutants got too high. Have you tested this in deterioration mixtures of high air pollutants?

MR. HASS: First, we are talking first generation.

DR. HADDON: You mean, urethane coating?

MR. HASS: Urethane coating. And we are in the process of testing it under oxygen pressure, temperature, humidity, vibration, pull strength, and cycling it in a manner which we believe to be equivalent to five-year installed life of the car, and it is passing these tests in fine colors.

MR. EDWARDS: In many of the devices we have come up with, we have run the device of this type through accelerated aging aspects also, to determine the in-car-life of the system, in car corrosion ability of the system, and in car dynamics of the system.

We have gone extensively through this testing, as we do any other product, or new ones.

DR. HADDON: You do this presumably on all components in the system?

MR. EDWARDS: And the complete system, which is highly important, interaction of the individual cars.

DR. HADDON: Let me ask you something else. Are there problems in the area of kids and mechanics, and that sort of thing, getting at this, taking them out to use for other things, inadvertent release in the shop, that sort of thing?

MR. EDWARDS: I think some of the initial designs

we have looked at this aspect of it, relative to fool-proofing aspects from a kid knowing that a device is on this car like this and triggering it on purpose. These would be some of the things we would have to look at.

DR. HADDON: Or taking it out to use to power a gun or toy, or rocket.

MR. EDWARDS: Similarly, as they remove ornaments from cars.

MR. MC LEAN: I would think the air storage system itself poses no greater hazard than presently and commonly available, as scuba diving tactics, same type of a pressure vessel operating at very comparable storage pressures. These are commonly available.

DR. HADDON: If one were to go to other sources of gases, such as explosive sources, would you feel the same way?

MR. MC LEAN: Very serious consideration when speaking about such materials. We have not gotten deeply into this.

MR. HASS: I think the general philosophy of this energy storage system is to make it as much an integral part of the car as possible. Additionally, with regard to vandalism, the stored air cushion would be placed in such an area of the vehicle that you would have to deface the instrument panel in order to damage the stored cushion.

MR. FERGUSON: Doesn't that kind of cross you up with the retrofit?

MR. HASS: The retrofit would be more susceptible,

depending on whether it was an external or in the glove compartment. If you could get it in the glove compartment, that would be the place for it.

MR. MC LEAN: I think probably it should be brought out, Pete, that it appears that in the development of the system that there is energy available to break through a vehicle trim surface, which you have not mentioned as yet. In other words, if you have a vinyl sheet of trim material on the instrument panel it appears there is adequate energy to break through this material, and we think the configurations should be possible so that the material itself, which is broken through, does not in any way enter into the bag deployment system, and the fact that such a bag might be concealed under the trim that is truly passive and attempts to make it more free from contaminant, and accidental damage than if it were laying visibly.

DR. HADDON: Less susceptible to pencils and that sort of thing.

Without in any way tending to bring this to explorations that might go on, one would hope that consideration has been given to the possible role of the after market of suppliers and installers, and so forth in this whole picture.

Are there any other areas we have not covered?

MR. BROWN: I might make one comment back on the subject you raised in tamper-proofing. In the sensing device

itself, probably affixed to the fire wall of the vehicle, it would be such that at least as we see it through day, it would be extremely difficult to initiate the same forces. You almost have to crash the car to get the force. You have to get that kind of a trigger.

So to strike it with a hammer or something of this type would not set it off.

DR. HADDON: Even if you hit the casing of the triggering device itself?

MR. BROWN: That is right.

DR. HADDON: Would you put the sensing device on the passenger compartment side, the rearward of the fire wall so it would not be obvious to people who were looking at it?

MR. BROWN: Yes.

DR. HADDON: I would like to mention one other point.

With respect to methods either for storing gas, or more particularly, with respect to explosives, we would be concerned if noxious gases were generated which might, particularly in a moment of panic, be inhaled deeply by the persons in the car.

For example, as far as I know, most of the explosive produced, NO_2 and NO, and things of that sort, we would not like to see these going into people, although it is arguable as to how much effect there might be. But I think the burden of proof would be on the person furthering the system of this

sort to the approach it was not toxic.

Anything else?

MR. SELIN: You did a fine job for me.

DR. HADDON: I sort of chaired this without intending to. Would you like to make any other comment?

MR. SELIN: I don't, myself, unless anybody else here does. I think the last comment I can make is that we thank you very much, Dr. Haddon, and everybody else who took their time to come down and discuss the current situation on a device of this type.

DR. HADDON: I would like to close, then, by saying we are dead serious about pushing the potential this seems to represent, and if there is anything I can do personally, or we can do as a Bureau to further this, to the point where it either succeeds or is demonstrated not to have the potential we now see, I hope that you or anyone else will be in touch with us.

At the same time, we think the initiative should be appropriately with the private sector, and we are in the role here of perhaps kibitzers and to some extent midwives rather than those primarily responsible for conception.

The meeting is adjourned. We will make this transcript available to others.

(Whereupon, at 4:00 p.m., the meeting in the above-entitled matter was adjourned.)