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Presented at
Mike Monroney Aeronautical Center
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SIXTH HUMAN FACTORS WORKSHOP
ON AVIATION

Sponsored by the
U.S. DEPARTMENT OF TRANSPORTATION
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FOREWORD

This document is a verbatim transcript of the proceedings of the DOT/FAA Sixth Human Factors Workshop on Aviation held at the Mike Monroney Aeronautical Center, Oklahoma City, Oklahoma on July 7-8, 1981. The subject of the workshop was aviation maintenance and the interrelationships among design, operation and human factors as they affect safety in continued airworthiness.

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LIST OF ACRONYMS

AD	Airworthiness Directive
AFCS	Automatic Flight Control System
AIA	Aerospace Industries Association of American, Inc.
AIDS	Accident Incident Data System
AMC	Avionic Maintenance Conference
AMF	Aviation Maintenance Foundation
AOPA	Aircraft Owners and Pilots Association
ARINC	Aeronautical Radio Inc.
ATA	Air Transport Association
ATE	Automatic Test Equipment
ATEC	Aviation Technicians Education Council
BITE	Built-in Test Equipment
CFR	Code of Federal Regulations
CRS	Certified Repair Station
CRT	Cathode Ray Tube
EICAS	Engine Indicating and Caution Advisory System
EIS	Enforcement Information System
FAR	Federal Air Regulations
FBO	Fixed Base Operator
FIDDS	Fault Isolation Data Display System
FSDO	Flight Standards District Office

LIST OF ACRONYMS (CONT.)

GADO	General Aviation District Office
GAMA	General Aviation Manufacturers Association
GPO	Government Printing Office
IA	Inspection Authorization
ICAS	Boeing-Inflight System Monitor
LRU	Line Replaceable Units
MBA	Master of Business Administration
NTSB	National Transportation Safety Board
OJT	On-the-job Training
PAMA	Professional Aviation Maintenance Association
PMI	Periodic Maintenance Inspection
SDR	Service Difficulty Report
TSO	Technical Standard Order
TWU	Transport Workers Union
VOR	VHF Omnidirectional Range Station

SESSION 1
(July 7, 1981)

MR. BEARD: I want to welcome everybody to the Sixth Human Factors Workshop on Aviation Maintenance. And I am glad to see so many people here.

My name is Craig Beard, I'm Director of the office of Airworthiness. After some brief introductory remarks I will be handling the program over to Joe Pontecorvo, the Chief of the Aircraft Maintenance Division in Washington, D.C.

I took my coat off to give you a good lead to be comfortable, so if anybody would like to strip their coat off, this is a workshop, let's make ourselves as comfortable as we can.

No aircraft has yet been designed, and I doubt if one ever will, that does not require maintenance. Proper and timely maintenance is fundamental to the continued airworthiness of aircraft, whether the aircraft be a small, single place sports aircraft or be it a large transport category aircraft capable of carrying hundreds of people.

As you heard from Mr. Luffsey, since last October we've had a number of Human Factors Workshops, concentrating on human factors as they relate to the performance of flight crew and air traffic control personnel. These workshops address the conditions under which these personnel operate and the environment in which they perform their duties.

One might say that when anything happens to an aircraft it ultimately becomes the problem of the pilot, but that doesn't mean our human factors consideration should end with consideration of the pilot's problems.

Today and tomorrow we'll be discussing the human elements as it must be factored into the aviation maintenance assumptions and operators programs. All too often in the past when the probable cause of an accident or incident was identified as a human error in maintenance, that was the end of it.

In the next two days, we'd like to take it a step further, not necessarily by coming up with any answer or drawing any fixations on any conclusions, but to try to identify the central issues that relate to the human factor in aviation maintenance.

What is human error? What causes it to occur? What actions can be taken to reduce the probability of human error in maintenance? What action can be taken in design or in maintenance programs to reduce the consequences of human error when it does occur?

Everybody in the Airworthiness System is involved in these fundamental questions. The designer must certainly recognize the realities of the environment in which the aircraft will be operated, which certainly includes the total maintenance environment. When the operator develops their maintenance programs, the human element must be factored in.

The training institutions, airmen's unions and operators that train and maintain the competence of maintenance airmen must also have a keen understanding of the human factor of what causes human error; of what kinds of human error to reasonable expect; of how to reduce their occurrences or alleviate their adverse impacts.

The mere holding of this Workshop tends to beg the question on: What is big Government's role in this whole issue? What role should Government play? The FAA's charter is public safety in air transportation. We recognize that industries' charter concerns both considerations of safety and operational viability. We don't consider these to be conflicting considerations, but rather we see them as complementary considerations.

The cost to safety and economic viability, of not adequately accounting for the human factor in aviation maintenance, is real and correctable. I don't want to have it assumed by the fact that we're holding this workshop that the FAA believes that a new set of regulations involving human factors in maintenance is necessary.

What we are trying to do here is to identify issues that should be considered by the total aviation community, considering ourselves a part of that community. If we serve as nothing more than a catalyst to facilitate communication and to develop awareness of these issues, we've done a great deal.

With those brief remarks, I'd like to turn the program over to Joe Pontecorvo who will explain the structure of the Workshop and how we will be proceeding and working on.

I want to thank you again for coming. I plan to spend the two days with you and maybe participate in some of the discussions. Thank you very much.

MR. PONTECORVO: I'm Joe Pontecorvo, I am Chief of the Aircraft Maintenance Division in Washington, D.C., which is part of the Office of Airworthiness, and I work with Craig Beard. There are a few things about the Workshop that I'd like to say. One is that we would like to keep the atmosphere informal. Also, I would like to announce right now that we have got revised agendas on the table just as you come into the door. So at the coffee break, everyone pick up a revised agenda and take a look at it.

The agenda you got this morning is not really current, there's been a number of changes. And there will be some additional changes as the result of people that have to make different schedules, so we'll revise those as necessary.

At the first break time, or lunch time, I would like to get together with the people that are going to put on presentations today so that I can meet those of you who I've only spoken to on the phone and get to at least see who you are and make sure that everybody is here and that we have the schedule all arranged properly.

A little bit about logistics. There is a message board right outside the door; most of you probably saw it as you came in. I'd also like to say that after the presentations are made, after each panel makes their presentations, we'll open the session for questions. And if anyone here in the room would like to make a little speech or give a presentation or give their views of your particular organization, please see me at coffee break or at lunch time and we'll make arrangements on the schedule.

We're not looking to provide any answers in this Workshop. We're looking for questions. We don't really know what the issues are that should be considered in the human factors area concerning maintenance, and we're trying to raise those issues. We're trying to find out what some of the problems may be that we should be taking a further look at in the future.

Where should we devote our resources in the months or the years to come insofar as maintenance and human factors are concerned?

As Craig said, in the past you had a maintenance error, it caused an accident, and that was pretty well the end of the book. You know, the page

of the book. You know, the page was closed and that was it, and we didn't really try and delve into a whole lot of detail as to why that error occurred; what could have been done other than redesign, to prevent it, in the way of instructions or motivation or other things.

So as I said, we don't have the answers today, you're not going to leave here with any answers after this Workshop is done, but we would certainly hope to raise some issues and have some thoughts from which we can do some further work and research.

When we're finished here, either tomorrow afternoon or Wednesday morning, for those of you that would like to stay, I'll arrange for some tours of the various facilities here.

As the Doctor mentioned this morning, some of you may be interested in some tours of CAMI itself; they do a lot of medical research there.

But also we have here in Oklahoma City one of the largest repair facilities in the world, for our airways facility equipment. All the radar antennas, all the equipment that we use, is repaired and maintained in the depot here. Some of you may be interested in seeing that.

We also have the most mixed airline fleet in the world. We've got one of everything, I think, at our aircraft services base here at Oklahoma City, if any of you are interested in that, those of you who are from airlines and the aircraft manufacturing industry have probably seen all the airplanes you'd want to see, but there may be some other people that are interested.

All the aircraft records and airmen records are kept here in Oklahoma City. In fact, this is the Airmen Records Building.

There is also a MAC Center here where we accumulate and print all of the service difficulty reports, air carrier and general aviation, and some of you may want to see that facility.

Now, I want to take this opportunity to introduce two other people that are here from my Division to help me. Leo Weston is Chief of the General Aviation Branch, and if I'm not around or you can't get a hold of me, you can contact Leo.

And Jack Flavin, Jack is hiding in the back. Jack is Chief of the Avionics Branch.

I want to tell you just a little bit about the organization that I work in. I'm not going to go into a lot of detail, but Walter Luffsey is the Associate Administrator for Aviation Standards, and Walt has several offices working under him. Medical, flight ops and the Office of Airworthiness. Craig Beard is the Director of the Office of Airworthiness. And in the Office of Airworthiness, we now have three divisions. This is a little change from the way it was a few years ago. Some of you may not be familiar with our new organization, but we have reorganized the Office of Airworthiness to take care of the machine from the day it becomes a vision in someone's mind until it goes to the junkyard.

We have the Aircraft Engineering Division. The Engineering Division is concerned with the design of the aircraft and the type certification; the aircraft products, appliances, propellers, engines, everything that's associated with it. And there's not much difference from the old Engineering Organization, except it's in a new office.

We now have a Manufacturing Division that then follows these products to be sure that they're put together properly.

And the Aircraft Maintenance Division, that's concerned with the continuing airworthiness, that's my Division.

That's really about all I have to say. If there are any questions concerning the logistics of the Workshop, I'll entertain those now. And if not, we'll get started.

I think we're just a few minutes ahead of schedule for coffee break, but I'll entertain any questions you might have about the general format. We can take a break and after that I would hope to have the AIA panel headed up by Jack Reese.

Yes, Ed, please.

ED: Are we going to have an attendance list here shortly and if not could we take maybe five minutes to find out who's here?

MR. PONTECORVO; Okay, that's a good idea. Since we've got the time, I think the answer to both of those is yes. I think we will have an attendance list, but why don't we start here and go around the room and go around the outside of it then come around the inside. Let's start with you, sir.

(Whereupon, all in attendance introduced themselves.)

MR. PONTECORVO: It sounds like we've got a real cross section of the maintenance people and engineering and maintenance, and I'm really pleased to see that we have got such a good cross section.

We've got the providers of the product, the users of the product and just about everybody here.

Why don't we take a break and Jack, would you be prepared then right after the break and bring your people up here and you can start off with the first session?

Please remember one thing. I do want to keep this informal and I do want participation from everyone here. Please don't think that if your name is not on the agenda that you can't speak up. We do want participation. We are scheduled to come back at 10:25.

(Whereupon a coffee break was held, after which the following proceedings were had:)

MR. PONTECORVO: Okay, I'll make a few announcements as a result of some questions that have come up during the break. First, about the buses. There are two buses in the morning for the students here, one at approximately 6:25 and another at 7:25 that leave from the Hilton Hotel. However, there is a special bus or buses at 8:00 just for this group.

Now, I understand there was some confusion this morning, so just for your information there are special buses at 8:00. If you want to ride out early, I suppose you can, no problem.

Also in the back with the agendas are some forms titled Identification of Human Factors Issues in Aviation. This form is a voluntary form. If you have something that you'd like to put down, identification is not necessary. If you'd like us to get back to you then, it's desirable. If you need more room, want to write anything else, just put it on the back. If you want to leave the form here with me or Jack or Leo, you can, or else you can mail it to me. My address is in the lower right-hand corner.

I think that's the only announcements. And now I'd like to introduce Jack Reese and his group of people. I'll let Jack give you his own bibliography.

MR. REESE: Thank you, Joe. This first panel on the program is representing the manufacturers of aircraft engines. I happen to be on the staff of the Aerospace Industries Association in Washington and moderator for the panel. That means I get the job of introducing these people, I don't have to make a speech myself.

I might indicate that we have one change from the people that are listed in the agenda. In place of Terry Wong we have Ed Yamada from Douglas Aircraft Company. Ed, you might stand up so everybody knows who you are.

The other members of the panel are Bill Gaffney from Boeing Aircraft, commercial aircraft company. Bill, do you want to stand up? You might start heading up this way too, Bill, because you're going to be the first speaker.

Tom Wherry from the Lockheed California Company. And Bert Bertone from Sikorsky Aircraft. Bert is also representing the Association for Helicopters. The Helicopters Association International as well as AIA.

I'll turn the microphone now over to Bill Gaffney who's going to tell you about maintainability as a contribution to aviation safety.

MR. GAFFNEY: I address this group with a measure of trepidation, because from the introductions it's clear there are some real maintenance experts here, which may cause me rough sailing, but I'm going to proceed hopefully and with confidence.

I'm going to discuss this morning maintainability and the fact that it is largely human factors technology. Although safety is not a primary concern of the maintainability program of the type we have at Boeing, we have a separate organization for monitoring safety, per se. There are many areas where attention to or disregard of maintainability in the design can be influential with respect to safety.

Maintainability means different things to different people, so I'm going to begin with a definition of maintainability as it is understood and practiced at the Boeing Commercial Airplane Company. You can see that definition; it is a characteristic of the design. That really is a very pivotal point. It's either there or it isn't when the drawings are released.

It depends upon performance, performance of human beings. It depends upon procedures, hopefully relatively simple ones. And it depends upon resources, tools, facilities, et cetera.

You'll observe that nowhere in this definition do we have the word "safety," but I think it will become clear that good maintainability practices promote safety by catering to and accommodating the idiosyncrasies of human behavior.

We saw by definition that maintainability is a characteristic of the design, and as such must be included in the design from the conception through the entire design process. To do this, Boeing has a dedicated group of maintainability engineers assigned to each airplane program whose responsibility is to influence the designer to include maintainability considerations in the design from the top system down to the detail part. It is their job to see that the airplane can be rapidly, easily and correctly maintained to the extent that that is possible with a very large and complicated piece of machinery.

Since aircraft maintenance is primarily dependent upon human interface, it is to this area that the maintainability engineer must direct his major attention. We all know that it is a basic characteristic of the human being, that they will fairly readily accomplish simple tasks and they will look for ways to circumvent or avoid complicated tasks.

It's in this area that trouble can stock the unwary, and safety can be unwittingly compromised to a certain extent. So our job is to accommodate the physical, mental and emotional limitations and characteristics of the maintenance person so that each task can be correctly performed as easily as modern technology will allow.

Let us first look at the physical aspects involved. Listed here are the considerations which address the physical limitations of the mechanic. If these are not adequately accommodated by design, the results are usually inadequately or improperly maintained equipment.

Much work and study has been accomplished in the past on physical limitations, and a wealth of information exists in Government and Industry Publications that help the designer. And I'm going to show some of the standards that we use to design, as a general rule. There are exceptions here and there.

Our designs accommodate the human body dimensions from the 5th to the 95th percentile mechanic. It just might be that we're going to have to change

this chart with more women entering the work force. We may have to change the proportions, but right now this is what we use for design.

Since airplane maintenance is not a full-time stand-up job, we must accommodate the various positions of squatting, stooping, crawling, et cetera, that mechanics are required to execute in the course of their jobs. That's a list of the design values that we again use in the general case. There are exceptions to those.

Accommodation has to be made not only for total body dimensions but also for what is possible with respect to portions of the body that let you reach with an arm, how much force can be applied with restricted clearance and so on. And we use generally values of this type. We have these all coded. There's no need to go through all those. My point in showing this is to point out that we really do consider all these things, or at least we try to consider all these things in designing the airplane.

To make certain that the physical limitations are considered early in design, we use foam core mockups adjacent to the drawing board for fit checks and access to critical maintenance areas. This foam core material is -- Well, it's a styrofoam core with what I would call a very light paper or cardboard facing on it. It comes in various thicknesses. Typically we use an eighth, quarter of an inch in thickness. It can be readily cut out with a scalpel and glued together. And we manufacture pieces from this material as the design is evolving.

That's a blade shot. I'm not sure whether it's the fan blade or the high-pressure. Judging from the size of the duct -- No, that's got to be a fan blade shot from the 757. And this is the 57 pylon area. This is a fairly rudimentary arrangement, but it's very early in the program where this is done. And we find some interesting things early on with even a crude mockup of this type.

I'll show you another one of these, another valve being loaded into the strut area. It's a very congested area. We pay a lot of attention to that location. Everything in the airplane, it seems, runs through there. We also use this approach early in the design stage to check the ability of the 5th to 95th percentile mechanics who reach maintenance areas. The methods are somewhat crude and rudimentary, but they are really amazingly effective in saving

time and money downstream, to the extent that we avoid changes downstream. This is a 95th percentile, this gent is fairly tall. Here's another one, this is the 5th percentile. We may have to change this end of the scale, I suspect one of these days. But these fit checks, we are able to become reasonably comfortable that things are reachable and doable.

As the various full-scale engineering mockups become available, further checks are made in a more typical environment to make certain that the addition of wiring and tubing does not adversely impede the maintenance process.

The previous slides I've shown you we do early in the program where we have basically the structural drawings released. The wiring is usually the last to be released. It goes in descending order of difficulty at installation.

The pneumatic ducting in the strut, that gets released just about right along with the structure. And then the hydraulic tubing is third. And the other wiring is fourth.

But as the full-scale mockups become available, we are then able to check to see that all of this stuff really and truly fits. This happens to be the 757, I believe. I can't quite read that, but I believe that's the Class II mockup. The classes refer to the fidelity, the dimensional fidelity of the mockup. At Boeing we do mockups. Class I is a general configuration often used for sales purposes. Class II is an engineering mockup; it is of mediocre fidelity. And by "mediocre," that means you cannot depend upon anything located to 100th of an inch or thereabouts. And finally we get on to the Class III mockup, and that's quite accurate. That's supposedly as accurate as the airplane.

There's a mockup of the strut area complete with the wiring. In situations such as shown here, we determine not only whether a specific job can be done but if it requires the attention of more than one person. These mockups are avilable in determining what special tools or handling equipment is necessary. We use the limitation of 40 pounds per person as a design guide for handling the equipment. The restricted access we size to the 95th percentile. In terms of reach dimensions and force applications, we design those of the 5th percentile.

That one on the drawing, it didn't really look as though anyone could possibly reach through that access hole and perform whatever task is being done.

And I believe it was taking loose a piece of pneumatic ducting. But on the drawing it just didn't look possible, but on the mockup sure enough it could be done.

That's a mockup of the precooler, and I believe that is the 57 precooler. Those usually are a net fit. The structure and the design folks prefer to avoid making large cutouts in the airplane, so everything is minimal size. And this is the check to see that the precooler will, indeed, go through that opening. When weight and accurate positioning are important considerations in the maintenance process, specialized tools may be necessary for the mechanic to accomplish the task of removal and installation. Built-in design features, such as alignment pins, key hole attachment lugs, quick attach clamps, captive nuts, all of these things tend to make the job quicker, easier and less prone to error, thus enhancing the person's ability to do the job right. There are many more examples of how physical limitations of the mechanic are considered in design, but these give you the general idea of the kinds of things we take into account.

Turning our attention to the mental and emotional characteristics, we address a more difficult problem. The physical limitations are rather well understood and can be accurately predicted. The ability of the human mind to circumvent established processes and procedures is virtually unlimited.

In this area we have a real challenge. Fortunately there are ways to design in maintenance aids that make it very difficult for the maintenance technician to do a wrong job.

A typical example with which most of us are familiar is the common problem of cross-fluid connections. By providing different sizes to different lines, that problem can be virtually limited. Virtually. We have cases on record where the really enterprising individual has locally fabricated whatever he needed to cross those lines. You can't make it 100 percent but we really do try.

Also we tend to avoid if possible the use of special fixtures, but in the case of something like a 90G, an integrated drive generator, that's way too heavy a package, and it goes into a tight spot, and I don't know how you could reasonably handle that without a piece of dedicated support equipment.

That's just a slide of an aft body sling itself. That, obviously, is something that's big enough and heavy enough to require its own special support equipment.

In the area of crossing tubing -- Let me see if I can say this in an understandable way. Cross hydraulic tubing is potentially a problem. The airplanes, as they become more sophisticated, there are demands on the isolation of the electrical systems as well. And so our current practice is to provide color coding on the electrical systems to assure that we maintain the degree of isolation that we require, so that no single event -- A common design case is a turbine wheel coming adrift and going through the airplane at some point. We want the electrical systems properly separated to prevent that from getting both systems. It's very, very difficult to read the numbers on those wires and go look them up in the wiring diagram, so we are now color-coding the bundles. And we are color-coding the hydraulic tubes so that you can tell at a distance which system is in question.

The red, this again is a 757 wheel well, in the red these are the left hydraulic system; the blue is the center hydraulic system. Is there green on there? I don't see it offhand. Oh yeah, there's a green one down there. Those little color bands we think will be helpful in avoiding cross connections. And as the airplane ages and repairs are made, helping the folks that maintain the airplane, preserve the integrity of the design.

Directional arrows on check valves and restrictors adjacent to those elements on the structure are commonly used to encourage proper installation to the extent that we can eliminate adjustments on the airplane by jig location of control components and fixed length control rods to remove the opportunities for rigging errors.

The provision for proper illumination levels in maintenance work centers on the airplane and the incorporation of built-in work platforms, steps, handholds and so on make the job easier and consequently more apt to be done correctly, reduce also the possibility of damage to adjacent structure or components. Most vulnerable there, of course, is wiring.

The foregoing examples are just a few of the many requirements and objectives contained in our internal maintainability design guide that we use in the design process. The purpose of this guide is to help the designer recognize

that in the real world of aircraft maintenance, that people tend to make mistakes and, therefore, prime attention should be given to designing the hardware in a manner which will leave as little opportunity as possible for incorrect maintenance.

The designers, characteristically, have the syndrome of how could anybody not understand that because he spent his whole life for the last three years with that. And that might by an 8-1/2 x 11 sheet of paper-size thing. He doesn't really appreciate the environment of the folks who have to maintain aircraft. The poor guy with the flashlight in his mouth and all that. So he has to be helped, and that's the purpose of my organization, is to make sure that he is helped.

We talked about characteristics of the design that can effect maintainability. I'd like to mention two other items that are considered in the maintainability definition, namely procedures and resources. The state-of-the-art hasn't allowed us to produce machines completely devoid of periodic servicing, adjustment and repair -- I don't know that they ever will -- and/or humans who are all knowledgeable in maintenance procedure and techniques with the machines.

Therefore, we must produce instruction manuals to guide the mechanics in proper maintenance of the airplane. This is not an integral part of the design process, but it's a very important aspect of maintainability. And it's important aspect of maintainability. And it's important to us that these be prepared by persons who are completely familiar with the operations and functions of the systems under review.

The need for precise, clear and logical instructions is obvious, but more than that where cautions must be observed, these should be prominently displayed and easily explained so that no doubt exists as to the proper method to employ. That is a real challenge.

The use of logic diagrams or troubleshooting trees are helpful in fault isolation and correction and take the technician through a sequence of events in an efficient manner. As equipment becomes more complex and sophisticated, the impact of improper adjustment or repair becomes much more critical, and maintenance instructions should be written in such a manner as to encourage the technician to avoid shortcuts and to the job as prescribed.

With respect to resources, the manufacturer provides special tools where standard tools will not suffice. Here again, during the design process every effort should be made to accommodate standard tool usage, and we do make all reasonable efforts to do that. The requirement for special tools encourages work around methods. Special tools have a way of not being where they are needed, they're always somewhere else.

Before closing, I'd like to touch upon an area in our new aircraft that we believe holds great promise for improved maintenance accuracy, and that is the increased use of built-in test equipment made practical by the proliferation of digital electronics.

Boeing's design goal is to be able to isolate a fault to the line replaceable unit level 95 percent of the time on the first try.

BITE will be especially helpful in avionic systems which have traditionally produced the high percentage of unjustified removals. The incorporation of nonvolatile memory allowing the technician to scan previous flight history and the identification and display of intermittent faults, we believe, will materially improve the speed and accuracy of trouble correction.

We've devoted on the two new airplane programs considerable attention and effort to designing into our electronic systems memory that will recognize and store anomalies in such a way that they can be called back on the ground. Because one of the most typical write-ups is that flight squawks won't repeat. We have, on the 57 and a version of the 67, a system that we call EICAS, Engine Indicating and Caution Advisory System. In the electronic CRT system, using text display of system anomalies, the computer system can be interrogated on the ground by the mechanic who can call up maintenance pages. There will be a page on hydraulics, there will be a page on electrics. A page being a generic description. There might be more than one page.

And the past history of the airplane for, I think it's like the last half a dozen flights, will be available on that CRT, and if there are some parameters out of limits, voltage or frequency or pressure or whatever, that will be announced.

In many cases, we hope almost all cases, it will be traceable down to the line replaceable unit. That's the design goal, that's what we are trying for.

So I've attempted to show how the maintainability engineer and the designer work to accommodate the physical and mental characteristics of maintenance personnel through the application of thoughtful and clever design features. Most clever being something that doesn't need to be maintained very much. Good maintainability encourages correct maintenance practices which in turn promotes aircraft safety. That concludes my formal remarks, I'll try to answer any questions on the new airplanes. There are a lot of structures and systems and whatnot, and I'm sure no expert.

QUESTION: Could you expand further about your comments on the use of the CRT to record or to display recorded in-flight discrepancies?

MR. GAFFNEY: We have on the center instrument panel on the lower half a CRT that is dedicated to -- I said dedicated, it is caution and advisory. It contains caution and advisory information in flight. But that same CRT can be interrogated by the maintenance folk to ascertain what the computer system knows about flight squawks.

Let me see if I can make an example. The landing gear door intermittent unlock light, for instance. That information would be retained in the computer. And if there were a write-up on the gear in the -- it's called the Form 1 -- the mechanic would then go through a selector panel to interrogate this thing and say what do you know about the landing gear.

And it would list out discrepancies, known discrepancies. Does that answer your question?

QUESTION: For instance, would its memory state how long an engine over temped and to what degree?

MR. GAFFNEY: I'm going to wing it on this, I'm not an expert on this system. It would define the exceedance. I'm not certain that it defines the duration of the exceedance, but it defines the exceedance and how much. So if the EGT or whatever were outside limits, it will define that.

QUESTION: Is this a system that's currently in operation, an on-line system, or a gleam in someone's eye?

MR. GAFFNEY: No. We expect to have it airborne about nine months from now. It's in the 757, it's basic. It will be basic to those 767's that have a 2-crew complement. The computers must be in the laboratory test stages by

now, although I haven't followed that development so I can't tell you that for sure.

QUESTION: Is it fair to say one of the advantages of this is if you miss a snag, this will pick it up? If they don't observe it, the computer will pick it up? I think it will hold 133 snags.

MR. GAFFNEY: Quite a few. We also hope that it maybe will improve the the reporting accuracy to some amount. What the flight crew thinks that they see, they don't necessarily always see. And so we would expect some improvement there. But the intermittents are -- Well, all these gents here that are in the maintenance business on a full-time basis know what troublesome things these are, and this will at least hopefully put a finger on it.

MR. PONTECORVO: Will you please repeat the questions when you get them?

MR. GAFFNEY: I may not get another one.

QUESTION: You say this is a self-programming computer, an on-board computer system?

MR. GAFFNEY: The question is: Is this a self-programming on-board computer system?

The software is built-in. In other words, the computer knows that 950 is the EGT limit, so if it goes 952, it blows a whistle and it tucks that away and says uh-uh, wrong. If he is pre-programmed, it will then file away exceedance. It will recognize that something has gone outside limits and will store that information, and that can be recalled on the ground later on.

QUESTION: You say it was the extent of six flights approximately; is that correct?

MR. GAFFNEY: Don't pin me down on that. I can get you an answer on that this afternoon, because there are bigger experts in Boeing than myself on that subject. I don't know how many flights. When I left the 57 program, it was in question.

QUESTION: Can the flight crew during flight play this back and check on a problem or does it have to be on the ground?

MR. GAFFNEY: Can the flight crew in flight play this back or does it have to be checked on the ground?

The answer to that again, I believe, is that most of the information the flight crew can retrieve on demand. Most, if not all. There was some debate on the desirability of having the flight crew doing that, and just where that was left, I don't know.

MR. REESE: Bill, we're going to have to ----

MR. GAFFNEY: I have to get out of here.

PARTICIPANT: My understanding of the 767 is that the computer loads itself on landing when the gear touches the ground. The squat switches load the computer with the snags. The snags are stored in the various units until it squats down, so I don't think they're available in flight.

MR. GAFFNEY: They're not available in flight?

PARTICIPANT: I don't think so.

MR. GAFFNEY: That was involved in the crew complement controversy, and that design decision really wasn't made the last time I talked to the guys who were working that system.

MR. REESE: Bill, I think we're going to have to ---

MR. PONTECORVO: I don't want to cut anybody short from questions, but I'd like to have all of the panel members from this particular panel give their presentations first, and then we can go back to questions. If you have some more questions of Bill, we'll give him another crack. And if we have to slip the next panel a little bit, we'll slip it. We've got a little extra buffer space in the afternoon, and I'd like to give everybody an opportunity to get their questions answered.

MR. REESE: Thank you, Bill. Bill will be around the next couple of days, so you might be able to catch him at the coffee break or lunch or cocktail party this evening.

Our next speaker is Bert Bertone, Chief of Human Factors Engineering for Sikorsky Aircraft. Bert is going to talk on human engineering design for maintenance.

MR. BERTONE: First I'd like to express my thanks to both the Helicopter Association International and to the Aerospace Industries Association for asking me to speak on their behalf and the FAA for hosting the Sixth Human Factors Workshop.

Sikorsky Aircraft at present is engaged in the production of four major helicopters, three for the military; the Black Hawk, which is a 10,648 pound empty weight vehicle designed for tactical troop movement, medical evacuation and tactical resupply. The close associate of the Black Hawk is the Navy Seahawk vehicle, and this is the Seahawk landing on the deck of the frigate McInerney. And you can imagine the maintenance problems involved in a helicopter at sea where you have very cramped quarters, a rolling deck configuration like this in which your maintenance personnel have to operate. And then also a Marine vehicle, the largest helicopter produced in the Western World, the CH 53-E, capable of lifting 36,000 pounds.

The only civil helicopter we produce is the S-76, this is the pride of our fleet. This is, as I said, the pride of our fleet, this is the S-76 vehicle. This is an executive vehicle, transporting vehicle or a utility vehicle. The human factors maintenance problems on each of these vehicles are unique. I will cover only two of them in my talk today, the Black Hawk and the civilian S-76.

The Black Hawk vehicle is designed primarily to operate in a combat environment under the most adverse weather conditions. The human factors design for maintainability meets or exceeds the Army material maintenance concerns and policies. It calls for replacement of components or modules, on condition maintenance, and that's extensively applied in this vehicle. Parts will be replaced when conditions or wear dictates, thereby providing full life utilization of components.

The end result is greater aircraft availability at lower costs. All major components and modules can be replaced with the use of common hand tools. This is the typical toolbox that's supplied with the vehicle. And with the aid of a portable aircraft mounted maintenance crane -- this is the maintenance crane also supplied with the vehicle.

It is part of the vehicle complements in that in the field this maintenance crane can be used to remove blades, remove the rotor head or remove transmission or any major areas of the vehicle itself.

Components are grouped to avoid queuing of mechanics in one area of the air frame. Another important aspect of grouping with which the human engineer and maintenance is concerned is to minimize the number of inputs to each unit and outputs from each unit to prevent the crisscrossing of signals.

I'll show you a series of slides now. This is the electronic bay in the forward nose of the vehicle. The next slide is the hydraulic grouping. Next is the modulized transmission. We have interchangeable modules, individual chip detector and integral lubrication.

Here is a clearer view of the transmission of the Black Hawk vehicle. And another view showing replaceable modules. Either of these modules can be used in another position on there. The next is the dual parallel power pistons. We have redundant systems on here.

The next is the plug-in servos. These plug-in servos have no connecting lines, they plug into the vehicle itself, and you have no lines that you have to use to connect those. This is the elastomeric bearing that is used in the Sikorsky helicopters. There is no lubrication required in this bearing.

Next, a hydraulic pump and then a hydraulic pump with single-point servicing. The individual merely places his hydraulic cylinder on here and dials the area that he wants to service, and he can service any of the hydraulic areas at a single point.

And finally, a titanium spar main rotor. It's fuel repairable, it's all prebalanced and it's corrosion free. By grouping, by modular replacement and by attention to foolproof design, we hope to eliminate or at least avoid improper mounting and installation. These provisions then include: 1. Physical measures to preclude interchange of units of components with similar forms but different functions. 2. Physical measures to preclude improper mounting of units or components. 3. Measures to facilitate identification and interchange of interchangeable units or components, that is, the use of color coding. 4. Measures to facilitate proper mounting, that means the use of alignment pins. 5. Measures to insure proper orientation, alignment and secure installation of cables and connectors.

Other provisions for ease of maintenance are concerned with quick disconnects such as those used in the rotor head for blade separation. This is a rotor head pin. When this pin is placed in this position and locked by this lever here, it compresses, which locks the pin in place.

Once this is released, the man can lift the pin out quickly, disconnecting the blade from the rotor head itself. We're also concerned with preventing damage to installed parts by providing means for certain units to be moved without damage.

This is the collective. In the helicopter you have two sticks instead of just one. You have the collective and the cyclic stick. This is the collective in its normal position alongside the seat. And then the next slide shows the compressed collective. The head turns, it is compressed, this allows easy access by the maintenance people to get in and out of the cockpit and also for the copilot to get in and out of the cockpit without the collective being in his way.

In the combat environment it's not only impossible, but it's not feasible to have an aircraft which cannot be maintained. Therefore, human engineering must be concerned with utilizing even the aircraft itself to provide ease in maintenance.

For example, side-mounted antennas are designed to provide handholds so that maintenance personnel can climb up the side of the vehicle. Let's face facts, if it sticks out a maintenance man will either use it for his foot or his hand, so we may as well design it properly for that use.

This is a radio antenna, it is physically designed for a person to grab a hold of it and use it as support as he steps on the step to climb up the vehicle. So in this case, we're using the vehicle itself as part of the maintenance area.

The steps on the sides serve a dual purpose. The step is designed either as a handhold by grabbing it here or stepping on it and using it as a foot hold. Windowsills are provided with nonslick surfaces so that they may be used as steps.

Here you see an individual actually stepping on the windowsill as part of the step in order to get up and down the side of the vehicle. The side engine compartment covers are designed and rigidly constructed to become part of the work platform when opened up to eliminate the need in the field for ladders and work platforms.

Here is a cowling which covers up the engine compartment, it's designed so that the man can stand on it. This was one of the first designs, you see it's fairly open on this edge.

Here you see the second design of that same cowling, we added an additional piece here which covers more of the structure on the top of the aircraft. And here you see a larger picture showing that particular maintenance cover. It covers up the complete portion of the engine here, yet it's serviceable for the

man to stand on as he goes up and down the vehicle.

Here is that step that we indicated before. In this case he has the windows closed, but the step is usually from here over to here up to here and then up to the work platform itself.

Access to the tail rotor would be especially difficult without platforms in the field, so human factors personnel design spring-loaded popout steps. These are spring-loaded popout steps which allow the man to climb up and physically get at the tail rotor in the field without any kind of a work platform available. Very little maintenance would be done on the tail rotor in the field because of its unique features.

The unique features here are the tail rotor requires no lubrication, no balancing and no tracking. In some cases, clever design aids maintenance and enhances the design of the vehicle.

Here is a case where the forward edge of the tail surface is used as an FM antenna. The whole forward surface here becomes an FM antenna on this particular vehicle. In other cases, interchangeability is the better approach as it cuts down on maintenance time. It permits either part to be used in more than one position, and it reduces stock and increases availability of units.

This is the tail rotor driveshaft. Each of the three pieces in the tail rotor driveshaft are interchangeable. The man has disconnects here, and he can change those pieces around so that any piece fits in any one of the other positions. Maintenance and design for easy maintenance are even reflected in the choice of materials for exterior surfaces.

On the Black Hawk the entire canopy, which is the forward pilot's compartment, is fabricated in one piece of a plastic material. The whole forward section is fabricated as one piece. This is even more evident in the civilian S-76 where major structures throughout the aircraft are made of composites.

You see we use honeycomb and sheet metal, sheet metal fiberglass and kevlar. The red areas are all kevlar. We are now working under Government contract to produce an aircraft called the A aircraft; it's an all composite aircraft. The whole vehicle will be made of a plastic-type material. But this is the civilian S-76.

The only sheet metal area you have is back in this area over here. Major

covers for the engine compartments of the 76 are one-piece kevlar and are very easy to maintain. These are all the major components covering the engine areas, all molded out of kevlar.

In the S-76 program as with the military vehicles, Sikorsky provides in-house maintenance training. An actual aircraft designated the maintenance trainer is used. Here is our maintenance trainer, you can see the American Airlines symbol on that.

American Airlines does all the training for Sikorsky aircraft at our facilities in West Palm Beach. They do both the maintenance training and the pilot training at that location. In conjunction with this training, we have classroom maintenance training as well as small groups and individual programs instructions. These are the small group type of things, and then we have individual carousels that the individual could sit with slides and tape recordings and actually do his own training. All of this maintenance training is supported by a series of manuals devoted to specific systems and the complete aircraft maintenance procedures. And this shows our general information manuals, maintenance test manuals, fault isolation procedures and specific wiring data manuals.

Again, as with the military vehicles, the human factors group in designing maintenance must concern itself with standardization of parts, with modularization so that the equipment can be replaced as modular packages, with groups of functions and with ease of accessibility.

This means that structural members do not block access to or removal of components. Checkpoints, test points, connectors, and labels are accessible and visible during maintenance.

Items which are more critical to system operation or which require more frequent maintenance are more accessible. Access of units maintained by one technician do not require removal of units maintained by another technician. Lubrication is achievable without disassembly. Edges and corners of units are rounded or otherwise finished to prevent injury to personnel. Accesses are provided, where required, with labels identifying accessible items, nomenclature for required auxiliary equipment, recommended procedure labels, warning and hazard signs. Access openings are designed to accommodate the 95th percentile technician; required access reach is designed to accommodate the 5th percentile technician. And weights of removable components are designed so that components

are liftable to required heights by the required number of technicians.

Removable items are provided with handles or grasp areas that accommodate the 95th percentile technicians. Steps and handholds are provided where required to permit access. These points are demonstrated in the following slides.

This is an engine compartment with complete accessibility to all parts once the cowl is removed. This shows cable routing, complete accessibility from the top of the vehicle for cable routing.

The tail rotor gearbox, once the fairing is removed, you have complete accessibility to the whole gearbox. Here is a module; this is the air conditioning system module. The whole thing comes out connected with very few connections. Again, the tail rotor blade you can see how simply designed the tail rotor blade is. A few screws and nuts here take apart the whole tail rotor blade.

This is the electronic bay, the side electronic bay and then we have the forward electronic bay. That's another one of the side, okay? And then we have the nose bay, here is the forward bay. This is the forward bay showing the radar in this particular vehicle. Because of the nature of the material that the 76 is made out of and it's small size and the fact that maintenance platforms will normally be available, it was not necessary to duly design the covers as platforms. Instead, the covers are hinged or totally removable. You can see the hinging here with the wide open area so that the maintenance people could get in. This cowling slides completely forward on the vehicle and is removed over the nose.

This is again the transmission and the rotor head area. Again, the rotor head swash plate area. Here is a man coming up -- Now, on this particular vehicle this door, which hinges closed after the landing gear is retracted, is designed as a step. He opens up the baggage compartment door and uses the bottom of the baggage compartment as a platform, and then he has easy access to the top of the vehicle.

Snap hooks up here remove this front portion; it slides forward and these lift up to allow accessibility to those portions. Each of these purposes is especially treated by non-slick material. We always think of maintenance in terms of mechanical, hydraulic or electronic. But in an executive aircraft, such as the 76, the human factors personnel must also be concerned with interior

maintenance. The carpeting, the seat covers, the floor mats and so forth that provide personnel with luxurious flight. All of this material must be selected for wearability, the capability of shedding dirt and the ease of cleaning. So all of these materials are selected by human factors personnel also so that it is easy to clean.

This is the executive version of the X-76. You're looking forward at the pilots' seats over here. These are executive seats, and then there is another row of seats over here. In the utility version there are three rows of seats in this aircraft, and it holds up to 12 people.

One of the problems we had in the utility version, it's used mostly to go out to oil rigs, and when a guy has gone out to an oil rig and he knows he's staying out there for several weeks on end and there's no liquor available, he tanks up before he gets on the aircraft. One of the problems we found with these kinds of people is that the floor became saturated on the way out. And we had to change the carpeting on the floor and go to plywood flooring in there to eliminate the odors that were developing as a result of people traveling back and forth to oil rigs. It got kind of messy for a while. But in the executive version we don't have that particular problem.

In summary then, the design for maintainability at Sikorsky Aircraft is accomplished through involvement by human factors engineers in all phases of design. In preliminary design they perform drawing reviews and component mock-ups.

In critical design reviews in the development of aircraft maintainability mockups. In training in the development of manuals and procedures. And in field tracking creating a user experience data file and a user manufacturer interface. Thank you very much for your attention.

MR. REESE: Our third speaker in this portion of the program will be Tom Wherry, Manager of Commercial Maintainability and Reliability for the Lockheed Company. His talk will be on communicating problems and method of correction to the mechanic.

MR. WHERRY: Thank you, Jack. As Jack told you, the subject of my talk is communicating problems and methods of correction to the ground crew. I'll talk briefly about the approach that was used on the basic L-1011, relative to fault isolation, some new subsystems that have been developed with the L-1011 and are

possible with digital equipment and also our firm fault isolation program we now have on the L-1011 and other wide bodies.

The aim in our organization for the L-1011 was a part of the engineering branch when the airplane was being designed and initially produced. The maintainability group was comprised mainly of ex-airline maintenance and engineering personnel. All the classic criteria for design and for maintainability were followed and monitored by the maintainability engineers.

Criteria such as accessibility, reduced complexity, modularization, testability, fault isolation, reduced potential for maintenance error, centralization of service areas were formalized in design directives. The types of fault isolation, the techniques and designs in the air frame were the schematic system control panels in the flight stations and service centers. We did have quantitative measurement devices. Of course, warning lights. Latching annunciators used in the avionics systems and pop-up filter indicators in the flight control system.

Zone indicators for overheat detectors. Built-in test panels and self-test features which were built into the functional systems themselves. This is a typical flight station control panel, this happens to be the electrical control panel on the L-1011 at the flight engineer station.

The layout is such that you have flow bars, a schematic kind of presentation with indicators and switch lights. Fault isolation devices were used extensively on the L-1011.

Primarily this slide shows the fault isolation monitoring of pinballs, as we call them, on the avionic system and the electrical test panel. We have self-test features in the UCS system, the electronic control unit, the prock system test and then the passenger oxygen system test.

The fault isolation capability on the later version of the L-1011 were drastically increased. For those systems using digital equipment, such as the ATA control system and the digital auto pilot. This is a picture of the ATA control system, fault isolation panel, which I'll talk more about later. And this is a picture of the fault isolation data-display system which is used in conjunction with the digital auto pilot.

On-board fault-isolation devices developed during the wide-body area, which we have referred to as digital equipment, were provided with digital

computer programs for continuous self tests. Provided digital storage identity of failed components. It provided means of storage of history of faults as to recall faults in flight on the flight data recall on the ground.

Digital computer programs for self testing on the ground. Computer accomplishment of FIRM diagram analysis and display of the fault code. This is the fault isolation reporting method and early devices have been considerably improved on later versions of the 1011.

This is a view of the ATA control system computer, two of which are installed on the L-1011. They are in the midelectrical service center, not accessible in flight. They do have a flight data recall button, a system component test and servos test button. The code display is up in the upper left-hand corner of the computer.

I have another diagram that indicates how the fault is incurred in flight. And these are the codes that are assigned to the various LRU's in the ATA control system. And this is the instruction sheet that comes along with the fault-isolation procedure. This is a view of the display. As indicating, we have a faulty impact sensor No. 3, and this has been found as part of the flight data recall on the ground. This is another flight data recall indication. This is another maintenance system that's installed on the later version of the L-1011.

This is an association with the digital auto flight control system, and it's what we call the FIDDS panel, it's Fault Isolation Data Display System. It's installed in the flight station at the flight engineer's panel. It's accessible in flight. In the design, many of the functions were combined with the digital flight data recorder, so many of these buttons do apply to the flight data recorder, but primarily I'll talk about the buttons that are associated with the maintenance features of the FIDDS, Fault Isolation Data Display System.

This system is currently installed on the airplanes having the digital auto pilots, which is Pan American and Air Canada, and I thank that Delta now has it also. The type of data that can be selected is documentary data, flight data recall, present status, non-land summary.

Documentary is primarily associated with the flight data recorder. It was decided that due to the additional size and complexity of the system, that it was beneficial that we do design a separate data display system primarily for maintainability and association of the flight data recorder. This slide indi-

cates the type data that can be shown if flight data recall is selected.

Airplane number, date, flight number, time of failure, position and specification of the failure. Active control system No. 2 failed and the failure was the left outboard aileron servo, which is another flight data recall indication.

Aircraft number, date, time, leg -- the active control system first fail light indicating a flight station, heading present conditions flap, switch box No. 1 failed. Up to 70 automatic flight control system and 30 active control system faults can be stored in the FIDDS computer.

Along with the development of the digital AFCS/FIDDS system and the active control system fault isolation panels, Lockheed has developed this FIRM-fault isolation-data collection scheme, which is now being used by other air transport carriers.

Primarily a data collection that's now covered spec-wise in the AT 100, and it's becoming a requirement on all new air transports. The FIRM method improves communication between the flight station and the ground; provides some maintenance with lead time since you can radio ahead when you have a fault; reduces fault isolation time; minimizes unjustified components removals. It is arranged so we have simplified diagrams logically sequenced, and it translates and inserts systems in concise codes and standardized reports. That's been a problem in the past. This is a slide showing the amount of data that's involved in a FIRM fault isolation program.

These two documents are the same. One is a loose-leaf document, this is a bound document. They are carried in the flight station. These are the documents that reflect the actions that have to be taken on the ground. They are extracts from the maintenance manual. This can be bound in one particular document, but in this case it makes ten volumes here.

FIRM manuals are available in two styles. A FIRM manual is carried in the flight station and used by the flight crew to establish a fault code, a code number which relates to a specific set of circumstances, an indication related to any aircraft system.

The code is radioed ahead to maintenance. By reference to the maintenance manual fault code index, maintenance can translate the code back to the symptom

observed in the aircraft. Various system components produce various certain systems that are faulty.

FIRM fault code diagrams identify the systems by asking questions about related switches and indications, in addition to oral warnings, odors, sounds and changes in aircraft performance are considered. The FIRM manual primarily consists of many pages of fault code diagrams, accompanying pages of log book entries. The two combined to form the copy of a FIRM document.

The flight crew performs some operating procedures, and after they perform the operating procedures they refer to the FIRM manual, when a series of questions are asked regarding the symptoms that occurred at the time of the fault and during the corrective action.

The answer to these questions results in the specific fault code which is then entered in the log book along with a corresponding log book record. The fault code should be relayed by radio to maintenance, where it will be used to plan maintenance actions prior to arrival of the aircraft.

Now, let's see how the FIRM fault code is used by maintenance. Each chapter in the maintenance manual repeats the FIRM fault code diagram. For direct maintenance of crew usage and also includes an index; a component locator; fault isolation diagrams; electrical schematics that may be required to support the fault diagnosis for each subchapter.

The FIRM section is followed by the fault code which may extend to several pages and is followed by a general explanation of how the fault codes are used in fault isolation procedures. This would be the fault codes, this would be the procedure and this would be the corrective action. Specific fault codes which detail the fault systems actually observed by the flight crew and the fault isolation diagram to be used.

These are all included in the fault isolation portion of the maintenance manual. The index is followed by the component locator referencing each component involved in the following diagrams both pictorially and by lists.

The list provides access information and maintenance-manual chapter number and references. Access area and maintenance manual. The actual fault isolation diagram itself is a series of numbered blocks which asks questions and requires certain observations or certain instructions. Each answer or observation is a

code by a flow arrow, leads to another block and progressively leads to isolating the cause of the fault.

This is my concluding slide. We feel that probably future developments would be the increased use of digital computers for in-flight conduct of system tests and analysis results. Increased capacity of digital faults detection and storage systems. And new systems for transmitting on request stored data on faults detected in flight, reducing progressively the need for flight crew involvement in the fault reporting process. And that concludes my speech. Thank you very much.

MR. REESE: That concludes our portion of the program. Joe, do you want to open up for questions?

MR. PONTECORVO: Is Terry going to put on a presentation?

MR. REESE: No.

MR. PONTECORVO: Then why don't we open it to questions. We've been asked by the cafeteria if we couldn't break a little earlier for lunch, so how about we'll go with questions until 12:00 or 12:15 and then we'll come back promptly after one hour.

MR. REESE: Well, I guess we'll open the floor to questions to any of the three speakers that we had.

QUESTION: I have one for Mr. Gaffney. He mentioned the hydraulic lines were coded and they were different-sized lines.

MR. REESE: Bill Gaffney.

MR. GAFFNEY: Yes.

MR. REESE: There's a question for you, can you come forward?

I'll ask the gentleman to repeat the question.

QUESTION: You said the hydraulic lines came in different sizes and were color-coded to prevent them from being crossed. Electrical wiring, you said, was color-coded. Is there any way of physically preventing, or are you planning any way, of physically preventing cross wiring?

MR. GAFFNEY: I'm not sure I know how to answer that question. The principal objective in color-coding the wire, again, is to maintain the isolation

among the electrical systems that we must have to meet the redundance requirement of the FAR 25 in its many aspects.

And what we are thinking to avoid there is some action which takes a red wire and just casually reroutes it through a green thumber, that's the thing that we are seeking to avoid. I don't know of any overt action that is being taken such that you would not be able to rework a connector to change the wires. That can be done, it's a matter of queuing everyone that bundles with this color designation should not be casually rerouted and stirred up with wires of a different color designation.

I don't know other than that. I probably evaded that question.

PARTICIPANT: What was the question?

MR. GAFFNEY: What overt action are we taking to prevent cross wiring? And I went through my explanation of the reason that we are color-coding the wire bundles, basically, to provide adequate separation between the electrical systems. Most generally to cater to things like turbine bursts -- I've forgotton the exact rule, but that sort of thing. That's really the principal objective. The issue of wires changing, that didn't have to do with it.

QUESTION: Bill, with respect to computerization of in-flight discrepancies, maintenance now has an obligation to clear all of the airworthiness items that are written in the log by the pilot before dispatching the aircraft. What are Boeing's thoughts relative to the need for clearing all of the discrepancies of an airworthiness nature that the computer may have compiled that the pilot was not aware of and did not enter in the log book?

MR. GAFFNEY: These should be few in number, I would believe, because the computer systems store fundamentally those pieces of information that come to the attention to the caution and warning system. The crew is also advised. This isn't a huge diagnostic device with nerve endings that go all over the airplane and monitor everything.

It's not that specific, at least at this point. I don't really -- I guess I don't know the answer to that question. I don't know.

QUESTION: In the L-1011 I think you'd have a flight-station indication of some sort first of all. Either in the caution/warning panel or in the control panel for the system that's involved. Then you go further into the

fault-isolation device to further find out what the problem actually is, so there's not a case of going in and doing a flight-data recall to find out where the problem is, you're already aware of the problem of some sort, it's to indicate the place of it.

MR. GAFFNEY: I don't know of a case where there could be a component failure that would not be announced in one way or another to the crew in the course of the flight but would be stored on this, because there has to be a catalyst of some kind to cause the maintenance folks to go talk to this thing.

Ordinarily you wouldn't go poke it up.

QUESTION: Would there be a ground supporting computer so you could dump the memory from your flight system or store it or work on it later for items you may not want to fix right now but you want to get to later on for recording keeping purposes?

MR. GAFFNEY: I can't answer that question. We went around and around in designing that thing, and it retains the information for some number of flights. I don't know how many, I don't recall. I just don't know whether there's a provision to extract that information, you would have to extract it on a date or by some means. I don't know of such a feature in that. It may be, but I don't know. I could find out.

QUESTION: I want to know what Boeing is going to do on their new aircraft or what they might do on the 747 nosegear handle to reach the handle or lower or raise the door?

MR. GAFFNEY: The question is: We've had at least one fatality on the 747, a case of an individual being caught in the nosegear doors. A typical scenario there is that the doors are open, and the ground safety handle gets restored to the flight position while the hydraulic system is depressurized, and someone then comes along and puts pressure on the airplane and the door goes closed.

The question is: What are we doing to preclude a recurrence of that problem? Now, if you think I'm stalling, it's because I am. We have some clever idea, I'm trying to think of what it was. I worked in the gear business on the 57 for a while. It's just a matter of making that ground door release handle very, very obvious and having the maintenance people aware of the fact that they're in jeopardy.

QUESTION: Like on a 747, it's up in the wheel well. Is there any -- Will the newer aircraft have a handle on the outside or maybe in a panel, or something like that, where you can watch the doors, look at the doors as you move the handle?

MR. GAFFNEY: I'm going to get myself in trouble if I'm not careful. The 47 is kind of a peculiar case. None of our other airplanes are like that, as I recall. All of them you reach through a small aperture in the vicinity of the gear. The 47, because of its size, is out of the way. Our objective is to have that handle sticking out so that you can see the thing very obviously from outside the wheel well. The gear doors, of course, are dangerous, but there are other places on the airplane that are a source of some hazard. For that matter, the flight controls, a fellow starts waving the rudder at you when you're in that vicinity and that gets pretty interesting too.

I guess I haven't given you a very satisfactory answer to that question. I can find out.

QUESTION: Was there any talk of redesigning the door handle?

MR. GAFFNEY: On the 747? I don't know of any. That doesn't mean that it wasn't done. The engineering organization at Boeing is such that we have a group that works on the 47 and 57 and 67, and I'm sort of a central organization, and I have people in all of these, but I don't, on a day-to-day basis, track all of these things. So I just don't know. I can find out and I will.

QUESTION: In answer to the previous question, whatever it is that's used that activates the hydraulic system in general, is the piece of gear which you use to perhaps chock up the wheel so that it fits into maybe a key which you have to turn to activate the hydraulics, would be the same key that you have to take out and take downstairs and stick up underneath your nose wheel, therefore nobody could come and have do. Nobody could come along and force somebody underneath. That seems a logical answer.

In the AT-11 being from England, nobody knows of it anyway, the chock that fits up underneath the wheel fits right by the side of the hydraulic system of the cabin so that there's a little flag on it so you can see when it's been taken out. You can see if there's anybody downstairs.

MR. GAFFNEY: We typically flag the hydraulics. You tend to get into trouble, and you get into trouble on the 47 pretty easily, because somebody

will put high pressure air into the high pressure manifold, and nobody necessarily connects that to causing the doors to close on the gear. I think there's a better connection between the electric pump and the fact that something may happen.

But that's been the source of some accidents on the 47, because people don't relate directly high pressure air in the starter duct to gear doors and that sort of thing. I'm afraid I haven't answered your question very well.

QUESTION: Talking about this new system of yours. You're saying that anything which is normally monitored is taken into this system. Now, somewhere somebody has decided that this particular pressure or indication is going to be monitored?

MR. GAFFNEY: Yes.

QUESTION: That's where the human error comes in. In that people are assuming where the fault is going to lie. And what you said subsequently, that the whole aircraft can't be served by nerves all over the place monitoring everything, you therefore have to decide what you're going to monitor.

Now, because it fails or it happened -- We don't expect things to fail, so I don't know how this is going to overcome the human factor. What's going to give you a much better monitoring system than you already have or the things that you already monitor? There's a limit to the size of computer you can get into an aircraft.

MR. GAFFNEY: There's no intent to monitor the entire aircraft at all. I'm not really sure that I understand what you're asking.

QUESTION: Mainly how much of the aircraft do you think you'll be able to monitor?

MR. GAFFNEY: Well, a relatively small amount, really. We hope to be able to track faults to the line replaceable unit level. I say hope, that's the design goal. We don't always achieve that. The design philosophy of the new airplanes has been to proceed on the basis that you really needn't do anything about various kinds of failures. If a hydraulic system quits, well it's nice to know about that, but it's really relatively unimportant. So there's no critical safety implication associated with immediate knowledge of that situation.

You go for a long, long time, and if you move the selector handle to the down position for the gear and it doesn't go anywhere, well you'll deduce that that hydraulic system has gone away. But the thrust of the design has been to have the airplane not require immediate attention.

As a matter of fact, really any in-flight attention or crew actions, those we prefer to defer until it gets on the ground.

ED: I don't have a question, but Tom Wherry mentioned the Spec 100. For those of you who are not aware, ATA Specification 100 is specifically for manufacturers' technical data. Back in the early 1950's, every manufacturer produced his own maintenance manual in his own way in his own format, and he came to the conclusion that there had to be some standardization in this area. So in 1956, ATA Spec 100 was first issued. This tells the manufacturer how to write a maintenance manual, how to write a testing manual, how to write a service manual.

And the bottom line for everything in Spec 100 is the mechanic, because the mechanic is the one that's going to end up having to use it. Spec 100 is a worldwide recognized document. It's developed by an ATA committee with assistance from the non-U.S. airlines. There is a European Spec 100 which works closely with our Spec 100 group.

There's an AIA Specification 100 that works with ours, but it is produced by ATA, it is issued by ATA. The people who are on that committee are airline people. Some of them former mechanics, some of them former engineers, but they all have the mechanic in the back of their mind.

This idea that Tom Wherry was talking about, that's a part of Spec 100, so that each time a mechanic picks up a manual from Boeing or picks up a manual from Lockheed or Douglas, or from whoever, it is in the same format, he can find the same thing in the same place in that manual as he can in any other manual.

And I just thought I would bring that out in connection with the presentation by those people here.

MR. PONTECORVO: Thank you, Ed. And I think this is a good time to point out that if anyone from the audience would like to make a comment, even if it's not necessarily related to one of the presentations, feel free do do so. All

of the comments from the floor don't have to be in the form of questions necessarily. Also we now have our microphone about two-thirds of the way back to help things a little bit and we'll pass it around as necessary. We'll make some changes to the agenda today as it's obviously necessary, but we have got the time and we have some extra time tomorrow afternoon. We may want to run up until 5:00 and if necessary we will do that.

So right after lunch we'll have Jim Rice and his panel come up here. And I want to thank Jack Reese and his panel very much for a very interesting presentation. I found it very interesting. And I think we'll break for lunch now and return promptly at 1:10.

MR. PONTECORVO: Okay, I'd like to get started. A few announcements first. One, there are going to be some folders put in the back by the Flight Safety Foundation concerning their next conference which will be in Atlanta, Georgia.

If you have any questions we have a representative here from the Flight Safety Foundation and he can answer any questions you may have. They'll put the brochures in the back.

Also, Dick Kost would like to make a quick announcement.

MR. KOST: This seems to be a good place to talk to maintenance people about maintenance people. Everybody is concerned about the increasing sophistication of aircraft and what type of maintenance an individual will have in coming years. There's also a lot of talk and discussing about splitting the A & P license into subcategories -- specialized categories, perhaps like the British system, perhaps like the Canadian system.

And this evening at the Hilton at Room 403, which is a meeting room, at 6:30 p.m. those individuals who are interested in discussing the pros and cons of specializing the A & P license into the air transport category, general aviation category, turbine category, whatever, we'd sure like to have you come over and give us your views. It probably won't be very long. The main purpose of the meeting this evening will be to identify you individuals who would be interested in working on a study or working towards a goal of either throwing out the entire concept, splitting the license -- I shouldn't say splitting the license, specializing it even more so than it is now.

Please come by if you have a point -- and if you are not in favor of it we'd like to hear that. If you are in favor of it, we'd like to hear that. At the Hilton, 6:30 this evening, Room 403. A know that's going to conflict with the hospitality hour a little bit, but at least come by and leave your name and address where we can get in touch with you.

MR. PONTECORVO: I'd now like to introduce the monitor of the next panel, Mr. Jim Rice, who is the executive secretary/treasurer of the Aviation Technicians Education Council, abbreviated ATEC. Jim is also president of A & J Enterprises which are contracted to the Houston Community College in the Houston School District training A & P mechanics.

And now I'll just turn it over to Jim.

MR. RICE: I appreciate the opportunity to come here and talk today. I'm representing the Aviation Technicians Education Council. For those of you who are not familiar with it, I'm not a pitch man for the organization, but this is an association of mechanics schools that's been in existence about 20 years. It's been largely a fraternal organization. We have associate members, the manufacturers, the airlines, the operators. And I brought some material, I'll put it back after the meeting, or after this session. And I didn't bring enough. If you don't get one of them, the lady in the green back there is my wife and if you will give her your name and address we'll make sure you get something on it. I appreciate the opportunity to come here to talk today, particularly on this topic of training. I've been in and out of the aviation business for about 30 years with Lockheed, Continental, Braniff, the old Midcontinent Airlines.

I went to Houston involved in the NASA project and wound up as an operator of a certificated mechanics' school. I've been doing this about 10 years down there. I've watched this aviation maintenance move for the last 10 years and I've been pleased with the way it's going, and I'd like to see it go further.

On this panel we have three other speakers and myself. I'll talk briefly on professionalism. We have Phil Kulp, who will follow me on FAR 147, the mechanic school regulation. We have Barry Strauch, who will talk on testing, and we have Jim Graham from the military, who will give a military position.

We'll try to keep it moving. My talk basically centers around the topic of professionalism, which is one of the key issues I feel we, as educators, face in the aviation maintenance training today. This paper that I'm presenting is an extract of a speech I gave to the local GATO FAA symposium in our area last year. Each March the senior A & P's have their inspection authorizations renewed. The local GATO asked me to present a talk on professionalism.

What I'm saying today is what I believe we must do to further develop this skill of aviation maintenance. To begin with, what does professionalism mean?

If you look in the dictionary it states: "Having an assured competence in a field or occupation" or "Having a great skill or experience in a particular field or activity."

This is the way that the dictionary defines it. To me, professionalism is really a state of mind. It's an approach. It's a way of looking at whatever your're doing. It's viewing the task through the eyes of one who has this assured competence in a field or occupation and is willing to use this great skill or experience.

It is a desire to do the job and to do it right. It's pride in having this assurance in your own ability. It is the craftsmanship of old.

With this concept in mind, professionalism, as we know it, must be transmitted to the new people who are entering the aviation maintenance field. In addition, we must find a way to recycle, retrain and further develop people already in the field via some form of in-service training. If you look at this business of aviation that all of us are involved in today, this concept of professionalism has been with us from the beginning.

A while back I read a book Kill Devil Hill by Harry Cohens of Learjet. This is a well researched book about the Wright Brothers. It paints an excellent picture of two brothers who approached the problem or task of air flight in a professional manner. Wilbur and Orville were not just a pair of bicycle mechanics who somehow stumbled into flight; they were real professionals.

One of the first steps that Wilbur took as he looked at the problem of flight was to write a letter to the Smithsonian Institute. In that letter were some words of his that have stuck in my mind. They were "I wish to avail myself of all that is known about the theory of flight."

To me, this is the first step in a professional approach, and it typifies what a real professional does at the beginning of a task. He proceeds with the confidence in his own ability but in addition he searches out all that is already known about the problem.

Another step in the professional approach is to identify, define and outline completely the problem you're attacking. The professional looks at each of the problems associated with whatever has to be done; it has a combination of many parts. He approaches each one in turn to finally achieve the successful, completed task. The true professional identifies problems, sorts, subidentifies each of the components and over a period of time develops the solution. The professional doesn't slam things together. He follows an orderly, logical, thoughtful path until he gets the right answer.

If you remember, the Wright brothers went back to Kitty Hawk for four years before they obtained the results they were seeking. Research, problem identification and logical process are the essence of professionalism.

I wish we had the time to review some of the examples of professionalism that went before us in this field. Lindbergh, the Wright brothers, the professional military aviators, the maintenance foundation, ATEC, people like Kelly Johnson out at Lockheed.

There's a whole host of examples of professionalism that have occurred in this field of ours. To move on, let's now relate professionalism to the training of aviation maintenance personnel as it exists today.

I am personally convinced that we have a situation here that has some parallel to the controller problem that existed back in '55. If you remember, prior to the collision of that Constellation and DC-6 -- I don't know if it was a 6 or 7 - over Grand Canyon, air traffic control personnel were in the GS-4, GS-5 level jobs, essentially subprofessional.

After the collision the jobs were re-evaluated and the element of independent judgment readily identified the controllers' job as a true professional. This judgment factor is evident in the A & P job. We have a major job design problem here in the A & P task. I'm not a proponent of breaking up the historic air frame and power plant or air plane and engine mechanic's job, I think it has served us well. I think there's an on-going requirement for an airworthiness specialist or representative who ultimately signs off the vehicle for flight.

But I think we have to take that task or job and design it for the field as the demands present themselves in terms of the hardware. The job has historically been a broad-based vocational one requiring skills in sheet metal, electrical, hydraulic, painting, fabric and assembly and rigging of aircraft.

The job content is very, very heavy. It's difficult for educators to attempt to give a base in a 2,000 hour or 1,900 hour curriculum that we have today. And yet it is evident that we need some additional training in the field in terms of strength of materials, additional electrical and electronic training, more rotary wing, more turbine engine and more exposure to the new composite structural materials.

How do you give this background in welding and fabric working along with the new material and do it in the same envelope that you're allocated? On the other side of the coin, a number of the schools, as Dick mentioned, are meeting tonight with the Aviation Maintenance Foundation people to look at the rationale of specializing or breaking up the historic A & P assignment. Specialists' jobs would ease the training task.

I would like to talk a lot further on this, but my time is limited, and I want to move it. I have more to say on the problems surrounding this job design. Up to this point, I've identified some problems; the next logical question is what can we in the aviation maintenance training activity do to solve these problems?

I feel there are three or four steps, at least initial steps involved. First of all, the schools must set the stage for professionalism on the part of the entry applicant into the field. Every three months when we enroll new students, one of my lines during the orientation is that if you want to turn nuts and bolts I strongly urge you to transfer to the automotive program down at the college. We intend to teach you a theoretical approach for air frame and powerplant mechanics. We want you to perform aviation maintenance in a professional manner, to get it right the first time because there isn't a second time in the aviation business.

The school's primary responsibility is to teach this professionalism as the people enter the fields. There's a parallel responsibility on the part of the aviation maintenance operators to insure that the people in the field continue to get in-service training and approach their maintenance jobs in a professional manner. The airlines, manufacturers and maintenance shops have the responsibility to keep their people current, to get them to the schools on the new aircraft, to keep them abreast of the new technology that is emerging.

There's no point in giving a man an A & P license with a base-line knowledge and let him go into the field and stagnate. These people should be sent to the manufacturers' schools. They should be sent to maintenance conferences. I know the training is costly but the operator should charge rates for their work, shop rates that will permit this.

The words "the budget doesn't permit" are, in my opinion, a cop out. There's nothing more irritating to me to pay $45 an hour for maintenance on an

$800 to $1,000 typewriter and at the same time see our shop in the field maintaining multimillion dollar vehicles at a lower shop rate.

The third area of effort in fostering this professionalism lies with the FAA. The agency has a definite responsibility to continue to develop this curriculum. I understand the philosophy of wanting to keep the historic fabric work, wood and welder. In Alaska last year we saw the wooden fabric airplanes still flying, but something has to be sacrificed to keep up with the new.

Pressure carburetors and radial engines that we are teaching in the schools today are largely gone, and yet our testing techniques focus on this. We're teaching an engine curriculum that's weighted four-fifths piston and one-fifth turbine. It's antiquated.

The FAA has a responsibility to restudy this curriculum, initiate the restudy and make it current. Phil Kulp of Embry Riddle will talk some more on this. Dr. Alan in his study initiated in 1966, commented on a revision to the regulation in '70 and recertification of all mechanic schools in '72.

It was a key move in terms of professionalism. Curriculum moved from nothing to the first step, but the problem is that the Dr. Alan study is now 15 years old and we must find a way of upgrading the currency of that curriculum.

As I've said before, the Aviation Technicians Education Council that I represent is an association of the mechanics schools, the airlines, the manufacturers. At our last four or five annual meetings, we have talked with the agency on the upgrading of 147. There's a lot of work involved for the agency and for the schools. It's much easier for the school operators to run the thing in a static load, but that does not give us the right end product.

These are some of the problems I see from a training standpoint. I think it's going to require a joint effort on the part of the schools, the operators and the agencies ot continue to develop this field in a professional manner.

To summarize, it is important for you and for me to look at what we can do for the aviation business profession today. I said at the beginning of this talk that professionalism is a state of mind. I firmly believe this.

I believe that professionalism involves looking at what you're doing, taking stock in yourself and saying I'm a competent whatever, I know what I'm

doing, I know how to do it, and I'm going to do it right.

What's more, I'm going to return something to the industry that has helped me make a living. It means being able to stand back from your day-to-day operations and make a contribution in addition to fixing this airplane or whatever.

It's seeing that professionalism is further in this field that we love. Professionalism is making a commitment. It's saying to yourself I know enough about what I'm doing that I don't have to worry about Joe Blow in the next hangar or the next office who's going to take business from me or get this job that I want.

It means I'm going to take that extra step; I'm going to see that this profession is fairly treated by the rest of the world. As professionals, we need to continue to enlarge our view and look beyond today's job or of the existing curriculum or the maintenance work we're doing. In the next study of the aviation maintenance school curriculum, which I think is due now, we should look at things that should be done in the field, not just what the task analysis is or what's being done out there now. We need to go upstream and do this job design, what we want done.

And then we need to build a curriculum based on what we find and the frequency of occurrence. I'm not a Biblical scholar, but in the book of Ecclesiastes there are lines about a time to live and a time to die and a time to grow, et cetera.

To me, these lines fit here. There was a time when the aircraft mechanic was just plain old Joe, the forgotten man. The times have changed, the vehicles have changed, the profession has changed. It's grown up. It's time for the old-time mechanic and for you and for me to accept this reality and to adjust accordingly.

Thank you. Phil Kulp will give you some words now on 147.

MR. KULP: My name is Phil Kulp, I'm a research associate with Embry Riddle Aeronautical University, and my field is Curriculum Development. The purpose of this presentation is to address certain areas in the certification and training of the FAR 147 technicians. One of the things that have to happen in the process of moving goods and people from one port to another is the airworthiness of the vehicle providing that transportation. This airworthiness

is maintained by technicians who are for the most part trained in the nation's FAA FAR 147 training schools.

Historically, this training and certification have kept pace with the industry. Due to (1) a steady pace of early technology, and (2) adequate FAA resources to maintain the integrity of the program.

The purpose of the FAA control is to insure that the skills and the knowledge reflect current efforts in those areas. A major effort, as the gentleman mentioned earlier, was conducted in 1965 through 1970 for a skills and technology alignment.

This was the Alan Report, or a national study of the aviation mechanics occupation. Since that time there have been several items that have all impacted on the maintenance technologist. All things happening in the aviation industry do affect the technician. Some of these are integral and internal forces that act upon the aviation industry.

The area of electronics, for instance. Some of the presentations this morning mentioned some of the new items that are happening in electronics. The question that immediately comes out is who is going to fix these things, that's generally the aviation technologist. The flight management systems, the new 757's, 767's are an example of technology or technical solution to manpower and efficiency problems. Composites are more readily being used, for example, the Lear fan, 727 component parts, and the military is heavily involved in composite construction.

The area of advanced engine technology with the push for fuel economies, more turbo charging of reciprocating engines, and we see the resurgence of propellers and turbo props phasing in and out of the industry, and it's again popular.

As a result of these advances, we end up with a larger number of more complex aircraft wtihin the aircraft fleet. And this rate of technology growth is a real problem for the schools in keeping up with technology.

The next area is regulatory. All sorts of items fall into this area. First of all the area of deregulation or reregulation has seen more new air carriers. Due to reregulations we've seen some FAA manpower situations that have changed. All of this means the FAA manpower situation means less correct FAA supervision in many areas.

The implication is that the aviation industry and the schools must bear more responsibility for maintenance of aircraft safety. And as a result, the technician himself has a greater responsibility and a greater role for maintenance safety. The next factor that we talk about has to do with economics, and this is a large area. One result of the reregulation is increased competition for the air transportation dollar.

Associated with these items are more feeder airlines, cub airports. All these things represent industry economic activity. Increased aircraft operations cost, the biggest ones here, as example, are fuel and personnel.

And there is an increased growing need to reduce overhead. With the results, there is an increased need for the aircraft-maintenance technician to play a role in the economy of aviation related operations.

Another result is that there's an increased need for the aircraft operators to control the cost of subsequent maintenance training. Subsequent maintenance training has to do with the amount of training that takes place after the mechanic is certified and also includes OJT training.

As a result, all of these factors interrelate and impact on each other. For example, the technology and economic interrelationship has to do with subsequent training. This gap is growing wider due to the rate of technology growth and the inflexibility of the present FAR 147 school curriculum, and this is at a time of increased economic pressures.

An economic and technical example is in the area of a push to reduce manpower with more complex technology. For example, some of the advanced maintenance systems with the self-analyzation items that we talked about this morning, and features. This still adds to the complexity problem who's going to fix these things. An example of the economic and regulatory interrelationship, we can see the FAA cutbacks. The technical regulatory area, where technology impacting on regulation has to do with certain things here are transponders, collision avoidance systems; these sorts of things have emerged.

We can even point to the struggle that involves regulation being used to control technology. Two-man, three-man crew. A-CAS, B-CAS, these different ideas. With the result that the aviation maintenance technician has taken on a greater responsibility for safety. He has a greater role in the economic picture in the aviation industry, and he has a greater need to maintain technical competence.

Given that these things are true, how and how well is FAR 147 meeting the growing requirements of the aviation industry maintenance technicians? The contemporary FAR 147 maintenance curriculum is dated and is pre-'60's for the most part at best. But more importantly, or more unfortunately, it is rigid and very inflexible in its incorporation of new technology.

It is unable to readily reflect the emerging role of the aviation technician. Again, we arrived to this point as to what is needed. As we see it, the important steps to be taken at this point are: (1) To grade the present curriculum to reflect recurrent technology and the technology that is developing into the future. (2) We need to systematically determine the role of the aviation maintenance technician in insuring aircraft airworthiness. (3) We need to develop a process to regularly and easily incorporate changes in the FAR 147 curriculum. And this is a result of the rate of technology growth. (4) We need to redesign and address the FAA testing and certification process to more closely reflect the emerging role of the aviation maintenance technician, which Dr. Strauch will elaborate on in a minute. To meet the challenges of the '80's and the '90's, the aviation maintenance technicians curriculum should teach current technology as well as the skills to master the new technology.

Train the A&P's in the real world decision making regarding the maintenance processes, and to develop the skills that are required to take on the major responsibility that will be required to insure aircraft airworthiness.

In conclusion, Embry Riddle Aeronautical University, due to the importance of this subject, is currently in the process of determining an industry-wide information gathering exercise and strongly recommends a major FAA involvement to insure that the technicians of the future will be able to meet the challenges of the future. Thank you.

And with that, I would like to introduce Dr. Barry Strauch, also with the Aviation Research Center of Embry-Riddle, who will address the subject of FAA testing.

DR. STRAUCH: My topic today is on testing considerations in aviation for aviation-maintenance technicians. And I'd like to give you a background to what we've been talking about today. Let me do that by talking about myself.

My background is in educational psychology, and my formal training is in that area and in the specific topic of testing measurement. In the last few

years I've felt an interest in aviation from the pilot's viewpoint, and I've been with Embry-Riddle for the last few months.

As a pilot, I've taken enough FAA written examinations to become concerned about what the examinations were doing, what they were testing and the effect they had on what students were learning in preparation for those examinations.

And in working at the Aviation Research Center at Embry-Riddle, I've a knowledge of certification in its relationship to the aviation maintenance technician. And I have several concerns which I'd like to talk about from the perspective of the effect they have on the work.

First of all, let me say I'm not against certification by any means. I think certification is quite important for a skilled profession such as aviation maintenance.

Certification assures that a basic amount of education is learned, and it is probably the best method of doing that. And it requires an assurance that a basic skill competency is mastered before we allow professionals to enter the field. My topic today is about a specific area of certification, and that is written testing. And, of course, the goal of all certifications is this right here, to get graduates into the industry.

We all hope that our students will reach that point. Written testing also has its advantages. First and foremost it's relatively inexpensive, and that's why those of us in the education field give written tests so often, particularly on a large scale such as the FAA does. It's relatively inexpensive.

Written testing assures that a basic level of mastery of factual material is encountered. Written testing also influences the level and extent of that learning. Written testing also affects the quality and context of material that is to be mastered. So written testing has its advantages, and it also has its side effects that we may not think about.

And here is a picture of people taking a test, I believe. What does written testing do? Well, I'm sure those of you who have taught in a classroom are familiar with this. I know I, myself, in teaching at Embry-Riddle, teach a course in advanced psychology. And every once in a while I get off the topic, and I get into something that I think is quite interesting but not related to what's being covered in class. And as I see my students busily taking notes, I see they're not really interested in what I'm saying for its effect so much as what rela-

tionship it will have on the test. I have to say to them before they will evidence the slightest bit of interest in what I'm saying that no, it's not going to be on the test. As soon as I say that, they all put their pens down and start listening to what I'm saying.

So those of us who are in testing are familiar with the phenomena that students, when they know what will be on the test and when they know how the questions will be worded, will study primarily what they need to prepare for the test and to pass the test.

Secondly, when students are familiar with the format of the test, they will learn to study for the test in such a way they will get the right answer as they perceive the answer to be right, not so much what good for the advancement of knowledge so much as what they need to get the right answer on the test.

Well, what happens after the test? As we all know, students tend to forget pretty quickly what's on the test about a day or two after the test. Well, the FAA written test, and this goes for pilots as well as aviation maintenance technicians, contain mostly factual information. They ask the students to basically tell the tester, tell the examiner, what it is they learned, what it is they memorized beforehand.

Well, what is wrong with that you might ask? Well, as Phil and Jim Rice said earlier, we are encountering a technology that is rapidly advancing, and when the test asks questions that are primarily recall and recall of factual material, very often the factual material that is on the test is outdated or irrelevant. Research and psychology tends to support that.

Tests of factual information tend to cover the kind of information that is forgotten first by students. As soon as the test is over, students have a fairly low recall of what it is they were tested on.

And more importantly, for aviation maintenance technicians, tests of factual information do not test the ability of those maintenance technicians to apply that knowledge to new and novel situations. And we've seen this morning highly knowable technology that will be in the market place and is being implemented right now.

And to illustrate the type of questions that I'm talking about, I've got these questions from the written test guide that's AC-65-22. And these are

questions of factual information almost entirely. The student really doesn't have to understand these so much to get the right answer, just memorize it.

And with the test being published today, this becomes an even more serious consideration from the testing viewpoint. Here's another question, straight memory. And one more. Well, the question is: Can we do better? And needless to say, the answer is: Of course we can do better.

Now, one theorist by the name of Gagne who's at Florida State University, an education theorist, has outlined what he calls the learning hierarchy that shows learning is basically a continuum of knowledge and of skills where the lowest skill is learning factual information, what he calls verbal learning.

And as one progresses up that hierarchy, the learner manipulates, masters that information to higher and higher levels, to the highest level of what he calls problem solving, which is the application of previously learned material or knowledge to a completely novel situation.

And my question here is: Why can't the FAA in the written test ask questions more from the higher end of the hierarchy, the problem solving end, than from the lower end, what Gagne calls the verbal learning or the learning of factual information?

And I've also brought some pictures of students learning A&P skills. We can see pictures of students applying them in the labs. And finally my favorite picture is your typical air frame power plant student at Embry Riddle preparing for her written examination.

Well, unlike tests of factual information, tests of problem solving ability require comprehension of that knowledge. Not mere memory of that knowledge. It requires the mastery of skills, and these skills are just the types of skills that tend to remain the longest after the test is administered. It tests ability that can be easily applied to novel situations, so that when new technology is implemented in the aircraft industry, the information that students learned and students were tested on, which can become quickly irrelevant if they are being tested on skills, those skills can still be applied to novel situations. And given the situation today where all the current copies of FAA tests are published and available to students, the fact that information is available does not denigrate from what is called psychometric quality or the educational quality of those tests because the skills are still in variant.

The skills of applying that knowledge to new situations remain the same, and students cannot merely memorize information to perform well on the test.

They must master basic skills. Well, to show you that indeed the same kind of skills can be asked within the current testing environment, which is the large-scale administration of written tests, with the help of Phil Kulp and some others I've developed questions to illustrate just what I've been talking about.

This question illustrates the application of a fairly typical situation in the aircraft field. Where the path of action taken by the aviation maintenance technician is described to the tester, to the examinee, and the examinee must decide whether the action taken by the aviation maintenance technician was appropriate, inappropriate or neutral.

In this case, you could have four -- We generally have four or five choices. The FAA has four choices. The asterisk there should indicate what the right answer is, but unfortunately there are two answers. The asterisk -- Only I think, C is the correct one.

Now, if as typically occurs the aircraft is brought back, that action is explained to the student and the student must again make the decision and duplicate what the aviation maintenance technician -- decide whether that action taken by the aviation maintenance technician was correct.

The student must parallel the thoughts taken by the A&P in the field. Okay, that's one type of question. Another type is we have developed a mythical technology called the BPMS, the Brake Pressure Monitoring System. And here we describe not so much what the technology is but what it does. It describes it to the examinee and the examiner from that, given a new situation, the examinee must decide based on the information he or she has on what that technology does, whether the technology is appropriate, whether something is wrong with the technology or whether something else has occurred.

And these are fairly real-life illustrations of a hypothetical technology. And in this case we are saying choice A is the correct choice. And this time we also ask the examinee to make a sequential judgment here that something should be done first even before the person goes in there and starts fixing things, and that is just wait and take a look and try to study the problem.

And finally, a third type of choice, and this is the type of question that's

given to technicians taking certification; here what happens in a simple situation is described. Cessna 172 will not start, and a series of choices is given to the aviation maintenance technician or the examinee. The choices are either good, bad or neutral. And the student doesn't really know whether the choice that was taken is good or bad until the student gets to the very end. That is, if the student takes choice A, in terms of the starter motor engages, then he's given some more information and from there must again make a decision, do something, do nothing or learn more about the situation.

Well, in this case we've said that the student selects choice B, in that case he goes and answers question no. 5. Question no. 5: The ignition switch is removed and the engine still doesn't start. What does he do now? As you can see, a higher level of skills is being tested than just recall of factual information.

Well, given what we know about the types of tests that are being given to the examinees, in this case the FAA written tests, they have a direct relationship on how these students learn for the tests, how they prepare for these tests and what they retain after these tests are given.

Given the fact that we know a higher order of tests can be easily written to test more complex skills, it appears to me and to those of us working in this area it's fairly clear that the tests of one must be upgraded. If for no other reason than to upgrade it is to reflect the new technology, much of which we saw this morning.

It is clear also that the questions should be revised to incorporate to a far greater extent the ability to comprehend the material and not just recall that material. It is also apparent that the tests must include as much as possible.

Questions of problem solving. The abilities that fall at the higher end of the learning hierarchy as opposed to skills such as recalling factual information on the lower end. And finally, given that we saw in Phil Kulp's presentation, that there is a new emerging role in the aviation maintenance technician. One making major decisions, in relation to that effect even the profitability of the corporation.

It is clear that the tests must be rewritten to reflect that emerging role of the aviation technician. Thank you very much, that is my presentation. And

I'd like to give the floor now to Major Jim Graham, who is Chief of the Manpower and Personnel for the long range planning of the United States Air Force, and he will talk about training projections, maintenance manpower, a look ahead to the maintenance profession.

MAJOR GRAHAM: Okay. Can everybody hear? My job in the Air Force, basically today, is to look out five, ten, fifteen, twenty years, if possible, mainly in the long-range, ten years or longer, and try to come to whatever conclusion that we can as to how things will be at that time. I do a lot of work with GAMA and some work with the AIA in looking ahead.

And in fact, lately in the last two or three months we've been consulting with them quite a bit. What I'm going to show you today is not quite so much military information but a look at your own industry. It may be right, it may be wrong, but hopefully it will force you to think a little bit.

As you know, there's a lot of controversy right now. I've seen several articles written that says there's no shortage of A&P mechanics in this country. And then if you talk to brother Kost and some other people, they'll tell you there's going to be a shortage of up to 80,000 in the next five years. Are you still saying that?

MR. KOST: In that neighborhood.

MAJOR GRAHAM: So this is my attempt to give you a position. By the way, I had a two star that was rather insistent last week and this week that I devote my full time to a couple of his projects. I had about 30 minutes to put this together. I didn't bring any paper copies with me. If you're interested in a copy of what I have to say, I'll put this chart up at the end again, my address is on the bottom. Here's what we'll talk about, and I'll go quickly, so please read the slides.

I'm accused of pulling slides before people have a chance to look at them. Sometimes it's for my own health. Okay. We know aviation is tremendously affected by the economy. Some of the airlines are doing well today, some are doing very poorly, some are about to go belly up.

Single engine manufacturers have dropped out of the market in general aviation, yet on the other hand other people are doing pretty well. Just about everybody in the business uses the FAA's aviation forecast in the air-frame projections that are diffused every fall of the forecasting conference.

So if the projections are wrong, a lot of what I'm going to say to you today is wrong. The first thing I want to talk about is demographics in this country. In 1992 the male and female population will decline about 22 or 23 percent. You already have seen it in the grade schools, it's going through the high schools and into the colleges right now. High school graduates will be down; college enrollments will be down. Minorities are increasing. The population of Mexico City by the 1990's will be 38 million people. There are no jobs there now.

President Reagan has already talked about opening the borders of Mexico, partially, probably, as an agreement to get some of the petroleum products down there. However, at the same time the young people are declining, the 24 to 44-age group will increase half again in size. So what I'm saying there, I guess, is today's managers and tomorrow's managers are largely in place.

As the younger generation comes along, there's a great need for some of their skills at the entry level, because most of the management positions are already filled. The median age in the country can go up substantially by the year 2000. If we take a look at it from a military standpoint, from your standpoint, in strength the services have declined steadily since the Vietnam drawdown.

At the top of that chart you see the decline of the cohorts. There will be a 25 percent decline in males, by the way. Four structural levels today are at the lowest they have been since pre-Korean War days. There are about 2 million people in the Service, it takes 400,000 recruits a year to maintain that force at pre-Korean War levels.

Strength of all the Services is projected to go up. The Navy is to increase from 450 to 600 ships. The Army wants to flush out a couple of divisions. And a lot of people have plans for us to increase by several wings and will become quite involved in the space program. So our in-strength will actually go up here. All these things occur at the same time the traditional cohorts, these 17 to 19-year olds from which we had traditionally recruited, are going to be in a state of decline. Very interesting things are coming down the road.

If you combine all the bad news that I've talked about before, this is a chart by Walter Muller from George Washington University who's a contractor to the Navy. He says flatly given all the information on immigrants and the de-

cline, the Navy will not be able to get the numbers of recruits that they need to man the high tech systems up through the 1990's.

That, of course, has implications for you as well. As we look at the demographics of the male population, up to 1992 there's a pretty much steady decline, and then a baby boomlet begins to come along. Of course, those influences are way downstream, so there's going to be some interesting times to say the least. Now, I do a lot of looks at a lot of different industries, and I want to show you some parallels with what I'm going to tell you about your industry.

Why do I have electronics' technicians? They are interchangeable, virtually, with avionics technicians. Eight percent of the industry, 671 out of 8500 companies were surveyed by the AEA, American Electronics Association.

Just those 600 some companies want 140,000 new technicians in 1985. They plan to double their recruiting from us. Dr. Hamlin at the University of Missouri says that we're far short on computer programmers. That has implications, of course, for industry and for everyone else. If you look at machinists and tool and die makers, we're not even making replacement levels we need. About 25,000 apprentices a year are entering the programs, but we're only getting about 5,000 a year. And the manufacturers continue to produce the new systems.

We look at engineers for a moment. Engineers are only 7 percent of college graduates in this country, yet they get 63 percent of the total job offers. That gives you some idea of the demand in those areas.

You look at Massachusetts electrical engineers. Reportedly on the West Coast, a little more than a year ago, Hughes alone was supposedly short about 2,000 electrical engineers. I talked to a friend of mine who's on one of the AIA panels I'm on and said, "Is that really true?" And he said, "No, but it was over 1,000."

There are serious shortages. What's been happening? Just a few degree trends here to give you a random sample. The top line there, the dash line is MBA degrees. In 1960 we produced 4,000 MBA's. The 1980 total of MBA's is about 55,000. Look how many law degrees we have. We have 300,000 practicing lawyers in this country. Japan has half our population and one-twentieth of the lawyers that we do.

In 1977 they produced 37 percent more electrical engineers than the United States did. And look at the arrow. Aeronautical engineering output has declined 41 percent since 1970. The word is out, aerospace is not the place to go because of the varying economics. This is one of Dick Kost's charts. Basically, I guess, what it says is more pilots, more airplanes, less mechanics.

I'm sure productivity and technology have had something to do with that. But it's also a disturbing trend in light some some things we'll talk about as we go along. In order to save time, this is a new chart I've put together just to summarize quickly. The average age last fall of all mechanics ever certified by the FAA was 58. So almost 60 percent are unaccounted for, the FAA doesn't keep track of everyone they should know of.

About 45,000 people at the airlines, the average varies from 42 and 55 at various companies. In general aviation the average age is quite a bit lower because that's always been the traditional entry level. Of course, nobody really knows a whole lot about avionics technicians, they're not certified, no one keeps track of them, they're sort of interchangeable with the electronics industry.

It's hard to say how many of them are out there. In '76, one of the schools in Ozark, Alabama, did a survey and they found there were almost three jobs for every avionics graduate.

Spartan on our GAMA survey this spring said they had about 12 to 14 job offers per avionics graduate. Of course, those were not all in aviation. It's an interesting trend if it's accurate at all.

But at the same time we talk about that, let's look at ATA member mechanics. And I just added the bottom line for '80. You can tell '80 was not a good year for the airlines.

Of course, again, this is the truck airlines and there's an interesting phenomena here you have to remember. There are 3700 airline pilots furloughed right now. Some airlines are hiring pilots. We have a lot of mechanics furloughed, obviously, but some airlines are hiring mechanics. Some airlines are preparing to hire substantially more mechanics. So this chart is a little misleading, but it does reflect history at the moment.

We look at airline, aircraft and service, and what's projected? Not much of an increase, but a moderate increase. We look at traffic projections, and

for revenue passenger and mile enplanements.

All scheduled up, the airlines are about 12 percent below that actually for 1980. Let's look at general aviation for a minute. An awful lot of these general aviation airplanes are virtually inactive. You can almost draw a line there, I think, at about the 1,000 mark, a straight line. You get some idea of what's going to happen there. What kind of systems are coming in? Much more sophisticated systems, turbines, turbo props, much more sophisticated aviation and much greater maintenance requirements for a lot of the older airplanes.

Again commuter traffic, one of the big areas of growth. Our man from Sikorsky left. There's a tremendous growth projected in the helicopter business. Last year in this country, military, foreign and domestic production totaled 1700, it's supposed to average about 2900 units a year through the 1980's.

A big requirement for people to build those machines, to maintain them and to fly them. This chart scares the Navy and the Army to death when I show it to them. If you look just at the projections of new oil platforms off our Coast, you get some idea of what's going to happen in the helicopter business.

And, of course, the petroleum industry has money to buy those machines too. There is some foreign opportunity. McDonnell Douglas is going into Saudi Arabia with the F-15. It scares us a little bit, because they have to maintain that airplane. They have to take about 800 technicians with them to do that. I understand about 400 have to come from outside the company. Where in the world today do you get F-15 experienced technicians? I'm only aware of one place. Some of the job offers aren't too bad, if you're not familiar with the Mid East lifestyle. This was from an ad almost two years ago. They also recruited pretty heavily outside some of our bases and got some flight engineers and other people. About a salary in the high 20's, free schooling, free housing, free vacation.

I'm sure you're all familiar with the enticements offered in the Mid East, if you can stand that life style. Look at industry for a minute.

Aerospace industry, despite its problems, is literally booming during a recession. Building a lot of airliners, general aviation has been going along, defense spending is to go up, and of course, there's still a significant export market.

As a matter of fact, one of the best American exports is in aerospace. The major manufacturer employee force is growing old as well, getting up near the age of 50 in a lot of cases. At one aircraft plant which I toured recently, they've increased their production worker employment by 65 percent just since 1977.

The Bureau of Labor Statistics says there's a tight labor market now. Overtime pay has been high and the quit rate is the highest they have ever seen, which means a lot of turmoil and transfer through the industry.

For a while anyway at Embry Riddle, despite the engineering shortages, the A&P's were getting more job offers. This is kind of a crude chart and I apologize for it, but it's still a working slide. Look what happened in the last recession, aircraft manufacturing employment went down. Look what's happened this time, it's gone up.

The blue line which is the only one I want you to pay any attention to on there is avionic technicians, our avionic technicians. Look how much lower their reenlistment rate is than other reenlistment rates in the maintenance area. Is that due to the economic conditions, demand, or is that due to what we do to them in the Service? Probably a little bit of both.

Here's some information from our GAMA survey which I thought might be of some interest to you. Only 23 of the GAMA companies responded to this survey out of 34, which unfortunately is a sign of the times too. Most of the people do hire from the military and are reasonably satisfied. And, of course, at the bottom: Do you use instructors? The answer is: Yes, yes, yes. I looked at Air Transport World last week, and I did not see a single airline that didn't have maintenance instructors employed. Look at where GAMA companies recruit.

Significant portions of the schools from the military, but more signficantly a lot of people from other companies, that turnover we talked about. It's kind of interesting. You're doing it to yourselves. The same thing here, where do they go? To other GAMA companies that paid more; to the airlines; and to the big aircraft companies which definitely pay more; and to the electronics industry. And you saw that chart on what the electronics industry is planning to do in the next few years.

Okay, let's look at the schools for a minute. There are 141 now or are we back to 142?

ANSWER: 146.

MAJOR GRAHAM: Oh, up to 6? There's some I haven't even heard about then. Okay. Production has been down a little bit. Again, due to the economy. What happened in a recession back in '70. A lot of need for instructors. It's hard to keep instructors in an A&P school if they can't pay.

Maximum production is going to be down a little bit. I'll talk just a minute about that on this chart, because all the graduates don't go into aviation.

Ten to thirty-five percent, depending on the school you talked to and the region, go to other careers. Dental equipment repair is another area that's not on this chart. Hydraulics and electronics. Jim Rice already talked to you about shop rigs. In the Navy, all the new fast frigates, destroyers are powered by turbines. Jet engine mechanics going to sea to maintain ships. The San Francisco Bay ferry boats, et cetera, et cetera. Where do you learn your turbine technology? A&P schools. We talked about this, just about everybody has some sort of a program. Federal Express has been growing like mad; they're maintaining their own Falcons now. They've got their own instruction programs there. Eastern has a very comprehensive program training new people. And, of course, United Technology has its own small airline. Sort of a typical 727, 737, Citations, big fleet, big budget, big requirements to train people.

A couple of charts that I did for GAMA, and you can poke holes in these if you want, but what we did was try to establish a mechanic/aircraft ratio, and they're rough, but nonetheless based on what we have today and what the FAA aviation forecasts say we'll have out in the future. I tried to just determine growth, and again these are minus the AIA companies.

AIA employees about 1,150,000 workers and I don't know what percentage are A&P or has A&P-type skills, but you've got to know it's a substantial number of people at Beoing, Lockheed and McDonnell Douglas, companies of that nature. They are not on this chart.

I'm trying to get some information from them right now to add to it. As you see, the biggest growth is going to be in general aviation. We kept that as a constant state in mechanics/aircraft ratio. If the systems get more sophisticated with higher utilization rates, et cetera, et cetera, that's liable to increase. We might get up to .8 mechanics per aircraft. If we do that we double

that requirement. In the airlines, as I said, moderate growth there but still a factor. Then we take that information and we take school production, subtracting from it the foreign students and the people that go off to other industries, and our rather conservative numbers, and we come up by 1990 with something of a short fall in the A&P business.

And again, minus the AIA companies on this chart. So I guess what we are saying is, if the growth occurs in aviation the way it's forecast to occur, we could have some problems in the future. Basically what we are saying here, I guess, is that the schools can replace the attrition but they can't account for growth.

If the growth occurs in the industry there are going to be some problems somewhere along the line. We look at our own people for a moment. Our strength is down, we are under authorization, we are critically short at the supervisory level. We have an increasing requirement for OJT, which I'll talk about in a minute, and at the same time we don't have enough supervisors on the line to handle the normal day-to-day operations. And we're doing a lot of things to try to work that problem right now.

Look at our own civilian work force, because I think maybe roughly it parallels with what's going on on the outside. There are 30,000 Air Force civilians directly engaged in aircraft maintenance for us. I have 37,500 in a computer study I did, so I think it's a pretty accurate sample. It's a much older work force as you can see. About 60 percent of our airmen are first termers, it's their first enlistment. On the civilian side, however, 40 percent of our people are almost 50 or older. And, in fact, in the next ten years we are going to have to replace more than half of our civilian work force. And again, training new people, if we can get them, we'll have to give up school slots for military to train some of the civilians coming along, so we see some problems coming there.

I want to show you this chart if I can get it on here. Just a quick comparison of pay. You can see the difference between general aviation; the manufacturing salary right here; some airlines salaries and military pay. Maximum military pay, this includes our tax advantage of our non-taxable allowances plus any available housing allowance and reenlistment bonus that one of our mechanics would be eligible to receive. I guess the bottom line is that an E-9 Chief Master Sergeant, 1 percent of our enlisted force can hold that rank, over 20,

just about equals an airline salary. Now, an apprentice airline mechanic, of course, would start about 19, 20, 21, somewhere in there and work his way up.

But basically it gives you a little idea of the disparity between general aviation and the airlines, our current situation today. Although United Technology pays about a dollar an hour less than airlines, they're pretty close to airline wages. And some of those people are paid pretty well. Dick Kost will also point out some of the people are paid a lot worse than what you see there. What's going on in technology, we've heard a lot about that today.

If we look at a military system, an early 1960's fighter, A-4, a system of that nature, that's about 150,000 pages of technical orders. A F-14 or a F-15 has about 300,000 pages of technical orders. At the same time this happened in the military, we've reduced our initial skill training due to budgetary restraints. Our initial skill training used to be almost 20 weeks in length back in the '60's, it's dropped down to 11 weeks in length today.

It points out the need for that OJT and the shortage of instructors that we are facing currently. What's going on? A lot of people are using uncertified mechanics. I know of a couple of shops with only three mechanics, and there's only one certified mechanic in the shop that signs off all the work.

General aviation is working to get more standardized components to help some of the problems there, and they also, I think, are quite aware of the disparity in the salaries, and hopefully are going to continue to work on that.

Aerospace has been hiring engineers out of the auto industry. There are a lot of people in the auto industry, which obviously is depressed, and I doubt really whether it will ever get back to where it was before, who have skills with a certain amount of retraining that could be used in aerospace if that requirement develops.

How about increasing productivity with technology, robotology, computers. Of course, when you talk computers you're talking already shortages. The robots, there's at least one automated aircraft engine plant being put in operation now down in Florida that I'm aware of.

What kind of skills does it take to maintain a robot? The same skills. Hydraulic, electronic, all those sorts of things. Communications revolution. I've been talking about this for a while, and lately there was an article in the Air Transport World in the June issue and in the June 8 issue of Aviation Week, if you read it.

Basically, I guess what my mission is as a long-range planner is to point out trends as we see them developing to give people an opportunity to perturb those trends before they become a problem. And this is one thing that may perturb that trend, and that's telecommunications. This is a pretty sketchy analysis of the threat, but some people are saying it could cut airline business travel 8 to 25 percent, particularly by the time you get out to the 1990's.

Most people say it won't have much impact this decade because people are still used to face-to-face. But as the travel costs continue to increase and the time is spent away from the job and the technology in that area improves, the attraction is going to grow and grow and grow. As we talked about, there is technology, you have got to accept it, and whatever, that will determine the time frame how quickly it's impacted.

It's also going to have a tremendous impact on general aviation because last year 90 percent of GAMA sales were to business, and at least 75 percent of the hours flown were business hours or business-related hours. So it will have an impact there too.

How much, it's hard for us to say, but if you talk to strategic planners in the electronic's industry they are making a concerted effort not only to cut the airline travel growth but actually put it in a negative growth mode. And they think they can do it. Some of those companies are also aerospace companies, by the way.

A different side of the house doing it to the other. Implications for you, it's going to be tougher to recruit people, there are going to be fewer people available, more people are going to want those people. You're going to have a higher turnover as people go off to other opportunities.

More emphasis probably on salaries, benefits and probably productivity enhancements as a result. Sort of the bottom line of our GAMA study is portrayed here. Basically in the past what you could market as a manufacturer determined your employment level. Perhaps in the future, the number of skilled workers that you acquire might be what determines what you can produce, turning the tables, so to speak, if things don't change.

Implications for maintenance manufacturers. With all the retirements, you're going to have a less experienced work force and you're probably going to get caught up in this turnover problem. You're going to have increasing

requirements to train all these people as they cycle through and you get the newer, younger person. And it's going to put an increasing burden on the supervisors to make sure the work is done properly.

Potential solutions. Deemphasize early retirements, try to keep people for a longer period of time. Bring in people from other industries. Older workers. Rely on immigrants. I've heard some fantastic stories about Mexican machinists. There's a least one aircraft plant in San Antonio that has almost 100 percent Mexican work force. They do very good work when they are trained properly.

Women, we talked a little bit about that, I think, in the Boeing briefing. The Air Force has had a rather bad experience with women in the maintenance force. It's one reason I emphasize males in the demographics, because obviously aircraft maintenance is still a male-dominated profession. I think there are, the last numbers I saw, less than 1 percent female mechanics. From the Air Force, we have three times the attrition from mechanically related skills of women than we do of males. Three times the attrition on the part of women.

Now, part of that are institutionalized problems. The way we recruit and some other things, this may not be a fair statement to make in some ways, but basically that's been our experience today.

But we're going to have to talk job redesign, tool redesign, maybe even equipment redesign to acknowledge for that. I think another problem that we'd all agree on is we all need to cooperate more. The schools need to know who and what to produce. The military and private industry tend to go their separate ways maybe doing the same thing, not sharing what they have learned from each other. We need a little more cooperation.

And as far as the military is concerned, we need to rely more and more on our guard and reserve forces, particularly in the Air Force where we have a much higher experience base and utilize this a little better.

Another thing is use that technology to reduce the complexity. We talked about complexity increasing and that's what the trend has been the last few years, but if we spend enough bucks on technology maybe you can reduce some of that complexity. Right now if you're going to R&R a black box, what happens to it? It's taken to an intermediate level maintenance or maybe to a depot and someone with extremely high skills rebuilds that box and it goes back on the

airplane. We need to get to the point where we can just pop that box and pitch it in the trash can.

Do you repair a $40 CB radio or do you just buy a new one? We need to get to the point where you have true repair and replacement for example. And, of course, the telecommunications revolution may have some impact on the growth trends that I showed you there. Summary chart. That's it, thank you very much for your time.

Is anyone interested in a copy? If you'll just write to me or give me a business card while I'm here, I'll be happy to put this together and get it back to you. That's all I need to get a letter to me.

QUESTION: Could you read the address out, please?

MAJOR GRAHAM: AF/MPXXX, Washington DC, 20330.

MR. RICE: That ends the prepared presentations on training, and I guess it's open now for discussion from the floor. Do you have any questions?

QUESTION: There have been quite a few comments about what the FAA should do. I don't think that part 147 really limits what a mechanic school can do. A few weeks ago NBC aired a program called the White Paper, America Works We Work or something like that. Where we need help from the FAA, from the military, manufacturers and anybody else, is getting down into the high schools to get the training that we need to bring qualified candidates into the mechanics school.

For instance, in Denver, Lowery Air Force School has laid vacant half the time. Those schools could easily be used to train high school students. They have one of the finest industrial physics labs at that Air Force Base in the world.

But over, I would say at least two-thirds of the time, it's empty. We have no cooperation between the military and the FAA. If something isn't an approved school, the FAA usually says we don't want nothing to do with it. We were lucky in our region to have a guy by the name of Paul Kerry that did help us get down into the high schools, but you can easily get flight schools started and aerospace training.

We need to get the maintenance-type training, metallurgy, electronics and that type of stuff started in the high schools. Thank you.

MR. RICE: Anybody else?

MR. PONTECORVO: Thank you very much, Jim, and the rest of the gentlemen. I enjoyed the presentations, and I think it's just about time now for our coffee break. I would like to say one more time that if you have not signed the roster please sign it now during the coffee break because we'd like to get it typed and reproduced. We'll take a coffee break. We now have coffee in the back of the room, and I'd like to reconvene at 3:00. That gives us 20 minutes.

(Whereupon, a coffee break was held, after which the following proceedings were had:)

MR. PONTECORVO: The next group, the General Aviation Manufacturers Association or GAMA, is going to speak on the subject of human factors issues in the design of general aviation aircraft. We revised the title of that particular panel a little bit and the moderator of that panel is Ted Moody. Ted is Executive Engineer of the Cessna Aircraft Company. And without any further ado, I'll let Ted come up here to start.

MR. MOODY: Okay. I would like to express my appreciation for the opportunity to speak to this group both on behalf of GAMA and of Cessna. It's kind of an interesting thing; I can't believe there's much more than about a half dozen of these World War II haircuts in this country, but I see there's three of them here in the room today.

You guys can't be all bad. What we will do and plan to do in this session of the meeting is address human factors from more of a design standpoint. The members of the group, myself from Cessna Aircraft Company, the Pawnee Division, another member from the Pawnee Division also in the engineering department, and a member from Gulfstream American also involved in the design or the engineering department. So probably the section will take a little different flavor during this portion of it, but we're going to try to duscuss it with you as we see the human factor side of the business from a design standpoint.

As Joe mentioned, my name is Ted Moody, I'm Executive Engineer with the Pawnee Division. I've been with that Division of Cessna for about 29 years, a little over. In my present position for about a year and a half and prior to that in the design function, both as a design engineer, project engineer and project manager and so forth in charge of the design.

One of the things that probably most of us have heard at one time or another is the comment they just don't build automobiles like they used to or

they just don't build airplanes like they used to, and there's some truth to that.

As I think back on some of my experience, oh, in the last 20 years in flying, I think about J-3 cubs and Lufkin, Taylorcrafts and Aroncas (phonetic) and 140's, and all the airplanes of the late 40's and maybe late 30's era, and what comes to mind is not today's airplane. It's an airplane that was drafty; it was cold in the winter, it was hot in the summer. It was noisy. It vibrated. It had minimal equipment in it. It was slow. It was hard to start, it was hard to stop, it was hard to land. You know, it wasn't today's airplane. Now, that isn't to say that those airplanes were bad; they certainly were anything but that. They were airplanes built to the standard of their day, and that's what we knew, that's what we built, and I wouldn't detract from them at all. But they're not today's airplanes.

The airplane that Bob and I flew down here this morning is one of our airplanes, a 210. It's well-equipped, it has RNAV, DME, nav comms, color-weather radar, auto pilot, turbocharging, all those good things that we come to think of and expect in today's airplanes. We really don't build airplanes today like we used to, and personally I thank God for that. So really then the question becomes: How did we get from there to here or from then to now or from the J-3 cub, if we want to use that as an example, to today's modern business transportation airplane.

And we are in that business. Maybe we're in competition with the airlines, I would hope that we are. But we are in that business of modern air transportation, and the simple answer to that question is two words, it's by design. We got there by design, and I'd like to discuss some of that design that took place.

Now, one of the things that I did as I began to think about this, what I wanted to say and how I wanted to say it, was kind of look at the things that I could see back over the last few years that had changed in design and how it related to the human factors side of the design problem, how it related to some of the key areas or groupings that I rather arbitrarily made up.

But nonetheless, to my mind, they are groupings that we have dealt with in the design of airplanes. One of those is maintenance. Another one of those groupings is the operation or the functional side of the design and the product.

Another one is environmental, and I'll go into those in a little bit more detail in a minute.

The maintenance portion of the design that comes to mind, and I defined that simply as those designs that relate to simplicity, ease of fabrication, ease of assembly, accessibility, serviceability, maybe keying things so that they can only be indexed in a simple one direction.

In other words, what it takes to design the product in a manner that it can be maintained. And I'd be the first to admit that there may be questions whether we do that all the time or not. I know one thing we do, we try all the time to design airplanes so that they can be maintained.

Some of the examples of the human factors side of that that come to mind, that I can think of over the years, early on in a lot of models that we design and have designed at Cessna, we have staggered control system turnbuckles in a manner such that the cables can't be put in backwards if they are ever removed. We've located the turnbuckles so that during their course of full travel from up or down or right or left or whatever the case might be, that that turnbuckle never goes through a fair leader bulkhead so that it could hang up on it. That's some of the human factors considerations that go into cable system designs.

I'm sure everybody has got horror stories of things where people have thwarted those designs some, and we see that too. I'll never forget the turnbuckle that come back out of the field when a fellow couldn't get the two ends of the cables together with the turnbuckle he simple tapped one end of it out so it fit the right thread. I don't think there's any way to design around that, but it happens. But you do, as you look at control systems, for instance, work on design in such a manner that you try to eliminate those problems that you can see.

Other examples that might be thought of in terms of the design that we'll go through is access plates on some of our models. And I'm ashamed to admit this, but it happened. We went for years with an access plate in the tail cone of some of the airplanes. One plate that was about four inches in diameter and a guide to rig the control cables through. As maintenance becomes a greater and greater factor in the design, in recent years we have put double access plates so a person can get in from each side. We are talking about small air-

planes now, not the big massive ones like most of you are familiar with where you can get to these things, but airplanes where one man might be doing this job.

Access plates, we try to put those in places that clearly need maintenance and inspection. Another example of such a thing is on the turbocharging system on most of our 200 series single-engine airplanes. We've made removable sections of the total cowl that used to be structure that was riveted structure to the airplane.

Today they are removable in a way so that you can completely open that side of the engine compartment to get at it. It means the difference in man-hours; the difference in the amount of skill it takes to do the maintenance on it; and it also means the difference in profit to the customer.

And, of course, as all of us are, in this business profit is one of the things that motivates the design changes we make. How can we make the product more useful for our customers? Other examples, in the case of our agriculture airplanes, completely removable side panels so that they can be washed out, they can be maintained. Fuel selector valves across the model line in the Cessna airplanes, and I'm sure other manufacturers do the same thing, we have keyed those linkages such so that they cannot be installed backwards. The holes are drilled off center to attach the fasteners, and what -- have-you, so that they cannot be installed to give an incorrect indication on the fuel selection. Those are simply some of the maintenance items that we, over the years, have integrated into the design from a human factors standpoint to eliminate errors and reduce cost in the maintenance side of the business.

Swing out engine mounts, fastener patterns that make it such that panels cannot be installed backwards or upside down or on the wrong side of the airplane or what-have-you. On some of our retractable gear airplanes, the 210 that I mentioned earlier, in the last couple years we've removed the gear doors at a practically negligible performance degradation in favor of simpler systems, reduction of hydraulic cylinders, removal reduction of some of the lines, getting rid of some of the hydraulic sequencing, all of that going to make simpler systems so that the maintenance can be easier done and for less chance for error.

I wouldn't want to suggest the removal of the doors off the 747 as a solution to the problem, but you might think about it. It's kind of interesting,

someone mentioned this morning, I can't recall where that question came from, but it was a question of hydraulic lines being designed such that they couldn't be crossed. We had the same problem in our airplanes, and over the years we have designed many of the oiling systems, engine oil and hydraulic systems such that they cannot be crossed. It's especially true on turbochargers for turbocharged engines, we've had to do that. That's another part of the human factors considerations that go into the maintenance side of the design.

Looking at some of the other areas, the operational or the functional areas and like I say, these categories are strictly mine but they serve a purpose, at least for my presentation. I would categorize those as the design considerations that go together or to produce some operational or utility benefit for the pilot or the passengers.

And some examples of things like that, early on we designed fuel caps, for instance, with veins on them so that when the fuel cap was on and closed the vein was fore and aft so that it gave it quick visual indication of the fact that the thing was on and closed and in its proper place.

Other examples, on many of our twins where an auxiliary power receptacle is standard, we install those on the trailing edge of the engine cell behind the wing for the simple reason that that places the mechanic or the line boy in a less precarious position when he's removing the auxiliary power once the engine is started.

Refueling steps, wheel fairing access doors, cockpit controls, all of these are considerations from a functional standpoint that go into design of airplanes, and I'm speaking not only for Cessna but for other general aviation manufacturers that have human factors connotation. We know that there's a chance for error, we know that there's a chance for things perhaps not to go together right or for things not to be used right, and we do those, we take those things into consideration as the design goes on. And some of the other gentlemen will speak on those in greater detail.

In the case of cockpit controls, there are FAA regulations, as most of you know, relating to position of cockpit controls. But we go even beyond that, many of us have been involved in various working committees with GAMA, suggesting color codings and some other things in regulations that make those even more standardized and more clearly identifiable.

Most engine controls on small airplanes have certain color requirements today, certain shapes and size, certain tactile feel, and those are also design considerations that go into the operational side of the design of the airplane that we'd look at from a human factor standpoint.

Another side that I mentioned a minute ago was this question of environmental. And basically I have defined that to myself and I'll define that to you, that those are the considerations that are related to basically the comfort of the passenger or the pilot.

Examples of those kinds of things that we look at from a human factors standpoint are heating and defrosting systems. Years ago it -- well, I'm not sure how the airplanes in the 30's were designed, but I know that most of them had pretty inadequate heating and defrosting systems. Probably if I know the way things happened, the design was done and checked out in the winter where the airplane was designed, and if it heated in that particular time and seemed to be adequate that's what was put into production.

Today most manufacturers will go to very cold weather, and I know Cessna does this, we check heating systems at night in the winter for the simple reason that there are few things colder than a dark cold night at altitude. And we'll go through some flight testing on that and develop heating systems and defrosting systems that will handle those kinds of situations.

That may sound a bit foreign to anybody involved in planes like the 747 or the L-1011 because those airplanes have, apparently, more heat than they know what to do with. But for general aviation airplanes, you're dealing with exhaust systems ordinarily, and in some cases combustion heaters, and those have to be tailored to that specific airplane.

And that's some of the things that go into consideration on the environmental side of the picture from a design standpoint. Air conditioning, all of us -- I say all of us, most of us expect now to have an automobile, at least in the Midwest, that's got an air conditioner in it. There's really no reason why an airplane that cost $100,000 or $200,000 and on up shouldn't have air conditioning, but yet that's something that has come into the picture in the last ten or fifteen years at best. That's an environmental consideration that is factored now into the design and something that we look at from the standpoint of human factors.

Ventilation is another one. Pressurization. Today pressurization -- Well, let's step back about ten years. Ten years ago pressurization, you found airliners in corporate debts. Today pressurization you find in many twins and in some singles, and that's simply another one of the environmental things that is considered during the design from a human factors standpoint.

Oxygen systems for the turbocharged airplanes, obviously is a must, but what about the masks? Cessna and other manufacturers have gone to great length to design a mask that is built for us so that that can be comfortable and something the average child or woman -- the pilot will put up with anything practically but the passengers won't, so we designed something that will work for the passengers and provide that measure of comfort for them when they are on oxygen.

It hasn't been too long ago, like about two weeks ago, I took my wife and one of my children to San Francisco. Over the mountains in a small airplane you see 16,000 feet pretty easy. They saw their first experiences with oxygen masks, but it's not a difficult thing if explained right and if the equipment is right and has been given some consideration that you can get people to adapt to. And that's some of the things that we've looked at as time has moved on in the development of today's airplane.

Another item that is considered that many times one doesn't think about, but the materials, fabrics, plastic odors, some of them give off plasticides when it warms up. A small airplane sitting out on a ramp can see 110 degrees or 120 degrees pretty easy on a hot day.

Another consideration, in terms of some of the things that are looked at in design from a human factors standpoint. Interior noise. Those of you who have flown smaller airplanes know that one of the things that has come along in the last 20 years is a constant reduction in the noise level in the airplane.

On the other side of that coin, the horsepower has been going up for that period of time, so many times that's a balance. But we have run tests and integrated into the designs, windshield thicknesses, double windows, propeller RPM changes, exhaust system changes, all of those things are calculated to do two things, reduce the exterior noise and also the interior noise.

So when we talk about human factors in the design side of the business and the fact that we don't build airplanes as we used to, that's really true, we

don't. I feel like we have taken a lot of steps towards improving those airplanes in getting from where we used to be so where we are today from the cub to the modern airplane by design, by careful attention to the man and the machine relationship, the interface of those two, and all centered around the human factors considerations that need to be there to make that airplane a usable product for the operator and the passengers.

I'll never forget something that happened to me about oh, I don't know, ten or twelve years ago, maybe fifteen. I was project engineer on a brand new airplane that we were designing at our Division and had a guy that had been working for me that had been given the responsibility to design a certain system, and he did just what he was supposed to do.

He did an excellent job. He designed it, he got all the work done. He got the thing out in the Experimental Department and they built it, they put it on the prototype and the test pilots went out and flew it. Well, they came back and had some suggestions, as you might expect, ways to improve this new system. So the guy dutifully took those suggestions, he cranked them into the design, he got it built. He got it installed on the airplane and the test pilots went out again.

Well, we went through this about two or three times. Either he wasn't listening or they weren't communicating, but it took us about four different configurations to really get there. About the time the fourth one was on the airplane, he came into my office and he sat down and he said, "Ted, I finally figured it out. I always though we always designed airplanes but we really don't, we just wear them into shape."

Well, I'd like to call that not wearing them into shape, but call that the design process that sees evaluation, that sees consideration, that sees the experience of the designers, and that's something that we have avoided just as the maintenance area does. But it sees all that experience and sees all those considerations that produces the product we have today.

It's by design, and that design to my mind at least has developed the finest general aviation airplanes in the world. And I'm proud of what we do. I'm proud of the general aviation manufacturers. And it is by design.

We've go two other people that would like to discuss some of these issues. The first of those is Tom Baroth who is of Gulfstream American. He's supervisor

of Industrial Design, I think, with Gulfstream American. He's been with them for some 13 years in that business. He will discuss some of Gulfstream American's design features and human factors considerations.

MR. BAROTH: I would like to quickly correct the possible misconception that you may have since you heard the word Gulfstream. I really have nothing to do with Gulfstream, the big ones. I've been with the Commander Division, which as you know, has been acquired by Gulfstream American. The airplanes I'll be talking about and the processes I'll be talking about center around the Commander Division products. I'm sure you've heard of them, somebody here.

As Ted has said, we don't build airplanes like we used to, and yet there is that element in the general aviation industry that most aircraft that we build today are not brand new air frames, but are derivatives of older designs. And those are designs which constantly get more complicated and more complicated. And, therefore, the equipment that we stuff in them would become harder and harder to stuff in.

Now, we have no systematic, unified institutional approach as regards to human factors and maintenance, but really I must confess that human factors type improvements are principally targeted at the operator/occupant and often such improvements are detrimental to the man who has to maintain the aircraft.

This has happened and has to be undone. Now, feedback from the field is a principal guidance in this regard. It is possible that product improvement has to be undone occasionally when maintennace detriment outweights occupant/operator convenience. There are some other negative factors.

Another factor that has to be weighed whenever we contemplate a maintenance oriented improvement, is -- I use the word weighed because it's just that, it's weight and cost, which in our industry is possibly a more stringent constraint than perhaps in the airliner manufacturing industry.

Some of the most obvious maintenance convenience items if you add it on, for instance, in-line connectors, access panels, quarter turn fasteners, will cost us both weight and money.

When we built Thrush Commanders with welded tubing designs and sheet metal panels that came off, we could take everything off and get to absolutely everything in the airplane at will. We can't do that today. Again, since we are

working with existing designs, derivative designs, maintenance gets harder and harder as we stuff more and more stuff into the same space.

Obviously if and when we get the opportunity to design brand new air frames, we have the chance, we do nice things such as roll out trays for hydraulic components, roll out trays for batteries and so forth. Bust most of the time you add gear to existing air frames. The continuous improvements, however, that goes on in these derivative designs is institutionalized to some extent.

At Gulfstream Commander, we have a system of yearly model changes that we call YMC, which is a very clever abbreviation for each model. A master list is generated each year with input from all engineering disciplines, product support and marketing, identifying all product improvements desired. A good 50 percent of these improvements are maintenance-oriented. Another perhaps more timely source of input, especially in the case of the new program, is the continued feedback during the experimental program preceding each type of certification.

And that, obviously, is a continuous process. Now, I would just like to briefly go over the history of the last two years, perhaps, of model year improvements and what we have done in just a sprinkling of items that we have done in various areas.

In the interior area, which is my specialization and job I'm most familiar with, we have gone and done some things that are quite obvious, some things we thought were quite novel. Quick removal panels in the baggage compartment sound obvious but it was new to us. And it enabled us to remove -- having an independent birdcage structure for the baggage compartment.

All panels, interior panels, are removable so that even the 95th percentile mechanic can get behind and work on the equipment behind. In the new model 1000 Commander, we have now a total removable lower side panel in the cabin. There's one panel that runs the whole length of the cabin, 110 inches long, when removed exposes all electrical avionics' wiring in the cabin. Again in the cabin, all seats track the total length of the cabin so they get out of the way no matter what end you want to get at and work at. We have concentrated with, of course, the cooperation of our electrical avionics and systems friends, all blackboxes, all must be accessible items in specific locations along the rear bulkhead and devised two quickly removable panels which will expose alternately either one of these groups of boxes.

We have devised, which we feel is one of our better innovations this year, we devised a center overhead panel in the cabin, in the model 1000, which can be removed by loosening of four screws. It comes down about 10 inches and hangs on cables, and this allows us to get at all the oxygen piping, all the cabin lighting and service it.

If, however, the problem is more profound and can be serviced on the spot, then the whole panel can be removed by just disconnecting two flexible couplings at each end and can be -- that means the whole passenger oxygen system and lighting system can be serviced and tested on the bench and then carried back into the aircraft.

Again in the baggage compartment, which also is among other things holding baggage, it also hides the batteries. We, by removal of the right number of the quick disconnect panels and angles, permits us to remove batteries without ever lifting any of them up.

In the electrical and avionic areas, we have done a number of things. All connectors are keyed and non-reversible. We have moved the electrical relay panel to the pedestal and added connectors. This cost us money and weight, but it was a kind of item where the advantages obviously outweighed the disadvantages. All our instruments now are front removable from the instrument panel, including the radar scope without removing the panel or any other component.

The instrument panel segments themselves, which are three, are removable separately without disturbing the adjoining equipment. All avionic wax in the aft fuselage compartment, which is behind the baggage compartment, are assembled with screws for disassembly purposes.

We have made all the bulbs for all the panel indicator lights standardized and replaceable in flight. There used to be several sizes, there's now just one size.

The face plate of the circuit breaker panel is quickly removable to get at the breakers. We have added smaller doors under the aft fuselage to access auto pilot servo cables, and we have added plate nuts all around the heated windshield to facilitate windshield removal without disturbing any of the framing around the windshield. This is just a sampling of one year's improvements.

In the systems propulsion area, of course, we do have the advantage, having a nacelle design which allows removal of all panels completely exposing the propulsion machinery. We have added this year new main landing gear brakes, which allows us to change shoes without jacking.

We have put in remote filling capability for the environmental control unit oil sump, as well as the oxygen bottle. They can be filled from a small door in the aft fuselage.

We have moved the cabin outflow valve to the forward side of the forward pressure bulkhead and thereby made the servicing of that much more easier. One of the most significant changes we have made is not necessarily in the area of design but in the area of maintenance manuals.

Similar to the ATA specs, GAMA has specifications. GAMA has developed specifications for maintenance manuals, and in our new model 840980 and 1000, we have redesigned our manual to conform with the GAMA specifications.

Now, this has meant that we really had to make big changes. Well, first of all, GAMA specifications are rather common sense ones, and they are certain human factors considerations which are rather obvious. Just to quote two examples: One of them is an insistence that removal is no longer simply a reverse of reinstallation, and vice versa, so, therefore, there are instructions for removal as well as instructions for reinstallation.

Also one of the very significant changes is that warnings and cautions, instead of sprinkled in the middle of the text, now perforce will precede the section to which they refer.

We have, and perhaps this is due to the help we have gotten from some of our manual writers who have lately arrived from the services, we have rewritten our manuals for less or inexperienced personnel.

Therefore, they are longer and more comprehensive. Our manual is by an average 50 percent longer. They have more and better illustrations. As a matter of fact, we have increased our illustrations by 200 percent. And the illustrations, themselves, are perhaps more on a human scale. They are less schematic and more pictorial. They show equipment in place, actual installed equipment pictorially.

We have added a new alphabetical index to augment the table of contents. And in the alphabetical index, we have every item that is illustrated, there's an asterisk. We have added troubleshooting charts in front of every chapter, and we have added operational and functional checks for every piece of equipment.

So we are making some progress, and I hope that from what we learn at this symposium from our friends who preceded us here we'll continue to make some more. Thank you very much.

MR. MOODY: The next speaker on this panel is a friend of mine and has been for a number of years. He's the Manager of Aircraft Styling at the Pawnee Division. I asked both him and Tom to give me a brief synopsis of their experience and their title and what-have-you. Bob indicated that one of his first interior design experiences was customizing a Lockheed Lear Star to carry people and polo ponies and that in itself has got to have some interesting human factors.

Bob has been with Cessna since 1966. He is a pilot and he hastened to add an all-around nice guy. Bob Matting.

MR. MATTING: It's a pleasure for me to be here today and talk to you about human factors. Unfortunately, there have been six of these seminars, apparently, and this is my first one. And not having a background on what all the subject matter has been about, maybe this is the first one on maintenance, but my area of expertise, if you will, is in the interior design portion of general aviation aircraft and the impact that human factors have on that area.

And so I'll tell you a bit about some of the challenges that we have addressed, and to some degree the impact that maintenance considerations have had on our product. We have a lot of products out there flying around.

Cessna has approximately 22 models in production, and we build about 54 percent of all the aircraft flying in the world today. Those are just sideline tidbits.

To begin with, it's very difficult to design a machine that places the user in a somewhat alien environment as does an airplane, without a total commitment to the subject of human factors. The relationship of man to the machine he is interfacing with, trying to control and trying to live happily.

Because of the high stress levels that sometimes can be encountered during a normal flight scenario, it's just important that the designer accomplishes his task as far as human factors are concerned.

Basic human factors considerations fill to the brim the control pilot interfacing portion of every aircraft. And when we scan the panel, we're aware of the many decisions that have to be made with regard to placement of instruments, location of switches, logical scan patterns, things that would aid the pilot in achieving a satisfactory give and take with his machine.

A systemized approach, if you will. The shape and size and orientation of basic devices, such as the controller wheel and the manner in which it's positioned with regard to the location of the arm on the armrest, all these things together with the switches that might be ever present to use, whether it be a trim switch or auto pilot disengage or drop the bomb or whatever else, those sorts of things have been placed in such a way and constructed as to allow a multi-faceted task with a minimum of potential air discomfort. The other aspect present on the panel is how do you retrieve the information from it? What do you look at and how does it strike you and how well can you interpret it, and with what speed and facility when you really need it?

To that end, Cessna embarked on a program, oh, some 14 years ago, to improve the legibility of instrumentation so that one could retrieve this portion with the least amount of effort. We looked at such numeral changes as enamel numerals. We considered the difference in layouts, whether or not you ran the pointer over the number or whether you had the indices beyond the numbers or inside.

And we made some mock-ups and we sat up task analysis and we determined that perhaps the advantage of very simplistic letter forms without the intrusion of a pointer would be the best results.

We did that and that was what proved to be true. We've had a difficult time working that sort of an approach through the system, because there's always been somewhat of a hangover from present instrumentation, military instrumentation, where the pointer reaches the perimeter of the instrument face.

These sorts of things have always been a challenge to achieve new ideas. Ideas such as in general avionics, we always thought that the only instrument panel was a black one, so in trying to present new and better and less taxing

situations for the pilot, we went to the neutral gray. Certainly it did not create perhaps a better situation for the night activity, but for day it seemed to be an improvement. At night it wasn't bad either.

We looked at the red light versus the blue/white currently being used, and suggested we go to the white lights. We have, in most instances, in our airplanes. Night lighting is a problem. Another area where human factors have played an important part is simply in the basic seating devices.

Whereas 30 years ago it was a board with a little pad on it, very little, we made a great big transition to such items as no-sag springing in which the pilot and passengers bounced up and down in turbulent air and strained themselves against the lap belt.

We put a more firm approach to seating. We designed the seat with a cushioning material over a diaphragm or a base that allowed a resilient cushion, but a better seat in rough area. We designed seats that have articulated reclines, that is the seat back reclines at a rate of about 2 to 1 to the seat bottom. This would allow a reclining passenger in turbulent air to maintain his position relative to the seat rather than slide forward and slide off and over stress his already stressed lower abdominal region.

Intending to make you more comfortable. These sorts of things we've done. We've worked out with the aid of vendors who are tuned into comfort and environmental problems in aircraft, inertia reels that have comfort zones in them that allow a little better interface between that lap belt and shoulder harness than before.

Things that would tend to improve the passengers' life on board an aircraft for about four hours. A 4-hour flight in a general aviation airplane is pretty much par for the course. Maybe that's on the long side, maybe two and a half hours is more of the normal flight. At any rate, we design for the long trip.

Such things from a standpoint of maintenance where we have made some inroads, and hopefully while we are making airplanes more complex with systems we are tending to simplify as far as repair is concerned, are some of the things in the aviation field, such as companies like King and ARC and various other avionic manufacturers where the basic radio design is constructed on circuit boards that fold up readily for maintenance.

The panel mount is designed for an easy removal to send off to the Service Department. These may not be very significant from the standpoint of overall costs, but they do affect our portion of that design.

In airplanes such as Cessna builds at the Pawnee Division, for years we stressed hiding all the fasteners on the panel, on the side walls, hiding and camouflaging all this detail. We've had a change of heart and we are now doing away with the 807 trim clips and the things that fail and break, and are mounting these things in a very positive way using screws and fasteners that are readily removable.

Things of that nature that would tend to improve the lot of the maintenance man or the mechanic. I've just touched on a few of these human factors elements found in modern aircraft, and I know there are many, many more that have had the attention of the Engineering Department, and I'm certain that there are many that need it. And hopefully through meetings like this we will become more aware of the problems and the solutions to problems and the big iron, if you will, that can help us design our airplanes.

Our airplanes are becoming more and more sophisticated. The G-2, the Cessna Citation 3, the Lear 35 Series. These are complicated airplanes that are merging on that domain of Douglas and Boeing.

Hopefully we will all exist or coexist together. I thank you for the opportunity to talk, again. Thank you.

MR. MOODY: Thank you, Bob. If there's questions, we'll be happy to try to answer them. I won't guarantee that we'll be able to.

QUESTION: Has general aviation taken a look at that vexing problem they have never been able to solve, that is behind the front panel access? They're getting more and more gear in there.

MR. MOODY: The question is: Has general aviation taken a look at the problem behind the instrument panel, getting to equipment back there, and the fact that there is more and more? The answer to that is yes. There are no, as I'm sure you're aware, quick solutions to that. We've looked at, on occasion, instrument panels that might hinge at the bottom or in some way fold away to get at it. We've also, on small models at least at Cessna, put access plates on the cowl deck. Generally that's right up under the windshield and it doesn't help a great deal on small models; it's out in front of the windshields.

Sealing that becomes a problem. I just simply have to say we don't have a good answer for it, but it's one of the key areas that we continue to work with.

PARTICIPANT: That's a major problem.

MR. MOODY: It is a major problem and you're right; we pack more and more behind there year after year.

QUESTION: Is general aviation incorporating some of the technology that we discussed this morning, such as the EICAS or digital electronics?

MR. MOODY: To this point, on the airplanes that I'm familiar with, I am not familiar with any that do incorporate that. Cost is a major factor in that. I don't know of equipment like that that could be put aboard these airplanes that we could afford, frankly. I'm talking now about the smaller single-engine airplanes. The more sophisticated Gulfstream aircraft, the jets, the corporate jets and what-have-you, they do incorporate some of that equipment but not specifically.

QUESTION: How about the twins, the 400 Series?

MR. MOODY: No, not to this point.

QUESTION: In the next ten years?

MR. MOODY: Oh, that's hard to say. I would think certainly something along those lines, whether it's -- I don't know enough about this yet. We have enunciator panels and have for the last six or eight years. I see no reason why that technology could not be extended into the maintenance side of the picture, and I would expect something like that.

I don't need to handle all these by myself if you guys want to say something, you can.

QUESTION: Ted, I've got a question. In your speech I got the impression that human factors are really a result from the input from the field. I'm just wondering if there is a point in the engineering design process in which you bring in people that specialize in human factors to look over things, or do you have a formal program to do that?

MR. MOODY: I didn't mean to generate the impression that it's strictly input from the field because it is not. As the design process goes on -- and I think every air frame company is organized in a different manner -- but as

the design process goes on, it is commonplace for the project engineer, the designer, to consider the things that we are aware of, and obviously we're not aware of all of them, but the things that we're aware of from a maintenance standpoint, from a functional standpoint. Not only maintenance, but functional, how do we design this so it can't go together the wrong way or the pilot can't misuse it or all things that are associated with human factors.

It's part of the design process. Now, to answer your question: Is there a specific group that you bring in and say, Okay, guys it's now yours, research it from the human factors standpoint -- No, we don't incorporate that, and I don't know about Gulfstream.

Any other questions?

QUESTION: Is there any one reason you might think of for who were seeing a sudden upsurge in AD's lately?

MR. MOODY: That's interesting. I'm probably going to call on the FAA to comment on that. I think from most manufacturers' standpoint, we probably resist AD's less than we did ten years ago. You know, today most manufacturers step up to the problems when they happen as best we know how, and as soon as we know how, and try to fix those problems. We don't really resist AD's like we used to. There are more AD's today on varied things.

Craig, you look like you want to say something or run, I don't know which. I'd be very willing to have you say something.

MR. BEARD: I don't know that this is the place to debate it, but I would like to extend an invitation for feedback, either drop us a note or call us on the phone and talk to us. I think there's probably an increase in AD's in the general aviation. I'm also concerned that there's an increase in the percentage of noncompliance of AD's in the general aviation. And I guess what concerns me most about the whole thing is that maybe one is the product of the other through a human factor called attitude.

Some people have begun to feel that the FAA is covering its backside or has found a convenient way of disposing of an NTSB recommendation by issuing an AD at the expense of everybody affected. It's an area that we are looking at.

Some of you may be subscribers to George Milligan's ACORDE Inc. paper. He had some conversations with us on the same subject. We've begun to discuss

this issue with a number of other organizations and other people. One of the suggestions that comes to mind when you get into the correction of service problems is that we should be looking for non-regulatory alternates to airworthiness directives, thus reserving the airworthiness directives for the big hitters. Maybe we need to come up with an effective system, a system that's respected by aviation community, of publishing non-regulatory airworthiness alerts or advisories to bring forward manufacturer's recommendations concerning safety enhancements that we think deserve a little more attention than they might otherwise get.

There's been many, many cases where there's an accident or an incident where we don't know whether it's something unique about that particular operator's way of operating an aircraft. Maybe a special kind of operation puts special kinds of wear on airplanes and we have a failure.

Quite often we find ourselves in a big hurry to resolve the problem, and we find ourselves issuing an airworthiness directive that affects everybody. If we had another system of approaching the problem, i.e., through an airworthiness advisory or an airworthiness alert system, where the operator could be advised of the situation and to look for it, we could buy ourselves a little more time to be a little more reasonable in our AD judgments.

We are just now beginning to look into this as time permits. We've got many areas that we're trying to look into, but that's kind of a backdoor answer to your question. I think there's been more AD's and maybe this has an adverse counter productive effect on compliance attitudes.

MR. MOODY: All right. Are there any more questions or comments?

QUESTION: I have one question. I would like somebody from the FAA to explain the logic of after printing an alphabetical or numerical index in the AD summaries and then put a notice in there that it's not reliable.

MR. MOODY: Who would like to explain that?

MR. PONTECORVO: I didn't know we did that. I guess I'm going to have to defer and get together with you later and show me where that is and find out why we did that. I don't have the answer to that. It doesn't sound like a very intelligent thing to do, I must admit.

MR. BEARD: I'm just guessing, and we're going to talk to the people that

write that, but what it might be telling you is that if you've got a Cessna 310 and you're returning it to service and you're about to certify that all AD's have been complied with, don't just rely on the index -- look at the AD's applicable to the Cessna 310.

QUESTION: There are instances where in the index there are airworthiness directives in the summary which are not printed in the index.

MR. BEARD: That could be. There are times when we issue airworthiness directives against TSO's article, or an engine or propeller independent of it's installation on a particular aircraft. It's just virtually impossible for the FAA to be able to determine every aircraft on which that particular article has been installed, so you will see applicable to a bunch of aircraft types.

Well, there could be other aircraft typed as well. We'll review this note that you're talking about.

QUESTION: What it has done is caused people to go through every page of every product in the summary if they're trying to assure that all has been either complied with or ---

MR. BEARD: I'm not entirely sure that wasn't the intent.

MR. PONTECORVO: Is there anything else? Okay. You may or may not have heard this morning that the bus is going to be at 5:10, so we'll try and break here at 5:00. And I'm going to change the schedule a little bit and put Dick Kost on now. Dick is from the Aviation Maintenance Foundation and he's going to speak about a subject that's on the agenda for tomorrow. I want to mention one thing, I was talking to Jim Graham at the coffee break, and when he and a colleague were in my office a couple of weeks ago and we were discussing his presentation, he told me at that time that there's a dental repair firm in Seattle that has a standing offer through a local A&P School there that they will take the top ten percent of every graduating class and put them to work in their business of repairing dental equipment; as he mentioned there are a lot of people drawn from the aviation technician field.

MR. KOST: There is indeed a large number of industries outside aviation that truly love A&P's. And surprisingly, they think more of them than our own industry does. Obviously we're preaching to the choir right here, but these other industries love the A&P's, because as mentioned earlier, they have got so many different and varied skills.

The dental equipment repair firm, I followed that up a little bit, and found out the reason why is because one, the discipline that you learn as an A&P. The integrity that you have, you're learning to work with very small parts and very close tolerances, and that's what you have in dental equipment.

And to repair something that means you have to be inventive. You have to be willing to fix it, to be willing to take a look at it. And most aircraft mechanics do have a good mechanical aptitude. I think that's one of the first things that you can say of an A&P, is that he does have an excellent mechanical aptitude.

A few comments about the AD's. You're going to have disclaimers in everything these days, so I see little wonder in why they say you can rely on this but not entirely. However, if you ever went home and said, "Honey, I love you, but don't rely on that." I've got a prepared text here, and I'm going to try to get into it, but I have a tendency to get away from certain topics, so kind of herd me back in a straight line here. I hope you won't feel too ill of me in that I am not an A&P, so we're going to have a chance to stretch. I want to see the hands of all the A&P's who are here. Who's holding tickets? Okay. Don, we'll forgive you.

How about avionics people? I can get you guys jobs anywhere you want.

QUESTION: How about A&C?

MR. KOST: How about AC's, Canadian people, British people? Jerry, you've got a license, don't you?

JERRY: Yeah.

MR. KOST: Don't forget, 6:30 tonight, Room 403 at the Hilton if you want to discuss the pros and cons of specialization within the A&P license. Some people are for it, some against it, not too many fence-sitters, really.

However, something should be considered, at least it should be studied to the point of finding out whether we should wait awhile or do it now. I know every day that goes by we lose that much more time. The complexity was not much beyond the need for -- Excuse me, Cessna -- bailing wire and promises.

This is, perhaps, an over simplification of older aircraft, but the point is that most all aircraft designed 30 or even 20 years ago were basic and not very complicated. Times have indeed changed, and today we see bigger and faster and considerably more sophisticated aircraft.

The aeronautical engineers have done an excellent job, a fantastic job, applying state-of-the-art technology to new aircraft designs. The new Lear Fan that flew on December 32nd. For those of you who are familiar with the agreement that Lear Fan had with Northern Ireland, it had to fly in 1980, so when it flew on Janaury 1st of this year they declared that December 32nd so they could have their financial commitments.

The new Lear Fan utilizes high technology graphite fiber design and construction, which is going to prove, and I believe it, a tremendous advantage to the industry. I think it's going to be a great advantage eventually when it gets down to the fine points of it.

I think it will be applied in even the larger aircraft. The new winglet design, which for the Lear jet Longhorn is not really a new design at all, but a new application for it.

Several years ago knowledgable engineers said that turbines would never find their way into aerial application; it would be too costly and not enough performance out of it. I think that's being proved wrong today. A new breed of jetliners, the Boeing 757 and 767, are being just packed full of sophisticated avionics equipment that are making them very efficient.

The list of technological advances being developed for our industry is becoming longer and longer. A few years ago it was only 150,000 pages of design in this one presentation, now they are up to 300,000 pages. So that list is becoming longer.

And avionics is, indeed, on the leading edge of technology; I think we've all heard that many times. We're all very proud to be in aviation. I know I am, I have been in this more than ten years, and it's one of the most exciting places I've been. There seems to be no end to what our engineers can develop.

However, we do have an old law of nature that states for every action there is an equal and opposite reaction. And this is what is happening to us right now. The foundation will be ten years old next year, and for the past nine and a half years, we have studied the aviation maintenance industry. We've tried to find out who the people are; where they are; where they come from; why they come into aviation; how much they get paid; where they are going; what age do they usually retire; how old are they now; how many kids have they got; what kind of whiskey do they drink. We try to find out a good demographic

analysis of aircraft mechanics, and we are finding out they're good people.

However, they've got some drawbacks to their occupation. These drawbacks are serious enough that we should consider them and very quickly. We are awfully late in doing so. While we've been building these sophisticated aircraft, we have seriously neglected the need to properly educate and train the people who are charged with the responsibility to maintain and service these aircraft.

True, our maintenance staff is some of the best in the world and trained to extremely high levels, but not to the level that the aircraft are being designed and manufactured. Essentially, tomorrow's aircraft mechanics are being trained today using yesterday's technology. Perhaps this may sound like something Jim Rice wrote, but this is something I've been preaching for many years.

People say I'm stricken with a Chicken Little syndrome, but I think it's quite true. We are better than a year and a half into the 1980's, but we're still training future mechanics on information and regulations developed in the mid '60's. I'm speaking primarily of the FAR Part 147.

A little bit redundant to what was spoken about earlier, and Dr. David Allen and his study in the '60's, which was implemented in the early 1970's. True, some advances have been made, but these are minor in comparison to the vast technological steps made in the past ten years.

In looking at the industry, it's terribly frustrating for me, and I work closely with the aviation maintenance technician schools. I work closely with ATEC in spite of some differences. We try to find jobs for young A&P's. We try to encourage youngsters in high school to come into this profession which we refer to it. As a matter of fact, we just finished publishing a career booklet entitled World of Aviation Maintenance, and we are now on our second printing of 25,000 copies, which goes to high school students seeking a career. And they contact us for information about the aviation maintenance occupation, and this is just a little booklet that lists some of the highlights. We don't go into the salaries; we don't go into where the jobs are. We go into kind of the generalities of the industry. Where the schools are, what kind of a -- you need a mechanical aptitude, let's say. You need a high degree of personal integrity, discipline, be willing to be educated to a high point. And so we help in those manners, and it's frustrating to me to know that the schools that we're encouraging these students to attend are still teaching to levels of ten

years ago, fifteen years ago, and it's sad in some instances because these students do go to school and then go out and get a job at a dental equipment factor or they go work on the ferry boat system for the San Francisco Bay authority or they go up to Canada and work in a pumping station for some of the pipelines.

One of the problems is the cost of it. There's a few schools here, a couple of them represented. I'd like to see the show of hands of those who have a PT6. How about a Garrett 331? Too damned expensive. They've got the old 18-foot long Westinghouse jobs that weigh three and a half tons. The theory is similar but not the application, really, so much these days. Not many schools have the necessary materials to teach repairs on bonded structures or even honeycomb structures.

The cost of the schools to tool up for the state-of-the-art training is becoming increasingly higher. When we start talking about the high cost for training aircraft mechanics on turbines or bonded structures, we can really hold onto our purse when we start talking about training aviation technicians.

I've been told that the rule of thumb for equipping a medium-sized aviation school, around 25, 35 students, is $400,000. And you're going to take two years, eighteen months to train them. It's quite an investment. A lot of Board of Trustees of schools, they say okay we can take a half million dollars and we can put it into this program and train 25 students or we can take a half million dollars and put it into diesel mechanic training.

It takes six months and they're going to go out and get a job for $11.50 an hour, and we can do 100 students for the same amount of money that we do 25 in aviation. So their rationalization there is that aviation is a great industry but they can't afford us either.

But we'll get into avionic technicians at another time, that's a can of worms I don't think we want to fish in today. One of the problems with avionic training is because we don't have any real licensing procedure for avionic technicians. And because of now licensing procedure, we have no established curriculum.

Yes, the FAA in times past has published a guideline for it, but as I said, we'll discuss that at another time. We are here to discuss a nice mouthful, the interrelationship between aircraft design and maintenance personnel and the effect of air safety.

In today's industry, aircraft are being designed by college-trained educated engineers for cost effective manufacturing and cost effective operation.

That seems to be the key to most of the manufacturers. How much is it going to cost us to make it and how much can we sell it for? What is our profit going to be after it's all done? I'm a capitalist myself, I'm all in favor of it; however, we have other considerations to make. However, these well-trained engineers have forgotten the people who are responsible for the maintenance and servicing of the aircraft and the environment in which these aircraft are maintained.

I think many of you are familiar with Chilton's motor manual, they have two for automobiles. We don't have any type of book like that in aviation. They give you the shop rate in the field, and they give you the factory time to do a job and there's quite a bit of disparity between the two. Many times I've heard A&P's make the comment they'd like to see the engineer who designed the aircraft try to repair them. I'm sure many of you have made that comment yourself. In fact, some of the older A&P's almost refuse to work on some aircraft models, and young A&P's are a little easier because they just don't know better.

Perhaps you have heard the stories about the Luney aircraft. There are, indeed, some serious considerations between air safety and aircraft design, because it's the human factor that has the biggest effect, and I believe in this. More of today's aircraft are being designed by good engineers, but only for other engineers.

They're not being designed for aircraft mechanics who do not have the benefit or the formal training. These are good, intelligent people, but they just don't have the level of education, the sophistication of the formal training available to the engineers.

The large majority of today's aircraft population are individuals who have probably two years of vocational school training. There are some schools that have crash intense courses. Part 147 schools that do go through in a year, but that is quite intense; where they had similar training in the military. In the military these days, as Major Graham can discuss, they're training specialists today.

Many aircraft mechanics today, especially some of the older individuals, received their basic training in the military. Another show of hands here.

Who received their introduction into aviation maintenance in the military and went on there to obtain your license? You did not go to the Part 147 schools because you achieved enough well-rounded education, which part 67.77 states that you have to have.

In today's military, they're trained as turbine specialists, or they're trained as hydraulic specialists, or they're trained as wheel and freight specialists. They don't receive that rounded training, so one of the problems that the Foundation sees is that we cannot look in to the military to supply us with the mechanics as we have in the past because they don't have the rounded education.

That's why we tell all, even military people coming to us for information about the industry, we suggest they go to a school. The training that they receive in the military will help them to a great deal but it's hard for them to come right out of the service and then go through 65.77 and win.

As I mentioned, they definitely lack the advantage of state-of-the-art knowledge that these engineers have. They were simply not trained to maintain service of the aircraft of the '80's. I see a lot of advances, I hear a lot of advances that are being made, and that's great. Having an on-board computer record, and you can interrogate it for discrepancies that the aircraft or power plant had while in flight, that's great. But that's still nine months away, according to the man from Boeing.

Yet IBM has their own computer that has been doing the same thing for the past eight, nine years. You take an IBM computer of eight, nine years manufacture, and it has a little panel, and you can poke the buttons, and you can get a pointout, and the computer itself will tell you I made a mistake on this many times, and I've got this kind of problem within me, and here's how you can fix me, in some instances.

We're advancing some places very rapidly and other places we're quite behind. As a matter of fact, most new A&P's only have the knowledge to work on small single engine aircraft or light twins. I think we all realize that every new A&P actually emerges into the aviation industry in general aviation.

All Part 147 schools are essentially regulated by the GADO's or FSDO's, not by the air carrier people. It's a general aviation side, so that's where their first introduction comes. And most of the schools, because they do not

have the budget, they just can't afford the state-of-the-art technology.

They can't afford the PT6's. They can't afford to buy a repair kit for bonded structure. This attitude is evidenced by many maintenance managers. I'm sure many of you realize that when you hire a fresh A&P, you're not going to turn him loose on an aircraft all by himself or herself. They say go wash parts or strip aircraft or here, be a gopher for this A&P, help this hand there a little bit, work a couple of years and we'll turn you loose on your own.

There's a saying in the industry, I'm sure you're familiar with the new A&P ticket, it's really only a license to learn. Kind of like a beginner's license, then you need two years of practical experience before you can be trusted out on the line by yourself.

In view of the current training situation, I must agree with this, it is not wise to place a new A&P in the position of responsibility without first determining the skills, and very important, the integrity of the new A&P. It's a sad but true note that there are a small percentage of A&P's who lack the skills and dedication and integrity that our industry needs and demands.

There are those individuals who hold an A&P license, they earned it many years ago, I'll say earned, but for the past ten years they have been working in a turbine overhaul shop. So when a friend comes up to them and says I've got a light aircraft, can you do a 100-hour inspection on it for me, he'll do a 20-minute walk around paper inspection and sign the log book and collect $50 or $70, or whatever the market will bear. And with regards to specialized endorsements of the A&P license, I believe that's going to be discussed later so I'll not get into it here.

Suffice it to say, ten years ago there was not such a strong need to look at specialization within the A&P license, but today our industry is advancing too rapidly and so we must look at it because the regulatory process takes too long, and currently it's too far behind us.

So it's necessary for us to take some measure and very soon. Any type of study that the FAA would do on this would probably take two years and another two years for implementation, so we're looking at four years. And I think that's a realistic figure.

Any changes that even if they started them today, it would still be 1986. I'd be surprised if it took less time. We feel that the need for the study, and

as I mentioned we'll have this meeting at 6:30 tonight, Room 403 at the Hilton -- I've got to get my plugs in here.

While discussing the relationship between aircraft designers and safety maintenance personnel, I'd like to touch briefly on Jim Rice's topic of professionalism within the A&P ranks.

Let's say you have two years of intense vocational training behind you, you've invested a couple of thousand dollars in tools. The average new A&P, within a year or two of graduation from an A&P school have in excess of $3,000 in his toolbox whether he goes to work for an FBO or goes to work for an air carrier, he still has a solid investment in his hand box.

He's got to have a Federal license too, let's not forget that, issued by the FAA for work on aircraft. Everytime you do, you're placing your career and your livelihood on the line, each time you essentially sign off an aircraft.

And in some instances I've heard of A&P's who were sued that did not even sign the log book, but they did work on the aircraft. So you're out there, you've got a ticket in your hand, you've got $3,000 in your toolbox, now what? You can probably get a job that pays $6 or $7 to start. Kind of frustrating.

What would your attitude be like? Many young A&P's who have a good potential within our industry become frustrated and leave aviation for other industries that appreciate and pay for these skills. Other industries are most willing to hire A&P's, because of the tremendous skills they've learned.

Dr. Rice went through a long list of 16 or 18 different skills, and any one of those separate skills can earn you more money in another industry.

Another problem we have in our industry, talking about the shortage, is 30 to 35 percent of all new A&P's leave aviation once they receive their license. Most of it is financial. We do have a certain population of international students who just come over here to learn, get the license, they're put on the role of statistics that we have so many aircraft mechanics, but then they go back to their own country and practice their profession.

Again as mentioned earlier, the increasing use of turbines in other industries is draining us. A&P's are the only trained group that knows how to maintain and service turbines. Outside the manufacturers themselves, the only place that you can really learn turbine maintenance and repair is at an aircraft mechanics' school. So we're being drained by these others.

The San Francisco Bay system ferry boats. They have ferry boats that have, I think, three helicopter turbines in each one, and they have a group of A&P's they hired away from the airlines to go and maintain these ferry boats.

Bus lines, pumping stations, standby electrical generating plants, railroads, many other industries are turning to turbines. Again, I've mentioned here the dental equipment repair facility. I understand right here in Oklahoma City when they built the new General Motors Assembly Plant, not too far from here, as the building was being constructed they were scouting around the FBO's in the area looking for A&P's they could get to go maintain the equipment once it was installed.

They probably are still looking for people. I talked with Catlan Aviation last year, and they told me when General Motors came to town they knew they had about three years to keep their maintenance staff happy, after that they'd probably lose them. So Catlan Aviation, just over at the airport, they went on a three-year salary increase program so that by the time General Motors opened, they would be competitive salary-wise with General Motors.

The scales of disciplines learned by A&P's are many and our industry needs to appreciate them more. I'm sure you can see the frustration of many A&P's when our own industry thinks less of them than the other industries.

The result is a well-disciplined A&P who will continue to perform while healing this frustration. As I mentioned, the Foundation will soon be ten years old, and we receive letters from long-time members, seven, eight, nine years, who say I'm sorry I'm not going to renew my membership I've left aviation and I drive a milk truck and I get $14 an hour. Or they go to work at a manufacturing plant because it's difficult these days to raise a family on $6 or $7 or or $8 an hour. True, they have got to pay their dues, and I think some of the older A&P's in the industry will say that.

Well, they've got to learn, they've got to pay their dues, they've got to bleed a little bit because then we know that they want to be in aviation.

Well, to this day we are playing by a whole new rule book, we're not playing by the rule book that was designed or used ten years ago or twenty years ago. I think in the year 1980 we had a whole new rule schedule drawn up. I've got a little story here, there is money in this industry, I'm sure you know it. I met an older A&E one time, and he said there's a lot of money in aviation,

it's been here over 40 years, and he hasn't taken a dime out so it's still got to be here.

Obviously there's a direct relationship between maintenance personnel and air safety, and we know that there are two tiers in aviation, essentially. We have the general aviation sector, and we have the commercial sector. We won't get into the military side, because they rarely have to have a license. And they rarely meet, with the exception of the area of maintenance. Almost all pilots residing in the commercial sector have their up duty TP rating and lots and lots and thousands of hours. They meet the requirements of that appropriate regulation, I believe 121. Most pilots in general aviation just have the ratings appropriate to their needs. If they are in corporate aviation, perhaps they have an ATP. If they work for an air charter outfit, maybe they just have a commercial multi with an instrument rating. So they don't really have to go to that extent.

But the point is, there is the diversification of licenses within the pilot ranks. Except we don't have that in the maintenance side, we have an A and/or P. We do have the inspection authorization, there's about 7,500 IA's. Most mechanics only need their A&P ratings to apply for a job, and as I said the coveted inspection authorization is held by about 7,500 individuals, that's about 6 percent of the total A&P population.

The A&P license is a good license, it's good for life, essentially. You need it to maintain a J-3 cub, 747. You only need an A license to maintain a hot air balloon. So with that A license you can go work on just about any type of aircraft. With that P license, the same thing. Put them together and you've got a pretty decent combination.

Once you receive your A&P license, it's good for life. Again, there are some reservations, but you don't have to do a medical. The FAA doesn't even know how many aircraft mechanics there are. Nothing derogatory, I think it's just the fault of the system that started on July 1, 1927 when they started issuing licenses.

They just kept track of everybody. According to the FAA, there's over 230,000 airline mechanics, but that's since day 1. You don't have to stay current in any manner, you don't have to have any recurrent education, you don't have to stay up with advancing technology really.

Does this affect air safety? That's what we are here to talk about. You'd be less than prudent if you said it didn't. Aircraft mechanics are about the only trade group licensed by the Federal Government that is not required to have any form of recurrent training. I'm a great proponent of continuing education, because I think that promotes professionalism, and professionalism does, indeed, promote safety within most any industry. I'll be the first person to say we don't need any more additional Government regulations, but in this instance I think the FAA's current plan to require A&P's to renew their license every three years is a good move in the right direction.

As the situation exists now it's not helping much. Hopefully this three-year renewal plan will help things quite a bit. The nonregulatory need for recurrent training has a dramatic effect on air safety because those individuals licensed thirty years ago, unless they are prudent, they have had some strong personal motivation, they really haven't stayed up with current technology.

That's what we've seen a lot of today. What's happening tomorrow, next year, 1990? Major Graham talks through the year 2000. He's very difficult to talk to because he doesn't know what is happening today. I'm sorry. He's talking about what's happening ten years from now. And just as a citizen looking at our military, it's scary to see what's going to happen to our military force. Many changes are going to have to be accomplished, so as I said they don't stay current unless they have a strong personal motivation. And this situation does provide a poor environment for professionalism. We all realize the need for more professionalism within the maintenance community and continuing education as an absolute necessity in order to accomplish these ideals. Perhaps ideals, perhaps true facts.

This continuing education must be supported, and this is one of the best parts of this little talk. The continuing education must be supported by those individuals and companies designing today's and tomorrow's aircraft. The parochial attitude that some organizations have with regard to the technology they develop is really not in the interest of air safety.

In fact, by not disseminating this knowledge, some attorneys feel these companies are holding themselves open to lawsuits. That's for the lawyers to decide. I do not feel that they have to give the store away by revealing all of their proprietary information, but there should be a stronger relationship between the manufacturers developing the technology and the schools who have to

teach the technology. And we have the mechanics who are in the middle who have to utilize this technology.

There's got to be a better relationship between all three of these people and companies. Most manufacturers do have specialized training schools at which they train aircraft mechanics for their specialized systems. And these schools are usually run in conjunction with the product-support department. The theory there being, you train the people how to use your product, and the better they know how to use it, perhaps the more they'll buy of it. It's a good theory, it's a great theory.

And they serve a purpose, but they do little to help the new aircraft mechanics. And as indicated again in Major Graham's talk, the median age of aircraft mechanics is slowly rising. I believe the median age of mechanic personnel within the FAA is past 55, 58, somewhere around that neighborhood. But schools, we've got to have more knowledge given to them, sold to them, provided to them in some manner. They've got their own parochial attitudes.

I've heard some comments by some reputable schools representatives say it is not their responsibility to bring new technology into the school. They teach what the FAA tells them under Part 147 to teach. I know from firsthand knowledge of some schools simply unwilling to work with industry, or for that matter with other schools.

And the FAA must take their share of the blame. Since the first aircraft mechanic received his license on that hot July day in 1927, the FAA has paid little attention to the maintenance community. I think this is evidenced by the continuing reorganization of the maintenance side. Further, there seems to be a lack of interest on the FAA to keep the FAR's current with the industry. There's some political cartoons that poke fun at the FAA but I won't put them up on the board, I'll send them to you.

On the one side, the FAA is charged with regulating industry, but after the regulations have been approved they just remain static. The largest part of the blame for this attitude must be accepted by us in industry.

We are really the manufacturers and doers, but we haven't done a damned thing to improve the situation. We look at the FAA to improve regulations. We look at the schools to provide new mechanics. We look at the manufacturers to develop new technology. But somehow, someway, none of this has really come together in a nice, smooth pattern.

We've been content to design and build new aircraft systems but without the proper support. And as I said, I'm not just referring to the manufacturers, I see the attitudes throughout the industry.

The Foundation conducts a lot of surveys of the industry. We have a small division called our Statistical Data Service where we survey the industry to find out, again, the demographics of the industry, of the maintenance side.

One of the questions that we ask in there: Do you feel aircraft aren't manufactured with maintenance in mind? Better than 90 percent say no. The other question that goes out to these people said: Do you feel that today's aircraft mechanics are trained to work on today's aircraft? Better than 80 percent say no. What are they doing? We conduct a continuing series, the Foundation does, a continuing series of aircraft maintenance service seminars for aircraft mechanics.

These seminars are held at no charge to the mechanics. And in order to put together an agenda for six or eight speakers, it's usually a two-day program, we've conducted over 100 of these seminars. We have to call 25 to 30 companies asking them to speak on particular subjects.

The ones who say no usually give the reason that they are not interested. Surely they're interested in selling their products, why aren't they interested in supporting it? Our industry is now moving into high gear, and this complacent attitude must be changed.

We, as an industry, must be willing to work more closely together. We must be willing to share information that is really not too proprietary. That means if a manufacturer should loan, lease, rent, sell, however, provide some of the new products that they make to the schools, whether it be on a revolving loan basis or something, I feel this should be done. And the manufacturer should be willing to open their training schools to the instructors.

The manufacturers can learn a lot from the schools because they see the industry on a day-to-day basis. Some schools live in ivory towers, others are pretty darned good. If an FBO needs an experienced mechanic but only a new A&P is available, that FBO should be willing to provide on-the-job training. We've all heard the old adage that most maintenance employers these days want a 20-year-old man with 30 years of experience.

Or they say I want a fellow that's got 6 years experience on this type of aircraft. Or I want him to have 7 years experience on a DC-9. Well Lord, if he's got that much experience on that kind of aircraft, he can get a job anywhere.

We have to come under some new understandings. We have new rules with which to work today. We've got to grow. Our industry is, but we have to prosper along the way. Some manufacturers are hurting, others are doing quite well. Some airlines are laying off, some airlines are hiring. Some airlines are making a profit, some are losing.

Personally, I'd like to see some form of an advisory committee established that's made up of members of the industry, whether it's organized by the FAA or by the Foundation or we start something this evening, I don't know. But I think that we should have representatives from all sectors and, of course, the FAA, to discuss these problems at some length. I think this workshop here is an excellent form for these types of topics, but we've got to continue beyond here and come up with solutions to the questions that are being asked. The purpose of this committee that I'm proposing would be to establish a method of transferring new technology information from the source to the schools where it should be taught to the new people.

This committee should also be charged with developing a plan to provide schools with new products, to introduce the next generation of mechanics to the industry without just being thrown into it.

In return, the schools can assist industry by advising of their training capacities and the quality of the graduates that the industry can expect. The products, their end product, is what you'd be hiring in the coming years. And additionally, the schools can provide knowledge of practical design that the manufacturers often overlook in their zeal to design efficient aircraft.

The interrelationship between aircraft design and maintenance personnel and the effect on our safety goes far beyond the needs to design aircraft that can be easily maintained. We do not have a bunch of dummies out there that don't know how to work on aircraft; we have intelligent people. It's just that aircraft are becoming far beyond the capabilities of one individual to assimilate the knowledge of.

It is a philosophy. Again, as Dr. Rice pointed out, it's a philosophy that must be more easily developed. In our industry, all sectors will prosper from it. We have experienced some tragedies in our industry. There was a problem in Chicago some time back, and no one is really to blame, but there seemed to be a lack of transfer of information from the manufacturer to the maintenance people as to what and what not to do.

It was just a tacit approval of go ahead and fix it the best way you know how. And that just doesn't cut it these days because the aircraft are too big, too sophisticated, and the individuals still have the knowledge from ten years ago, fifteen years ago. We must avoid this type of sadness at all costs. We must avoid these tragedies.

Aviation is obviously destined to become the primary transportation. I think that's quite evident, otherwise we wouldn't be here. But yet we are barely into the second generation of aviation as we know it today. If you think about it, aviation as we know it today really only started post-World War II. That was 33, 35 years ago. So we're barely into the second generation, but yet our knowledge is still halfway through the first.

Aviation has a job to do and I think all of us here will pitch in and help work with it, but we've got to work closely together. I see a good rapport starting at these workshops, and I'm sure I'll plan to attend more. I won't take up any more of your time. The bus leaves in ten minutes. Thank you for having me, Joe, I appreciate it. Are there any questions perhaps I can respond to?

QUESTION: Do none of the American airlines tend their own personnel?

MR. KOST: American Airlines, I believe, does have some in-house training capabilities ---

QUESTION: I mean apprentices.

MR. KOST: Apprentices?

MR. PONTECORVO: He means U.S. airlines.

MR. KOST: Excuse me. No.

QUESTION: There are no apprentice schemes?

MR. KOST: We do not have such an animal in our industry. There's no such

thing as an apprentice. You go to an A&P school or you go and get 18 months of experience for one license, 30 months of experience for two licenses, and then you can sit for the examination. And if you pass the examination, then you can earn your A&P ticket.

QUESTION: That's the root of the problem then, isn't it? We're only a small airline but we've been running our own apprentice scheme for the last 15 years. Both avionic and A&C, and that has worked for us.

MR. KOST: I think in our industry, industry looks to the individuals and and the FAA and says okay, in order for you to come to work for us you have to have an industry level license, which is termed the A&P, that at least says that that individual is up to a certain level of knowledge and expertise, and prior to that it's plain and simple. A lot of people, many people, love to work for the airlines because it's decent working, you work on good aircraft, salaries are great, the benefits are super, so everybody would want to go to work there.

So the airlines, themselves, have to have some sort of screening device, and this is how they do it. They say to come to work for here, I want an A&P. Right now, the Foundation is working with two of the new upstart airlines, as they call them, and they placed, I guess you would call it, an order with the Foundation.

They want 100 A&P's by the end of this year. And I said, why don't you train some people? We don't have time to train them. Why do you want just A&P's, aren't you a repair station? We have repair station facilities, but we want that entry level knowledge. And that is why the A&P ticket is so coveted, is that it does give you an entry level into the airline, into most any job. It shows you have accomplished something and you have at least provided that personal determination to be there.

QUESTION: But surely the airlines must, at this stage, they must recognize that they must put something back into the industries themselves?

MR. KOST: Good question.

PARTICIPANT: In fairness, and I shouldn't be speaking to this, an American boy should be speaking. I think there is a difference here. In the United States there's 146 schools that teach A&P for the license. And in most of the European countries, and like in Canada, we've only got 8 such schools,

and those schools can't meet the need of the industry. So the airlines in Canada do have apprentice programs. But I'll assure you, if we had the proper number of schools, which in relation to the American schools we would have 14 or 15 schools, but we've only got 8. I'm sure the airlines would hire only directly from the schools, if we had enough schools. But we don't have, so we have to have an apprentice program to supplement the schools.

QUESTION: Obviously from what is being said today they don't have enough schools in the United States either.

MR. KOST: This problem has only come about in the past couple of years. Previously we had an over-supply of aircraft mechanics, that's why the wages were so -- you had to open up the hatch to find them. They were way down low, we had an over-abundance. We had World War II, we had Korea, we had Vietnam, and they were training mechanics by the multi-thousands. And when they came into the industry, they would gravitate towards the airlines and the airlines, they had no need for any type of apprentice program because they had a constant incoming supply of military trained personnel.

So there was no need for it. Now again, we were into a new rule, new rule book, we're still writing them. And this is why we've no apprentice program, it's something that possibly can be considered. Some of the schools may have comments to make about that, but I think a topic like that could be discussed for a full day itself.

Are there any other questions?

PARTICIPANT: I would like to make a correction. We at Eastern Airlines do have an in-house apprentice program whereby we provide in-house training for a limited number of unlicensed employees not only to acquire their license but to gain some practical knowledge in the field of aviation.

MR. KOST: This should be corrected. There are some organizations that do have this, but it's really not industry widespread, it is mostly within certain companies and it's a very obviously self-servicing purpose. One last comment?

QUESTION: I just wondered what it would cost to get an A&P ticket now.

MR. KOST: Embry Riddle, Fred, what's your tuition?

FRED: $1,350 a trimester. There are five trimesters. That's just tuition.

MR. KOST: $6,500, plus tools, plus books, plus plus. Some of the public schools say just buy your books. Some of the public schools say it's $100 tuition or $500 tuition. Some public schools even provide the books and the tools. So it varies from state to state and depends upon what their educational process is.

Okay, we've run out of time. Thank you, Joe.

MR. PONTECORVO: Thank you very much. We have about 15 minutes before the bus yet, so you don't need to run off.

SESSION 2

(July 8, 1981)

MR. PONTECORVO: Good morning, gentlemen. There are going to be a few changes to the roster -- I mean the agenda, I'm sorry. I've got roster on my mind. I'll go through the changes in the agenda.

The reason I mistakenly said the word roster is there are some new people her this morning and would you please sign the roster so that we can get it typed up and distributed. Also I want to remind everyone that there is a message board outside the room. If you would check it at the break, it's just on the wall. As you go out the door, turn left and you will see it.

Also there's a phone in Room 124 for those of you that need to make calls. I think that's all the logistics announcements. Now let me tell you what we're going to do with the agenda proper.

This morning we are going to have Ed Thomas from the ATA who would like to say a few words, and then we'll have Mr. Kraus, who was scheduled for yesterday afternoon, following him. And at that point we'll get back to our regular agenda. We'll try and schedule lunch from 12:15 to 1:15 and then right after lunch another addition to the agenda will be Ed Koziatek; Ed is with the Transport Workers Union.

If there is anyone else that would like to have a spot on the agenda, then get together with me at lunch or during a coffee break or any time that you see I'm free. And with that I'll ask Ed to come up. Ed Thomas.

MR. THOMAS: Thank you. When Walt left me yesterday, he said that he hadn't defined human factors yet. After listening to the presentations yesterday, I decided human factors means whatever you want it to mean.

I got my introduction into the aviation mechanic business about 42 years ago when I was turned to duty as the assistant to an old Buck Sergeant Crew Chief. My first job was to -- he sent me over to the supply room to get some aluminum soap so I could wash the -- (inaudible).

Do any of you know what a Buck Sergeant is? Any of you who know what aluminum soap is, you're probably older than I am. After a number of years as

a mechanic, I decided I wanted to be an engineer because I figured engineers didn't know what the hell they were doing when they were designing airplanes.

I figured that the only thing that they really did was to find out the thing that was always going to go wrong and then build the airplane around it.

We heard some comments yesterday that I think gave, perhaps inadvertently, some misconceptions of the aviation mechanics and I think particularly the airline mechanic. The airline mechanic is a very important part of the airline organization. There is a requirement in part 121 that there be a maintenance training program and the mechanics are provided training. They're provided recurring training, and they are provided training whenever any new equipment comes on into the inventory. They are required to have this training. The manufacturer supplies this training in some cases.

So there are training requirements that keep the airline aviation mechanic current. The other comment that was made which I think may have been inadvertent or may be made in ignorance, I'm not real sure which, is the concept that a mechanic -- he gets a license and then he can go out and do anything he wants whenever he wants.

And I'd just like to read -- I don't often quote FAA's own regulations back at them but I thought this would be useful. And to set the record straight. If you look at part 65 and part 65.81, which is general privileges and limitations.

It says a certificated mechanic may perform or supervise the maintenance or alteration of an aircraft or appliance with part thereof for which he is rated but excluding major repairs to and major alterations of propellers and major alterations to instruments based upon (inaudible) 65.85, 87 and 95.

However, he may not supervise the maintenance of or alteration of or approve and return to service any aircraft or appliance or part thereof for which he is rated unless he has satisfactorily performed the work in turn at an earlier date. If he has not so performed that work at an earlier date, he may show his ability to do it by performing it to the satisfaction of the administrator or under the direct supervision of a properly rated mechanic or certificated repairman who has had the previous experience in the specific operation of concern. The certificated mechanic may not exercise the privileges

of a certificate rating unless he understands the current instructions of the manufacturer and the maintenance manual for the specific operation concerned.

And 65.83, which is titled "Recent Experience Requirements," says that a certificated mechanic may not exercise the privilege of his certificate and rating unless within the preceding 24 months -- I'm about to burn my fingers -- unless within the preceding 24 months the administrator has found that he has been able to do that work or see he has for the last six months served as a mechanic under his certificate and rating technically supervised other mechanics, supervised in an executive capacity the maintenance or alteration of aircraft or been engaged in any combination of what I just said previously.

So, you know, the piece of paper doesn't make you a mechanic. That's number one. But number two, before you can exercise the privileges of your certificate, you have to know what you're doing. And you have to be current. And I think the record should show that what was said yesterday was not exactly true. Thank you.

MR. PONTECORVO: You might take that with a grain of salt. I think the person that made that statement was not a certificated A and P mechanic.

MR. THOMAS: That's right.

MR. PONTECORVO: So, you know --

MR. THOMAS: He's been in the business for ten years though.

MR. PONTECORVO: That's what he says. I don't know.

Yes, it is. I don't think a reply is necessary. Anything else?

Okay. Ed Kraus. Ed Kraus is with the National Transportation Safety Board. And Ed is going to tell us a little bit about some accident statistics. Ed has been on the Board for a number of years doing accident investigation in the field and is in headquarters now and wroks a great deal with the numbers so he is highly qualified.

MR. KRAUS: As Joe said, I'm with the Safety Board in Washington. We just happen to share the same housing that Joe lives in down there on Independence Avenue.

I sort of felt for a while I was going to be the senior man here, but Ed Thomas beat me out by one year. I've been sort of fooling around with this business for the last 41 years. And I sort of feel that the experiences I have had are some of the experiences that some of you people are having now and some of the ones that you probably will have a little later.

I specialize in the systems investigation with the NTSB and by that I mean the hydraulic systems, the power plants, the electrical systems, pneumatics, whatever system you are going to refer to. Normally I don't do too many power plants or structures investigations. We have basically specialists for that; however, I do get involved with those from time to time.

The work that I do basically is in the area of air carrier and corporate aircraft. I don't get too involved in general aviation aircraft, meaning the smaller type. I started research of this subject of lessons learned from maintenance errors, and I thought that I would be presenting a comprehensive picture of facts and figures.

I started looking into the -- this and come to find out that the accident picture in relation to maintenance -- I have to keep in mind we're talking about maintenance -- is that it wasn't too bad at all. In fact the more I look at it, I see it's a pretty good picture. This whole thing we've been talking about, all this training and all this schooling everyone says, "Say do we need all these things for safety?"

Everyone throws the word safety into the picture because that makes it more impressive. Because the thing is, what are we really talking about and the end product is no accidents. If we have no accidents, we must be operating pretty safely. And I was surprised to find out after reviewing 103 reports -- and I used them -- I'm basing this on all of the reports that the engineers have put out. There were only 12 accidents that I could really associate that the maintenance people had -- or the maintenance area, had any relationship to the accident.

That's only about 11 percent, and that's only of these air carrier and I must say between air carrier and also commuter accidents were cranked into that. In order to give some direction to my little talk here, I chose four categories to talk about. They are the air carrier, general aviation, home

built and bogus parts. We want to keep in mind that I'm relaying only to human factors and aspects to the personnel association with the accident.

I selected a couple of accidents that I'm going to read, and I guess maybe a little later when I'm through reading, if you want to go back and discuss that, we can do that. But I'm going to just review them. And keep in mind like I mentioned, the human factors aspect.

Last fall we had a DC3 down in Florida. Started down the runway, by the time he gets the tail into the air, he finds out both air speed indicators weren't working. So he aborts the takeoff, taxis back to the ramp; and I think it was about eight o'clock at night. And it was last Setpember I think it was. September or October. So try to get related to that fact that it was still daylight. Taxis back to where they loaded the passengers. It was a charter flight over to the Bahamas. And as you probably are aware, they did not exactly have too many mechanics on the ramp. Exactly none. The only man they had there was the director of maintenance. And he immediately jumps on a stand. The fellow worked on a DC3 years ago -- I guess I'm giving my age away here. But the first thing you do, you run and out and look at the pilot heads hanging down there, and you say, "Ah, yes, the mud daubers have filled up the holes."

So the first thing you do, you get a piece of safety wire to bust the mud out, told the pilot it's okay. So the pilot jumps in the airplane, loads the passengers back on; and they said, "Oh, we'd better test this thing before we get into the air."

So they make a high speed taxi test down the runway, get the tail back up in the air again, you know. I guess both air speed indicators moved and they taxi back, put the passengers on and away they went to the Bahamas. Except they never landed in the Bahamas as they landed in the Atlantic Ocean. And at this point we never recovered the airplane.

So what we are really saying is: What happened to all the rules and regulations, all the mechanic's certificates, all the refinements that we have for doing certain types of work. And checking things to make sure that things work. Everyone said, well, anyone can fly an airplane without air speed if you have got experience. The point being it was the air speed indicators were certificated to be operable for use in that aircraft. And at this point no one know whether they really were or not. Another case.

A DC9 -- for those of you who probably remember this one. This was the Air Canada DC9 that the rear pressure bulkhead blew out up on takeoff out of Boston. What's interesting about this accident, this -- prior to the accident there had been cracking in the rear pressure bulkheads and there was an AD out on the rear pressure bulkheads.

So, what I'm trying to tell you is that previous to that everyone had been looking at rear pressure bulkheads. Even Air Canada. Four months before the bulkhead failed, the bulkhead had been X-rayed, which was a requirement of the AD. But what happened?

Well, this is one of the ones that we really never know what happened because when you go back and everyone looks at the X-ray and look at the crack, right there on the X-ray was the crack. So it's not something that anyone didn't know about. It's just that no one was able at that moment to interpret that crack on that X-ray. So just keep in mind I'll be getting to a couple more of these and keep in mind and see how these things are showing up as a trend or pattern of what we are doing.

About two years ago -- two and a half years ago I guess it was -- Gulfport, Mississippi, a Beech 70. It was a converted 65 to the excalibur modification. Took off and crashed on the airport. It was interesting that when we first got there to this accident we had all kinds of witnesses. It took off right there -- the runway just happened to go past the front of the terminal. We had witnesses watched the airplane take off. And of course he just climbed and did a slow roll right onto the airport, and everyone said, "Well, gee, that's fine. We heard some funny noises and what have you." To make a long story short, what really happened was the nose cargo door come open. That doesn't sound too fantastic at the moment because we have other brand aircraft that these cargo doors are continuously coming open as far as the Safety Board is concerned.

But anyway, in this case the cargo door came open. And that investigation, I guess about the second or third day, it was interesting what we found. We found one thing that ten years prior to this accident, ten years to the -- I wouldn't say to the year. Not exactly, no, but ten years previous to this, we lost eleven nuclear physicists out at Albuquerque, New Mexico, for the very same thing. The front cargo door came open.

Now, that's interesting to think that ten years later we have the same accident. But it was more fantastic just because of the door coming open or should I say how the airplane got into the air with the door not latched. On all of these particular model airplanes the cargo door, when it opens, it opens in line with the right propeller. And so the first thing that happens is the right propeller starts chewing the door up. And Beechcraft put a safety circuit in that door, that when the door was not closed you cannot start the left engine. All it did was cut out the coil or of the starter relay, and you couldn't start the engine.

So what do you think people do to overcome those problems? Maintenance wise? Well, on the Albuquerque, New Mexico, one we found out it was -- what they did, they politely took the safety circuit out of the picture so that regardless of what the door status was, you could still start the left engine. But this accident I'm referring to in Gulf Port, they had complaints on the left starter or left engine not starting.

However, they sent it in to a contract maintenance at the airport. They didn't have any of their own mechanics at that station. The way they worked it, the pilot was responsible for getting the maintenance accomplished wherever or whenever he could at a station that didn't have maintenance personnel. So he chose a -- the local maintenance base.

I think the airplane went in there in the evening about four o'clock, and it seems like he stayed there and watched some of the work being performed -- whatever it was. We never really found out what happened or what was really being done. But anyway, it's what the maintenance people did. They politely put a jumper wire across from one magneto switch to the other magneto switch, which in turn completely cut out the safety circuit. So that when you got power to the right starter switch, you also had power to the left starter switch. You could start either engine. Of course the crew members, all they were interested in was would the starter work. That was their main objective. The next morning they get out there, both engines start. They take off and the door comes open. There's a lot of reasons why the door came open because the agent who unloaded the airplane never went back to close the door. The pilot never checked the door. We realize all those things.

But it was interesting in this case they put this jumper wire on it. It was very obvious when we started looking into the safety switch circuit was that almost all the wiring in the airplane was white. White plastic type wiring -- (inaudible) -- but the jumper wire they put in there was perfectly a bright red. It couldn't have been any redder than you want it.

It stood out like a sore thumb when you found it. It was interesting. We went back and tried to find out who put the jumper wire on it. And of course a week later and a hearing later, we never could find out who put the jumper wire on it. I talked to maintenance foreman. I talked to the mechanic who worked on it. We talked to everyone, but nobody put that jumper wire on it.

So what I'm really trying to tell you is that the mechanic that put that on, he knew what to do. When you say what to do, he knew how to get the electrical circuit completed. He knew what his problem was of getting that left engine started. You had to have power to start a relay, and he got power there. So it's a good example that some people do go out of their way to overcome something, but if he had gone a little bit farther and would have really understood why the safety circuit was in there, we might not have had that accident.

The Dehavilon 6 about two years ago out in Colorado somewhere or Wyoming. The pilot started the engine. I think I should say attempted to start the engine. Got a hot start. Decided that even though the temperature gauge hadn't gone up to the red line, he would tell the maintenance people about it. They looked at the engine. And I don't know what all they performed at this point, but they determined it was okay for service. On the next takeoff, the turbine wheels let go. So they lost the airplane, because they couldn't make it back to the field.

Of course, there was a case that you might say is faced by almost every -- that's for sure -- almost every airline mechanic that works the line operation, these are routine occurrences, and they are called upon to make a spot judgment at that time. What to do. When we look at it and it looks good or when we take the cowling off, we do a little more internal borescope work or whatever is determined to be done, it's up to the mechanic. And he's the one that has to make that decision.

Next one I have is a Grumman 21. That's a Grumman Goose. I think most of you older fellows, and I don't see too many of those in the room, probably have heard of Charley Blair. He was Maureen O'Hara's husband until this accident caught him. His airplane sitting across the street from our office every day. When you look at it, it's a P51 which he set a record going across the North Pole in. And he was an ex-Pan American pilot. But anyway, he is the one that started his own little airline down in the Virgin Islands and flew those air boats which you might have all heard about.

His operation had been called down a couple of times by the FAA prior to this particular accident for different, quote, infractions of the rules. However, in his accident, when we got involved in it, we got into the maintenance records and quite a few things turned up on the way they were operating, and in the record keeping system.

First, let me give you just a little bit of the maintenance records problems. Since he happened to be the owner, operator, president, general manager, pilot-on-the-spot type of operator, he was in everything. He was in the mechanic's tool box. He was just one of those fellows that had grown older in the service.

He had always been able to do anything he wanted because he was the chief of all -- everything that was going on. And he was familiar with everyone personally. There was this type thing called close cooperation. If Charley walked up and says, "Do this," and he said, "Saw the wing off," you sawed the wing off. That type of thing.

In this case one of the things Charley didn't like to do was to fill out the log books. They would have airplanes that would be out of time as far as inspections go, and if they needed some more additional flying to meet the schedules that they had and some of the pilots wouldn't take it because it was out of time, Charley would jump in and he would fly the ship all day long. Didn't make any difference how many hours it was. He flew the trip, and guess what? He never filled out the log page.

We found four and five days that the airplane was flying. And to give you all a clue as to how we find those things out, all you have to do is go to all the stations and collect all the gas slips for any particular N number.

And you find out that's funny, the airplane is flying and it's not on the log book. So there's a lot of ways of tracking things down.

But on this particular accident, it was engine failure. Most of you realize a twin engine aircraft, you don't have too much problem. If you maintain altitude, why you can keep right on going. But we found -- this was after a little bit of research -- we found out that the cowlings had been changed. Beech 18 cowlings had been put on the airplane.

In addition to that, the next thing we found that created or caused the accident that kept the airplane from flying, was the fact that the propeller on the good engine had been filed down. Now when you say filed down, we're not talking about a couple of nicks. On these air boats, we sent to Hartshorne asking for their minimum tolerance print on the guy or propeller blades. Of course what happened was when that print got to Antilles, they figured out the maximum, they just got started from there.

And these propeller blades were over half an inch under the minimum. And I want to say very poorly contoured. I'm speaking of the face of the blade. The contour they were supposed to keep, they didn't keep. Now the reason it was hard to keep a contour on a blade when you're filing it down maybe once a week is the fact that everybody files a little bit different, which I think we all realize.

But in this case this propeller blade was way, way under. No one really knew how this thing really stayed in the air. And that's what really happened. That's what really got him. He was trying to make a shallow area and just never made it on a single engine, and he was in a constant descent of about 150 to 200 feet a minute. And just never made it and had to land in rough water. And of course the thing dug in and that was the end of it.

So what's interesting was that we could never find out who made the tolerances at Antilles. Of course like I was mentioning, when you talk to some people it's pretty hard to get the right answers about it. So we learned there about filing prop blades.

Another accident that some of you might remember hearing is this takeoff accident of a PA31 in Las Vegas where there was a bunch of tourists on the airplane. I think it was heading for the Grand Canyon. But they never left the airport either. And the conclusion or the cause was that the elevator

stop bolts had backed out. Now, when I heard that, I sort of got excited, because in my experiences it seems like 30 years ago every stop bolt that you had gotten a control service had a piece of safety wire on it to make sure that the lock nut was tight or at least safe.

However, today we have eliminated a lot of the features that -- I'm speaking for myself now -- some of the features that we used to do, I can see every day happenings that we don't do any more. We don't safety a lot of things.

Now, everyone says safety wire can't hold the airplane together. It's not so much holding it together as it is the fact that, at least at the time, someone tightened the bolt. They safetied it. And you sort of have a very good idea that someone was there.

Today no one looks at the elastic stop nuts. It's on there. You can't tell whether it's tight or whether it's ready to drop off. You don't know how many times it's been used, but yet I'll have to admit and we'd get a lot of people to admit the same thing, that the original requirement for lock nuts were that you throw all the elastic stop nuts away after you use them. Always put new ones on.

The feature of elastic stop nuts was sold on the fact that you would put a new one on and it would always be tight. They would never vibrate off. However, I think if you go back to safety nuts today, you'll find out that they have been used so many times that a lot of them are -- you probably put on finger tight which is sort of bad.

Interesting part of this accident was that there was nothing in the maintenance manual that says periodically that you have to check the elevator travel or the control surface travel. It's interesting. You check them for freedom of movement and items of that nature. Check the cables for hanging up. But in this case there was nothing on the inspection sheet, even on the inspection, that you checked the actual travel. In this case it was restricted something like over three-quarters of the travel was restricted because the stop wouldn't come out there that far.

The interesting thing is very rarely are you ever required to push nose down on an airplane. When I say very rarely, I am speaking of extreme elevator

travel. And consequently, a pilot on major control surface travel is always -- he's pulling back to get the airplane in the air, and he can almost tell when he hits the stop. But very rarely forward.

In this case, and no one knew how long this airplane had been flying in that condition. Interesting part is the airplane was only a little over 300 hours from new. It had three 100-hour inspections performed on it, and the last 100-hour inspection was performed five days before the accident.

Another accident, the Beech 99 out of Richland, Washington. This accident was caused because the stabilizer actuator was bad in it. You say, why wouldn't maintenance catch something like that? Interesting. They didn't have any stabilizer actuators in stock at the time this airplane had its first complaint of the stabilizer difficulties.

And what is the first thing that a lot of people do when we don't have the parts in stock? If it's working, we'll put it on the deferred list. And we'll get the part tomorrow. We'll get it from the next station. We'll get it somehow. We'll put it on the next time the airplane comes through.

In this case it took three days later after it was originally written up. The procedure that they had at this particular outfit, and this is unique -- not unique because there's a lot of the units are doing this now.

A community with maybe ten airplanes will start out of a central headquarters base. Maybe ten airplanes will take off in the morning and fly in all directions all day long, and that night ten airplanes come back home. They're all at that base. The maintenance people go out and work on them and do their thing.

But in this case they kept all the maintenance information on all these airplanes in the hangar. They kept the deferred sheets in the hangar. The purpose was that the maintenance people -- the maintenance foreman can keep track of everything he needed and all the work that had to be scheduled for that night, and he knew exactly what was coming up and what had to be done. In this case the pilots never -- there was nothing written in the log book. The deferred information was all kept down there. So consequently the pilots that are taking the airplane out maybe for the first time, this crew taking that particular airplane out, didn't know that they had been having stabilizer problems.

So in this case we sort of felt that here's the crew member supposedly needing to know what the status of the airplane is, what's being carried over or carried forward and what has been written up in the past. They never knew.

Another accident. CL44 down in Miami. Here's a case where an airplane has gust locks that are actually separate hydraulic cylinders on each control surface that are only used there for locking the control surface. The reason being the wings are too high from the ground or what have you.

However, in this case one was leaking, and again they didn't have the part. So to keep the thing from leaking, they merely blocked it off and put caps on the line and decided to make a ground control lock--and you fellows are familiar with the old DC3's and what have you. Wooden control locks. They made one for the one elevator.

On this airplane--for most of you fellows that are familiar with this system, it has independent elevators, meaning they are controlled by the tap instead of by a direct push rod. So consequently, the one elevator was still being locked with its actuator, but the other one was floating free so they made a control lock for that. And to go back, they never took the lock off before take-off.

Typical night accident. They claimed they had a streamer flying from the lock, but we could never find it. That was a case where the maintenance people didn't take the lock off.

Cargo airplane. A Lockheed 382. I think that's a C130. I think it's equivalent to a C130. Left wing failed in flight. This wing was inspected--when I say inspected--it's a scheduled inspection for the total airplane. They inspected one month prior to the accident.

A year and a half prior to the accident the wing had been X-rayed. And like we mentioned on this DC9 X-raying, we go back and look at the X-rays and see where the wing failed. You put your finger right on the point on the X-ray. But yet at the time no one picks it out. So it's interesting. I just want to put up number two for X-raying.

Here we have a DC10. On take-off number one engine cowling blew off. Its damaged wing and parts went into number two engine. The cause--we said

cause was a shift change. That's what took place. Shift change, the crew was getting ready to put the cowling on, and they got it all in place--and as the old saying goes--the whistle blew. They went and told their foreman who, quote, was supposed to make all the necessary paper work out and pass it on to the next crew.

The paper work was passed out. The next crew to come on that was going to be assigned to it, at the last minute was sent to the gate to work on another airplane. Consequently, that crew never did get back to that airplane in that shift.

Guess what happened? That information never got to the second crew--I mean the second shift later. And the cowling is all sitting up there, but it was never latched. So it's interesting. The company had procedures in writing. Everybody knew about them. But it was one of the those things that just gets lost in the particular hustle and bustle of the shift changes.

A Beech 18. Right wing failure. As I mentioned before, all you have to do on these types of accidents is go back to negative and--of course find where the failure was--go back to negative.

And this one showed up on six previous inspections. Six separate negatives had the same crack showing up on them. Nobody caught it.

Another DC10. Cargo door came open in flight. This is one of the ones where the ramp agent was responsible for closing the--for seeing the doors were closed after the cargo was loaded on. However, he couldn't quite get the door closed properly. Went and told a mechanic. The mechanic came out and looked at it. Whatever he was we never really found out. But the complaint of the agent was that the vent door was not closed on the cargo door. And the mechanic went out and looked at it and said it was okay and it was latched. Of course what we found out later that the vent door--the position of the vent door is very important because if it's anything but closed, it's a good clue that the locking mechanism hasn't worked properly because the last thing that happened is the vent door don't close.

So that was a case where--typical--it's a night operation. So the majority of these things are one of those that I know how it happens. It's just hard to say why it happens. People just aren't quite that sharp out on the ramp at night with the engines running. The feeling is here's all the

passengers on board, the agent is saying, "How is the door?" and you're looking up and saying, "It's good," or "Bad?"

It's just you wouldn't say it's that simple, but that's the way a lot of these things take place on the spur of the moment.

A Beech 99. Prop blade failed. It failed right at the hub because--if you fellows are familiar with some of these smaller propeller blades, the balancing is done by adding washers inside the hub on a stud. And what they did, they bored that area out and they bored a little bit deeper, and they put the wrong radius in the bottom of the counterboard and fatigue set in, and it broke off there.

That's all I have for the air carrier. Let me just review the general aviation type accidents. Carburetor heat valve is improperly rigged after inspection and the valve would not close to let the carburetor heat. And I think the general aviation mechanic, if he's out there doing any kind of inspection or doing any kind of engine work, should by that point know that the life blood of a general aviation airplane is the carburetor heat system.

It's only worked about every take off and landing, and it should be working properly. I have another one. A fuel vapor return check valve--vent valve--was installed backwards. Talked to the mechanic, and as far as he was concerned, he put it in right. I mean, he looked at the arrow on the valve before he put it in, and he thought it was going in right.

Another one. A Piper 23. Cabin heater valve, a line was not safetied. The line backed off--I mean the nut backed off his line and rubbed a hole through a fuel line that was adjacent to it. So there's where just a safety wire again might have helped the situation.

Beech 19. The engine failed after take-off. Then they found out the fuel bowl was not safetied and what really had happened, it has backed off. And interesting, the aircraft was only one week old out of Beech Aircraft.

Another one, a Cessna. The right gear bolt fell out after take-off. They found out that the lock nut was missing. And this was the first take-off after inspection.

We have an Aluette helicopter. The main shaft failed due to faulty machine. And this was a factory part that got through the factory and was

below tolerance. And we had to class that as a quality control problem, but it shows where human factors get involved.

A Cessna 402. The landing gear jammed in the up position. I don't know, going back a few years back to the DC4, DC6, and Connie era, I think, if any of you fellows worked on them, one of the problems that showed up in that era was different size tires. And it always came from the retreading process.

Retreaders want to give you more landings per tire and one of the things they did they put more rubber on. In this case they got oversized tires that got caught up in the wheel well.

Another gear problem. The gear restraining block on a nose gear was left off. The maintenance people left it off and by leaving it off the gear jammed half way retracted position.

A lot of the accidents that we have coded in general aviation, it's hard to find the maintenance-related items because they're found after the accident. But they might not necessarily be coded as the probable cause. Example. A lot of times an engine can fail and it might not be considered probable cause because the pilot just goofed up on his landing and couldn't get the airplane back down on the ground in a satisfactory manner in a good landing area. And at that point they code the accident as a pilot error type thing because even though the engine quit, he didn't get the airplane on the ground under the circumstances. So you have a hard time then finding the maintenance related items in the coding system.

Let me give you a quick rundown on home built. And I think a lot of times people figure well, the home built--the problems are they really didn't think these things out and they sort of goofed on their ideas of home built and what have you.

But after researching a little bit, I'm really surprised at some of the things that show up on these. B-nut fittings improperly installed. I'm going to go down these very quick. Another one. Right wing rib stitching restricted aileron cables.

Another one. Several spark plugs not installed. Now that's sort of hard to believe, but I think what really happened they were put in finger tight for starting and of course they came out and the aircraft hit the ground.

Another one. The right rudder turnbuckle was disconnected, and it had been held together with safety wire instead of the turnbuckle. Well joints had little penetration. Another one. The engine seized and the findings were the ring gap clearances were too small.

Another one was the timing was off, and they used the wrong spark plugs for the engine. Another one, the valve clearances were off, and they had excess ring clearances. Another one, spark plugs loose. Another one, magnetos loose and shifted and changed timing. Another accident. Spark plugs loose. Another one. Carburetor needle valve--(inaudible)--came loose blocking float arm. Another one. Battery failed. The battery hadn't been looked at in six months. Piston rings improperly installed. Another one. Vapor lock was caused because the fuel system was not installed as per the manfucaturer's recommendation.

Another one. The connecting rods cap bolt came loose. Interesting, the engine hadn't been run for two years and had never been pickled and this was the first take-off. Another one. Screw driver in control box which jammed the elevators.

Another one. The pilot became lost. New compass had just been installed and no one had swung the compass. Another one. The carburetor was not installed properly. Now a lot of these, I don't have the details on general aviation like I say, but only because they didn't show up on the computer run as to exactly what the maintenance people did. But that will give you an idea what happened in the home built area.

In fact it seems like you could say if you had to come down to one or two categories, it's the engines and the fuel system that could be sort of cranked in.

Bogus parts. In this case I'm not referrring to bogus parts the way a lot of us think, that someone made a bad part. These are parts that don't belong on the airplane or someone does something. Puts a part on that's not the certified part for the aircraft.

Took off with controls locked. It's not so much that they took off with controls locked, but the mechanic had put a bolt in instead of using the standard control lock system for the airplane. He put a bolt in the system where the lock should go which the pilot never recognized other than he should have checked them.

The next one. A pilot installed noncertified exhaust system. Another one. A chemical hose was run through the cockpit was replaced with improper type. The hose ruptured and blinded the pilot. I think this was on an agricultural sprayer.

Here's the one that I guess all mechanics always saying how a guy could do that. Original steel rivets in a nose gear retract rod were replaced with aluminum rivets.

Another one. Tail wheel spring attach things were replaced with open-ended S hooks instead of connecting the cable to the arm. A Cessna 404 belt cranes and landing gear actuator were nonstandard. They had been modified. Landing gear had previous cranks which were reinforced with a soft iron tube.

Another one. A yoke rotor hub on a helicopter showed signs of fatigue. It had two serial numbers and two part numbers on it. Another one. A central hub separated from a certrifugal clutch. This was on another helicopter. It had been manufactured; the web had been manufactured below the tolerance requirements.

Two weeks ago I was up a Lycoming with an engine that had been shipped down from Alaska on a twin engine airplane Beech 31 that had quit on take-off--or not quit on take-off--quit on go-around, and they sent it down there because the mechanic was a pilot, and he was the fellow that just worked on the airplane, and they had magneto trouble. To make a long story short, we started investigating the engine and one of the first things you sort of do when you get to a factory--the factory wants to see, well, they hadn't seen the airplane--the engine probably for years, but they want to see what it looks like and what it's been doing out in the field.

The first thing you go to is the name plate. And as soon as they saw the name plate, they threw up their hands. The name plate is a bogus name plate. So that was interesting. We didn't think too much of that. The reason we got involved was because modifications that were performed on it, were not approved by the factory either.

So during the course of examining the engine, the turbo waist gate valve, when we looked at that and that had a bogus name plate part on it. So it's interesting that this bogus name plate and swapping of name plates is still going on.

In fact we had a fellow just come back from Alaska Wednesday. He was up there on a helicopter accident, a Hughes helicopter, which the aircraft had just crashed up there. But he was working on the investigation. But to make the story more interesting, the helicopter had crashed and was destroyed in 1974. And you know what happened? The name plate was now back in service again. And what I'm trying to say is, bogus parts, things of that nature, are still going on.

It's not something that is past. Now the maintenance human factors cargo area has had very little investigative or analysis in the past. The Safety Board, we really never dug into why -- we'll say why the mechanical people did things. We always say, "Why did the pilot do this?" We will go back to his training record. When he got up in the morning, what he ate. But usually we never dug too deep into the maintenance.

Going back over the accidents that I just read, my question is: What could we have done to prevent them? Would more training, would more time on the job have prevented some of these things? Would specialized licensing have prevented those? Would it have made the mechanic more proficient or more knowledgeable so that he wouldn't have done those things?

I've talked to mechanics, inspectors and foremen, engineers after an accident; and I guess you'll have to agree that as long as the maintenance or mechanical end of the business is not at fault, we as investigators usually have a good rapport with the maintenance people. However, as soon as we get into an area where maybe the maintenance people say, "Ah ha, we sort of goofed," we sort of lose a lot of information, which I guess we can say is understandable.

I think that maybe GADO inspectors that do the majority of we'll say of the general aviation accidents -- and when I say accidents, I say it's nonfatal; because the Safety Board does just about all of the fatal accidents whether it's large or small or one pilot type operation. But the majority of nonfatal accidents are done by the GADO inspectors. I sort of feel that when they are out there maybe just on a one-to-one type of operation man-to-man, they can really talk to the maintenance people and maybe get a better feel for what was done and why it was done.

The Safety Board this year has started a new group. We only had one accident they worked on. And we called this human performance. We're not going to call it human factors now. We're going to call it human performance.

And they're going to go and look into these aspects. Why people do things. And look more into their backgrounds. A lot of times our human factors people before never got too involved in the pilot's life style. And now in this case if it's a maintenance-related accident, they'll go back into the maintenance people and look at the life style of the maintenance man. By that, meaning was he unhappy in the morning when he came to work and did he have an argument with the foreman or whatever the case may have been.

I think the future mechanics have a great responsibility. There appear to be less certificated mechanics coming into the picture. And there is more highly complex machinery to work on. And it is going to be quite a challenge for everyone for the FAA, for the schools. I think the issue that the schools brought out, at least I'm not so sure that I still understand their problem deep down. Last night's meeting we sort of felt like it might have been a money problem.

But regardless, if it's not the money problem and the schools are having a problem of trying to satisfy the needs of the industry. Maybe there is a good area that someone will take a look at and find out is the picture still the same as it was 40 years ago? There's a lot of things have changed in the last 40 years in all industries and things of, people have to give a little bit and take a little bit and change them.

But maybe this is a time now that the next couple of years with sophisticated equipment, more technology, a person really has to understand. Maybe should be looked at. Just a rough figure I have come up with, approximately five percent of the accidents that the Safety Board investigates we've come up with that can be related to the maintenance or mechanical problems.

So I thank the FAA for asking me to come out. If you all have any questions, I'll be glad to field them if you do have.

SPECTATOR: Do you have any statistics on the general aviation side? What percentage are maintenance problems?

MR. KRAUS: No, the only reason I said that is that the computers, the way the accidents are coded going into the computer. And they don't put in there -- they might put in there mechanically related, but they don't put what the items are. So it's sort of hard to say what percentage, because they don't lump them together in order to get that percentage rate.

SPECTATOR: It might be something to look at because we all noticed the air carriers -- (inaudible) -- general aviation tends to be a little more on the short side, both on experience and money, and we might want to take a look at that aspect.

MR. KRAUS: I also think that when the investigators go out on a general aviation accident, the majority of the time I might say the number of investigators might be one or two people, and when I say that one of them is a NTSB man if it's a fatal accident and the man with him is the local GADO man.

And other than that sometimes they are sort of short of help and sometimes there could be a lot of maintenance-related issues involved but sometimes they just don't show up.

SPECTATOR: I would have to take exception to your earlier comments. When you started out, you implied that having no accidents implied safety and there is a factor of luck in there. I don't quite agree with that statement.

And also I thought this might be interesting if you told how the Board interrelated with the FAA. You mentioned, for instance, a case of finding six X-rays that showed a crack prior to an accident. And you just don't let it drop there. It might be interesting to know what the Board does in a case like that, how they interrelate with the recommendation process.

MR. KRAUS: Well, I just mentioned usually at any accident scene we do have a representative Safety Board and a representative of FAA. If we do find an issue that we'll say is so glaring that you say, "Well, we've got to do something about this," within a short period of time depending on the urgency of the issue, we might go directly to the FAA and ask them to issue an emergency AD or even their man at the time or whoever is in charge of the investigation will go to the FAA and determine what we should do immediately.

If it's not an immediate issue, usually the NTSB and one of our basic things we do is to make recommendations to the FAA. It's a process whereby

somebody in NTSB recommends to the FAA that they do something. Whether it's a change of rules. Whether it's to put out an AD. Whatever it may be.

And it takes time. Everyone thinks that everything should happen tomorrow, and we all agree that even we at the Board agree that we want action a lot quicker than what it's taking now. But the wheels do turn slowly but in the long run, the FAA will get a recommendation from the Safety Board. And of course at that point their representatives who have been on the scene, they had also been working on it. It's not an issue that no one is looking into.

It's one of those things you have to sort of look at and say if a man said he didn't see it and then it's pretty hard to say what to do now. You say, well, let's get a man that can see it. That becomes a big issue or a big problem I should say with the FAA to sort out what you really can do with a lot of these problems. Some you really just can't turn around and say here's what we're going to do and then wipe the whole slate clean and that will solve the problem.

I think you see here, I got three issues here of X-rays that caused a big -- a larger type aircraft accident. And yet we thought through the years our non-destructive testing would be the solution to everything.

Companies have spent a lot of money on equipment. We have had to qualify certain people to run the equipment, certain people to look at the X-rays. So you might say we've done everything that you would expect us to do to try to cover the problem.

But sometimes you just can't do that. But the answer is that the Safety Board does recommend to the FAA and then the FAA after they have further investigated they will issue some kind of corrective action whether it's going around and have all the GADO inspectors look into all of the certificated non-destructive testing facilities and their procedures and maybe just sort of upgrade them every year or two. But it's things of that nature that you have to keep after.

SPECTATOR: What would happen to the man who put the piece of safety wire -- if you had found out who --

MR. KRAUS: No, sir. Even at the hearing we questioned all of the mechanics that had worked on that airplane --

SPECTATOR: I'm sorry. Had you found out who it was, what would have happened to him? To what extent does he take responsibility for that accident?

MR. KRAUS: As I said, the FAA would take the action. We wouldn't take any action. We would really just recommend to the FAA that they resolve this situation.

MR. PONTECORVO: We would take enforcement action, and enforcement action can vary from a letter of reprimand up to certificate revocation. But that would be the process. Had the NTSB found out and we would of course have the information, the FAA would take enforcement action.

SPECTATOR: Can you tell me --

MR. PONTECORVO: Oh, yeah, in between I mentioned could take anything from a letter or reprimand up to revocation. In between there are several penalties of varying degrees.

SPECTATOR: Can you tell me how many people have ever had their certificates revoked because this is possible in the United Kingdom, but I have not been able to find a case where it has actually happened.

MR. PONTECORVO: We have had certificate revocations. I can't tell you the number. I just don't have those statistics available, but we have revoked certificates. We have revoked a relatively large number of pilot certificates and a lesser number of maintenance certificates. But only because, as Ed Kraus pointed out, the maintenance record really is not bad in spite of everything he's told us today.

Mr. KRAUS: I might mention for your information that another responsibility of the Safety Board is that if a mechanic does get his license revoked by the FAA, his only appeal at this point, he appeals it then to the NTSB, and we have some law judges that sort of review the case and make a determination as far as his appeal goes.

SPECTATOR: Are you finding as the cost of spare parts is spiraling that you see more and more bogus things in the field?

MR. KRAUS: I think one of the things that I have personally found in my investigation is there are getting to be, as time goes on and parts become scarce, is there are becoming more PMA type of parts coming into the picture. And I'm not so sure that maintenance in the future we might have problems

with those types of parts even though everyone is trying to make a part the same as the original based on its original specifications.

SPECTATOR: How about military surplus parts -- (inaudible) -- into the helicopter field?

MR. KRAUS: Well, the example on this helicopter that had the bogus name plate on it, this helicopter was really one that seemed to be under question as far as certification. There were certain model Hughes helicopters that were not certificated, were not to be used but they found out that this one somehow -- where it came from I don't know -- but it seems like it got under the wire somehow and was really not an approved or certificated machine. Anyway at least the name plate was from completely from another airplane.

SPECTATOR: Had you seen an increase in maintenance activity in the commuter type airplane due to the fact that there's greater competition and less surveillance from the FAA? That type of thing?

MR. KRAUS: Well, I sort of feel at this stage of the game I've been following the commuter accidents for about the last five years. And I sort of feel today we finally got to a point where five years ago we hoped we would get to. And that was the fact that the commuters are really nothing but a small airline that is doing the same business. The public is expecting the same service and the same safety that they get from flying with a commercial operation. I mean an air carrier.

And I sort of feel that the FAA in the last five years, the action they've taken in changing the rules -- and if the rules weren't changed -- everyone keeps thinking that the rules are always written to try to slow or stop everything and slow the airline down and cost them more money.

Almost every rule I feel confident is written because something has transpired and taken place in the past that caused the problem, was hazardous or whatever you want to class it as, and we want to prevent it.

And if I just told you not to do something, you'd say, "Okay." But that doesn't mean that you're not going to do it. And there's no guaranty that you're going to do it. But if you have a rule that is sort of involved with licensing that you're holding and you say to yourself I'm not going to put myself in jeopardy and do something wrong, then you're going to do the

right thing. So the rule is to help everyone. It's to prevent things from happening. It's not to try to put the increased costs on to the airlines.

A lot of times we find out and I've noticed in the past couple of years, the cooperation that we're getting from the smaller aircraft manufacturers. Years ago the small aircraft manufacturers fought the NTSB. They thought that we were out to shut them down. And you see we really never had that in mind.

Because what they didn't realize was the NTSB was on their side trying to resolve the problem. If you resolve the problem and put a better product out, isn't that better for them?

Now they've sort of come a long way and found out working with the NTSB is a hundred percent better than working against them. Let me give you a good example. Service bulletins that all of the manufacturers put out. I don't know how close probably some of you maintenance people get too close to the service bulletin, meaning the original copies. But you take Boeing and Douglass and Lockheed. After you get down past the title of the service bulletin, they will put the reason for the service bulletin. And it will say four operators have reported that they had 15 failures of this part.

Now when anyone reads that, one of the first things it does is put that little doubt in your mind and says you will look at our part. I mean, whatever they are talking about. We might have never had a failure, but we ought to look at it.

I notice what the general aviation people do, they hide behind the fact that there's 20 failures or something and say it's a product improvement. And no one ever knows what the picture looked like. Now, improving a product is nice, but it doesn't get anyone in the maintenance department's attention.

If everybody knows that a tire keeps going flat, everybody is interested in stopping the tire from going flat. They look at this tire more often and look at the wheel or look at something. It's calling their attention to that problem that makes it a hundred percent better in the long run. They resolve the problem and it goes away and everyone is happy.

But trying to hide the problem doesn't help the situation at all. When we go to an airline, and I can base this on 12 years with the Safety Board, I always found a hundred percent cooperation in an airline. When you go in

there, you can get anything you want from the standpoint of records, talking to people, looking at things, conducting tests, that type of thing.

And I think when the general aviation reaches that point, I think we'll have a big product improvement because really the whole thing is to help the airline. We're not here to hinder them. We're trying to make the thing safe for the public, too. We're, quote, an independent agency that Congress says, we want you to go in there. We don't want you to be on the FAA's side. We don't want you to be on the airline's side or the mechanic's side. We just want you to go in there and find out what happened. And that's the way we always approach it. And we're just looking for the causal area and let's correct it and get on with business.

I just told Bob Hainey from TWA. Hadn't seen him in quite a few years. Hadn't been to TWA in probably ten years. And I said, isn't that great. That's the best thing that's happened. I used to be with United. I haven't been to San Francisco in probably six or seven years, and I say, isn't that great. And the reason being as long as we can keep the accident ratio down to nothing, I think we have come a long way.

And I think the airline accident rate the last year and a half now is fantastic when you come down to the number of trips, the number of flights, the people, the conditions, the urgency, and the changes of scheduling, and the new people, and what have you that we are still able to operate in safe -- manner that I think is fantastic for the airline's position.

I think it's fantastic for the FAA to get everyone together and these airline people and all work towards that end. Because that's all we're here for. It's nice to feel that we can get an airplane here that you're going to get to Washington in, and it makes me feel great that the record is reflecting this type of safety. Any other questions? Thank you.

MR. PONTECORVO: Thank you very much, Ed. That's a very informative discussion. Has Bill Rourke shown up?

You'll notice on the agenda that Dr. King is scheduled but Dr. King had an accident over the weekend, and I was notified that he was not going to come and evidently Bill Rourke has not shown. That's the only case where someone was scheduled who did not appear without notification.

So, at this point I'm going to let Ron Smith from San Jose State come up here and give us a little discussion on the challenges of training on today's scene. Ron Smith.

MR. SMITH: Good morning. I sort of wish I had been on the scene yesterday when all the schools were up here. Some of my points I wanted to make this morning have been addressed somewhat. But I think it's interesting to note that on both coasts we have constant tread of thinking along the training aspects of maintenance.

And let me say coming from the San Joaquin Valley in the heart of Santa Clara County and San Jose, the southern part of San Francisco Bay, that Michael Parks process of technology is here. We're seeing from the last Boeing conference that -- (inaudible) -- electrical-mechanical systems will be replaced or in fact are being replaced now by additional technology. Why? Because they have a very high reliability and we're seeing an entire systems approach to aircraft planning. Now, additional equipment coming along is going to require some changes in training. Why is that? Well, one thing we're seeing a systems integration of the aircraft. The additional equipment coming along is going to impact more than just the so-called avionics technician. The mechanics, the trouble shooters, the engineers are going to have to inter-phase with electronics to the nature of power plants and technical systems with the entire package of an aircraft.

So what they are saying now is that basic additional knowledge is going to be required by many people especially in the air carrier market. On the general aviation side, which is a very large side, and is unfortunately neglected both in the accident investigation cases and in statistical analysis. As was mentioned yesterday, we are seeing a higher ratio of complex aircraft coming into general aviation market.

The light single-engine aircraft sales are down. Turbo prop, turbo jet and cabin class swings are on the way up with very complex systems. The complete package of avionics is going into your so-called light aircraft. So I want to say a few words about the state of the current training.

Are the present training requirements being met? Yesterday there was some talk about Dr. Anderson's study. That study was precipitated back in 1964 by a little simple red book which was processed along with the first major

study of the aviation mechanics market. And this was put out by the Aviation Human Resources Study Board. And they did a fairly small -- it covered pilot training and mechanic training and said, let's get together. 1964. They commissioned the study which was, part one was in 1966. Phase three came out in 1970 and the famous Anderson study said, here is what you have to know. This is phase three of the much quoted Anderson book.

And you can see this in eleven years out of date as of right now. And that's part of what the problem is. It said you had to know at least this, and we've come eleven years down the stream since then. Now project long look that was precipitated 17 years in the past that new aircraft will require higher technical training, constant review and evaluation of training methods is required.

Now, I'm going to quote from air carrier records of the last Boeing meeting. There are some points which I think we should -- even though it may not be true -- it's this conception of what is true and that's what counts.

He said today's FAA examinations do not qualify an individual to work in the air carrier industry today. They found that the caliber of their new A and P's are not what they would like, and they were not in pace with today's air carrier technology.

That they had no background in electronics at all. The carrier found that it must do a lot of extensive retraining on their own to bring them to where they thought they should be and that the air carriers giving constancy can't afford to go back and teach basics.

I think that's the point to look at is basics. Are we in fact teaching the basics? From my experience at -- say Jose State -- because we offer a four year program, not a two year program. We're seeing a lack of communication and language skills and not only the freshmen but in junior college transfers.

I think a good solid basic with everybody given the state of the economy and the high technology coming along is the ability to communicate technical information in a clear and concise manner is somewhat lacking. Now this is a serious drawback because in a highly technical world, failure to communicate in any way or form leads to misunderstanding, time loss, frustration and possible dangerous situations.

We are also seeing a lack of understanding or a -- just a lack to learn sometimes the other important fundamentals of math, physics, basic chemistry. We are not seeing that today. Now I think this is a disruption of what human factors would call a cumulative learning sequence. Each level is built upon something learned in the past. You get a good foundation, and you build on that to make your firm structure.

I've seen some people come in with very good manipulative skills, but seem unable to understand the basic underlying reasons why they're doing something. Now, lack of knowledge in mathematics and physics will tend to inhibit the learning transfer from one situation to another. If you have a good solid foundation, you can apply this to different aircraft and different situations and become what we all should become in the maintenance field, a good trouble shooter. Not rote learning tied into one situation.

The basic skills that we need to learn making manipulative perceptual language. The latter two are I think suffering nowadays and should be re-emphasized. (inaudible) -- is very important, it should not be over-emphasized at the expense of the basic theory. Why do you turn the nut. Why do you apply 128 pounds of force and not 300 pounds of force? Why do you safety this device and not the other?

A good trouble shooter or an engineering background person should have the grasp of the fundamentals and therefore be able to work in many new situations and not be tied to one or the other. So basically what we are seeing in new technology is here. The aircraft complexity is increasing as we heard yesterday. Boeing says a 757 or 767 will be two to three times as complex as a 707. I think the basic skills must be emphasized and new skills must be acquired.

Okay. How do you do it? The knowledge in schools required by maintenance personnel is growing at almost -- (inaudible) -- rate. Aircraft complexity is increasing even down to the general aviation level where the majority of the A and P's work. Now is the time to consider some changes to the training and certification of the maintenance technicians.

Now, I am going to throw some questions out for us to consider. First of all, should there be levels? Not necessarily specialities but levels of the A and P certificate to reflect the increasingly broad spectrum of knowledge that the technicians deal with. For example, open fabric on one end to micro-processors on the other.

The flight engineer certificate has reflected this for years by recognizing the basic difference between -- even though he's a flight engineer -- the recipe, the turbo prop and the turbo jet. Perhaps the A and P may have to have like a basic requirement of basic baseline knowledge to make him a broad well-rounded individual and then have digital points added or knowledge added or recognition for knowledge added as the person gains knowledge of the field.

By having differing levels of a technician, he would not have to learn it all now. He could master the basics first and then build on them as required or as he wants or needs. This would then tend to free the schools to screen our applicants for a higher level, emphasize solid foundations of basics and try to turn out a general list and not a journeyman.

Having to inspect -- (inaudible) -- a journeyman mechanic is getting harder and harder. This would also not add required additional courses, and by required I don't want to see this book get bigger than it is for us to cover in the time alotted. If we made the program longer, it becomes more expensive, and would probably include training that many students don't really need. They all don't need micro-processor training at this time. They could qualify for a basic type course that would meet the requirements of the industry and the people who have been in the industry for a while and then could add additional skills and ratings at a later date through on-the-job training, continuing education, in-house schooling, fender schools and receive recognition for it.

Make sure you could get the record. It doesn't have to be a 147 school. A qualified school. And then say this man now is qualified to work here, and he'll be recognized absolutely for doing so. A big problem in the schooling aspect now is that too much specific training on a specific product that's costing a lot of money -- (inaudible) -- any individual or most of us tend to forget items in just a short period of time if we are not actively engaged in that specific task.

Thus, I maintain we should teach the theory and the basic scientific formula aided by of course lab work. A lot of the flexibility interpretation of 147 because it's interesting to note that 147 is only -- that's all there is to 147. That's the actual law, and then the study comes along and lays this on us. How do we interpret which one to go to? It becomes a problem now. Then the costing aspect. We get a lot of individuals who tell us once he has received his basic portion of the required technical training, he can either

build on it if he plans to go on to the air carrier or more sophisticated type of work. If he goes down the street to work on basic aircraft initially as many people do, the majority do, then he could tailor his needs to fit that point, stop there, and acquire additional training later on if he goes to an air carrier, receive recognition the air carrier is going to give him.

I just want to show a quick slide or two on our approach to it -- (inaudible) -- because we are a four-year institution, and we have tried to find those aspects into our program.

This is our degree in aeronautical maintenance which we think tends to offer the person who is going into the air carrier industry, for the person who would like to become a field engineer or service rep or a good trouble shooter, and that is it combines what we feel are the best of two worlds.

One is the engineering training which is reflected in the major. He gets his -- inaudible -- science, computing, some economics which are sure enough with us all today, two semesters calculus, two semesters of advanced chemistry, three semesters of engineering physics. Here again emphasizing a good solid basic framework. He ties those in with -- and here again each one is built from the other -- it takes the basics and his math and physics. He also takes some basic aerosciences, aircraft material and our first basic lab course which will deal with basic production processes. Hands on riveting, hands on welding, hands on drilling and tapping. Just to get a feel of what's available so if he does go into the field work or design work he can tell if it's pure design engineer as you can't do it that way or you can't properly work it because I've done it myself.

We go on to the basic propulsion instructors, and we have the basic introductory lab for certificating engine and basic sheet metal. We go on to that with the advanced courses of propulsion, advanced lab to cover the systems. Hydraulics, electromechanicals.

In this case we start to add at the upper level advanced aerodynamics. One year's work. Subsonic and supersonic. Advanced structures. And as we wrap up to meet the FAA requirements built into this program is the A and P license. If you can't pull it out as a two-year agenda, a portion of the entire program will remain over a four year period. He wraps up his A and P side with the final lab which would here again take the time to cover all

the small projects that the city says they should do and in many cases -- here again we're forced to do a study for the examinations.

Wrap it up though with advanced aircraft design, two semesters of avionics which are not enough nowadays to meet the needs. We are going to have to take a stand on this if you can find the time.

This type of approach we feel emphasizes the basics along with the State of California required general education aspects. We've got writing in here -- (inaudible) -- regular English. This I think is an interesting approach for the modern day type technicians. Upgrade the program. Gives a grounding both in the physical sciences, mathematics and a hands on ability for the engineering aspects.

We'd like to build on that. That's why I'd like to see some discussion flexibility in the part 147 training. Another side of that for the person who is not mechanically oriented but wants to go into the ever-required business aspects of the market, is another program that we call operations, but we still work on the basis of grounding in the physical sciences.

In this case the person isn't going to be engineering-oriented so much, but he still includes those general chemistry, general physics and math up through introductory calculus. And then from here out we tend to -- this person tends to specialize in the business aspects. Additionally, business, statistics. To make things economically viable in the great competitive situation.

Everybody takes the basic aero courses in propulsion and structures, the general education requirements, and we give them three options in this case depending on their needs. (Inaudible) If there is room because of the cost constraint, those that want can also blend into this degree a maintenance management degree that includes an A and P license for a straight administration side.

So that's been our approach to it out there to try to cover the basics. If you teach those basics, then we can turn the man loose to the industry and they can sure enough teach the specifics. Because that's been one problem that was mentioned the other day was the complexity and cost of the training increases and there are sure very few good surplus turbines around. They run until they self-destruct in most cases.

We feel that industry should take a larger part in helping the teaching institutions from the hardware point of view. This is especially true in our laboratory environment. Current systems we have to teach to show what's available I think are very necessary to help transfer knowledge.

Even back in 1964 project long look recognized this and said that the college programs must have continuous and substantial equipment from industry since the high cost is beyond the dollar reach of most schools, and that is surely more so today than it was 17 years ago.

We're seeing California now, the inflation going up and the budgets being cut back. We're going to be forced to go to tuition if the State will buy that one of these days. We also find that industry and academic cooperation is also needed in the refreshment of skills. And that's a human factors term, refresh yourselves, so to speak.

In a rapidly changing technical environment, obsolescence is always close at hand. Current thinking now holds that an engineering degree is obsolete five years after you receive it without current update. Five years and you're a has-been right now. So Industry must I think be very visible to the instructors through sponsoring seminars, special staff development, bringing us back to the schools so we can pass the word on to the young man or young woman coming up the line.

There must be a constant interchange of information and knowledge keeping each other up to date. Continuing education both for the instructor and the people in the air technical field know that you guys are updated all the time. We need the same thing. If we're not, then our students are not informed which reflects a bad light on everybody.

I'd like to close then, with here again going back to project long look, looking at 17 years ago and the Lord knows times don't change very much from certain aspects. That no industry or no company can complacently assume that it will always have the manpower required, as the Major pointed out yesterday much to my surprise and was very interesting, the more specialized the skills or the requirements the less likely to find the skills will be met.

The longer the training time, the more costly the training, the more necessary it is for business to consider the manpower supply and demand. Thank you.

MR. PONTECORVO: Any questions?

SPECTATOR: Out of curiosity, can you perhaps or someone else in the room give an estimate as to the number of people that are graduating from academic institutions going into say the commercial carrier--the availability of people that you graduated as opposed to the needs that are upcoming and how many are coming from academic institutions and how many are coming from the military? Is there a definition right now as to what the problems will be?

MR. SMITH: Do you have any data on that, Jim, of people being trained and people going into the industry?

JIM: That's really difficult to come by, particularly in each individual area. Might have some data. I tried to check that, and the answer I always get is in the selection process, the time the selection is made--(inaudible) --where they came from.

But I can--I might could talk afterwards if I have any specific questions. I have a lot of stuff I didn't bring with me along those lines, things I have looked at. But I think in my own opinion, the person coming out of the military now, the Navy probably does the training that is most appealing to general aviation because it's more general evidently in nature. It's more the A and P type training because of the missions of the carrier. You can only take so many people on a carrier and there are more jobs to be done than people.

In the Air Force, due to our constraints, our--(inaudible)--told you yesterday our training has gone from 20 weeks down to only 11 weeks today. It's going to go back up, but in the face of this complexity it's caused us a lot of problems and because we can get by with cheaper training we pay the penalty of more people. --(inaudible)--

Our people after they leave the military are probably more eligible to be picked up by an air carrier if they have a large operation that has some needs for specialization here and there than they would be in general aviation.

MR. SMITH: I think also the point that our graduates, which of course tends to fluctuate with the times, historically United used to pick up a lot of our maintenance grads. --(inaudible)-- Years ago in the mechanics side and cross over to management later. Lately they put them in a management

training program because of certain divisions they've set up.

Douglass went through a large--(inaudible)--a while back with a few service engineers. One year at the factory at Long Beach and one of my best students was lucky to get in air transit I believe.

Lockheed is the same. When that area quieted down, the military now is doing very well. A lot of people are in the military to pick up on their career and to get experience on heavy equipment right away. On the operations side we see a lot of our students go into marketing sales, finance.

Then to cover a broad general area, a lot of students are very flight-oriented. However, I'd like to emphasize my background includes both military flying and some flying for Pan American; and you need that secondary skill. I think they are a very flexible bunch. The FAA coop program picks two or three people a year for its air traffic control system. So I think here again a broad general background--(inaudible)--used to do very well.

SPECTATOR: Do you have any input to the group on the percentage of people you are actually putting in aviation versus how many people you are losing to aviation at your particular school?

MR. SMITH: We've tried to canvass the graduates, and unfortunately trying to find graduates sometimes is a very elusive thing. I don't have any numbers on that. I believe that this past several years we have seen fewer people going into aviation than we have in the past. I don't have any specifics, though I can probably dig that up and find out how many have stayed in aviation. (inaudible)--go up the street and make more money than I make. I have no specific numbers on it.

SPECTATOR: Based on what Major Graham said yesterday about projected manpower shortages, do you see that having any effect on the curriculum--(inaudible)--to get started out in the field sooner?

MR. SMITH: Well, in California we have a large extensive junior college system that they attend if there's a need for the two-year program, they tend to pick up on that. I think one of the problems we talked about yesterday and today is, if you keep adding more on the A and P, you're going to run into certain problems. If you give up anything at all, you give up certain parts of 147. You set good foundations in there, if a person has the basics he can do anything. He can build on that. If he jumps past that point, then he

becomes strictly a rote memory type person. It doesn't help anybody. There's a problem.

SPECTATOR: Along that same line, at a recent avionics maintenance conference that we had, a lot of the airlines--virtually all the airlines supported the things that you said concerning particularly the need to train and the ensuing problems with not seeing the particular units to work on. The recurrent training problems have long been recognized by the airlines.

But what I'm not clear on is when you said fabric and dope to micro-processors. And along this same line of thinking. Typically the majority of line maintenance on avionics systems is done by A and P mechanics. I'm not clear exactly what you were proposing in terms of how much micro-processor training for that level A and P a mechanic would get because he would not use it a lot.

MR. SMITH: I just finished reading two statements. I don't know if anybody here went to the Boeing conference. I read notes that my department wrote back to me. One is that Boeing claims that the line mechanic must have some knowledge. This is their statement. I've just read it.

Swiss Air has been using Digital mals in their DC9-80 and 747 systems. They're gearing up for it right now. Of course, being a European carrier, they do have the four-year apprenticeships. They foresee the line mechanic being able to go out and understand how to troubleshoot and be able to change the LRU -- is line replacable units.

Now you go in the black box. Before you said: That's not my job. Now you're going to do things with it. You're going to interface with it. You're going to quarry it. You're going to ask it questions and it -- You have to understand what you're asking. I have two small booklets: Bouillonism -- Bouillon Algebra (phonetic) and one on Logic Circuits. Flip-flop diagrams that Swiss Air is expecting their line mechanic to have a basic knowledge and they're going to put him through a 40-hour school on basic digital logic systems.

So you just can't politely push the button and say: Tell me the answer. You have to use the noggin. At that point they're expecting to see their mechanics level of supervisors slant troubleshooters to be taught the same as their engineers.

He's going to go out and ask the line mechanics to troubleshoot on the line when it comes in. This man -- They must they say understand it. That's where they're coming from. Neat little booklet if you want to take a look at it.

SPECTATOR: Ten years ago, I went down to Cape Kennedy to the NASA workshop and talking to the mechanics there, which is probably the higher level technician, and the questions was asked: What's your mathematic ability?

Every one of them said: First year Algebra. That's it. I really don't see the need for all this math. All these accidents that he talked about are basic mechanical functions that were unproperly done.

And I think the lack of training of mechanics today is good basic mechanic training and the thing that I have an argument about with 147 is in the general Section, for instance, there's nothing in basic tools, use of colors and special tools that you could find in the aircraft trade; nothing in tapping the things that build a mechanic.

That's what we cover in -- That's not in 147. The 147 needs changing. You need to go back to some of that stuff. We talked about yesterday where they were testing on the five areas back in those days and they need some theory of that basic training, then they can build on that. But you're going to find that the best mechanics are the guys that make this kind of mistake is the guy that understands the stop bolt and what the hell it's there for and why it should be ported (phonetic). Not that it has some high mathematical ability.

MR. SMITH: I think the trick is you have them both. You have the mechanical side where you must teach the basics, but you also have to expect whether they see, -- you want the person to be more professional and knowledgeable. You need the mathematical training, too, which is a good, rigorous disciplined practice in problem solving. That's all mathematics is. It's a way to solve a problem.

The basic safety wiring, proper tool usage must be learned and we try to do that before they come into the next -- (inaudible). A man that doesn't know how to run a --(inaudible) --set or nut or proper torque something, then he's behind the eight-ball already.

You're right still on the basics.

SPECTATOR: Well, doesn't this bring up a problem though? When you talk about the lack of skills and knowledge in the upcoming people that are coming into maintenance, shouldn't we be looking perhaps then to a trade-off where the checkout would just involve plugging in a sophisticated test unit that anyone -- a trained person can plug in that has a self test feature; you push the button and it tells you whether that box is good or not rather than to train the maintenance person to such a high degree that they understand the whole theory and operation of that black box?

MR. SMITH: It's been my good experience -- first, some sort of -- understand a quality bite system that will do the job for you. I have spent some time around the military to see some of the nice things that are supposed to work and they just never seem to. It's a nice situation. You have to interface with the computer. Everybody -- They try to sell you the home computer. It's easy as falling off a log. It is and it isn't. I think the more you understand, the more you can get out of it.

Because a separate hope -- when you see the machine says: 634 and you go to the code back 634 means B2, chip 4. I just -- My philosophy you have to teach them. They need to know why.

Until you understand why, they'll work better than just pushing buttons.

SPECTATOR: Okay. I guess that thing -- that question has another combination in that you would probably then have many more maintenance people available if they were not so highly specialized. You were talking about levels. Could we not have levels of maintenance where each man would not have to be trained to such a high degree, but would progress into levels as in the military where they would have certain classifications and the lower level of screening could be done by the lower levels of skill levels and that to segregate out and have specialists, but for the general maintenance person to be able to screen -- I won't say the central problem, but to screen to a certain level if they run into problems, require higher skill level to intervene and to carry it on?

MR. SMITH: The question was about different skill levels and maybe if we make the requirement too big, shortage -- How can we fill the shortage? What is the base line? Where do we say: Here's an A & P mechanic and then how do we build from that? That I don't have an answer for. It's very complex.

I think we need to generate this dialogue and come up with this answer. Where do we draw the base line and then how do we give credit for training later on down? That's interesting.

MR. PONTECORVO: Thank you very much, Ron. One thing is obvious. The FAA needs to look into the area of technical needs. This will change somewhat with digital avionics coming into being, and I think it looks like both skills are going to be needed. The basic mechanical skills and an individual can actually perform those tasks when they are needed. You are also going to need the skills necessary to interface with the computer in order to do the troubleshooting where you have those kinds of systems.

There's still going to be a lot of airplanes flying around that won't be using digital avionics to a large degree for some years to come. I think we've earned a coffee break now. We have coffee in the back. I'd like to make two announcements.

(Whereupon, a recess was here taken.)

MR. PONTECORVO: I'd like to make a request that people from the floor who have some comments or questions of the speakers, please use the microphone that's available. It's right in the middle of the room. People in the back are having a difficult time hearing those folks up here.

(Discussion had off the record.)

MR. PONTECORVO: Our agenda now calls for Don Korande, AOPA. Don is going to talk about the cost of the maintenance today.

MR. KORANDE: I appreciate the opportunity to speak to you all today, and I must admit that I, too, like a few other speakers was a little concerned about the topic since it's not something I'm normally allowed out of the office to discuss. I was asked by AOPA to come before you to discuss some of the problems as we see it, and in case you may not be familiar with AOPA, it stands for the Aircraft Owners and Pilots Association.

We are an association that represents the interests of approximately 260,000 aircraft owners and pilots. So I think you can see from that number that we certainly are what you might want to consider a consumer group.

We are consumers of the product manufactured mostly by the general aviation manufacturers. I want to make a few extra comments here before I really get into what I was going to discuss, because I think they are just, in general, interesting.

Sitting in my office, the job I have is answering members' letters, trying to help them with their problems. And these problems range from everything from enforcement problems with the FAA to maintenance problems.

And I've had an interest in the maintenance problem so they tend to funnel it, the letters, and the reason why I am here. Most people don't seem to see too much of a problem in the maintenance area, but I was always wondering how accurate the members' letters that I get are.

In other words, we get a letter saying: Gee, can you do something about all those AD's coming out and on top of that, I can't understand what they're trying to say, and I'm a mechanic and can you read this service bulletin and tell me what they are talking about?

I also put out in the newsletter some information on AD service letters and bulletins. And I started reading through these things. I never had been involved in them. I started reading them from the standpoint of a pilot and found out they're not all that easy to read.

Maybe mechanics, since they look at them, they're more familiar with it. But when you read them, they almost in some instances hide what the ultimate purpose is and that is to get the information across of what the difficulty is for a service bulletin.

It may be something that when you find out what the history is that the battery blew up 15,000 times and they found all sorts of accidents and the title of it is: Battery Improvement.

Well, it is a battery improvement. There's no question about it, but it does need to be brought out. I just thought I'd like to mention that. Let me give you a little background on myself.

I am not an engineer. I am a pilot. I have some maintenance training back in the Air Force as a avionic's technician working on C5's and 141's. And I can identify with a lot of things that are being said by you who are mechanics, particularly in the standpoint if there's a way to get around working on it, the mechanics can find out or I defy any engineer to design something and I'll give you -- You put a good mechanic on it. I'll give him ten minutes and he'll find a different way to do it and one that is going to be a little bit easier.

I can remember vividly some of the equipment we worked on -- very sophisticated equipment. Their black boxes, pop them out, everything. But we used to work on these little cards. They would put these little dinky screws and you would have to be a contortionist to get yourself into an avionic's bay on a big C5 or 141 and stoop down, hanging in weird positions to put these dinky screws in, when all they could have done is take it apart, put little foot things on the top, push it down, push them over in a locking position, and that's it.

Now, of course, I think that's coming out more and more with the avionics. But -- So I consider myself basically a pilot that had some maintenance background.

In listening to all of the other presentations, it has been very informative and what I am encouraged about is the fact our members are reporting accurately the problems that we're discussing.

I've always wondered whether this was just an isolated occurrence or one guy having a problem or -- Now, I'm finding out indeed there's a problem out there and our members are being accurate in their reporting of it.

In listening to everybody I sometimes get the feeling that the term: Human Factors -- We're all saying, yes, there are human factors and I represent company XYZ and this is what we're doing to take care of these human factors. And I haven't really pinpointed where someone has come up and said: Human factors is something we're just now coming aware of, and we didn't design our airlines with that in mind, and we're really working hard on it now. We're putting people into the human factors area. We're getting more specialized. We're having mechanics look these things over before we put them in the field.

I don't see any real strong commitment to this with the possible exception of some of the larger manufacturers who have been involved in this longer. That's understandable.

The smaller aircraft manufacturers wouldn't be expected to jump into these things right away. We don't expect them to be in the forefront of this type of technology, but we do expect once they're aware of it that they try and apply it and apply it in the manner that it's going to be beneficial to the consumer.

So I would like you to kind of view my remarks as a report card. I don't want any of you leaving here thinking, particularly from the standpoint of General Aviation Aircraft that everything is okay.

Human factors is going forward and, you know, there is no problem in the design of these aircraft because we think there are significant problems that are being addressed, but what we'd like to see is a more vigorous program by the manufacturers to try and pinpoint what these problems are, and I don't think that -- I don't mean to stand up here and say we have a solution.

I am going just to point out some of those things. Deep in the office jungle at AOPA there exists this office of which I'm in charge and it's called rather descriptively or whatever -- the Service and Reference Department. And you probably have a similar department.

They go by the name of the Dear Abby Department. You might recall -- refer to it as the PR Department. It's the type of letter that you get. You say: My God, look at this person. Where did you get this problem? And: This is not my job, and I'm going to send it on down to the next office.

So I get these letters and we start to take a look at them to see, you know, what the problem is and whether or not we can help the member. Although some people might think this is the way I also got this particular job was speaking to this group, it's not the case. I do have an interest in maintenance myself and so I'm very happy to sepak before this group.

So as the consumer group, perhaps we have a unique vantage point. We are a national group, have 260,000 member pilots, and they're writing us, telling us what those problems are. I'm sure, however, we're not the only ones being talked to because the letters I get are often copied to the manufacturers, and the manufacturers know these problems. They're aware of the problems.

The question is: Why aren't they being corrected? In trying to determine what I would speak on in this particular instance, I first turned to an examination of the goals of the workshop which read basically: To present and discuss views concerning human factors issues and priorities on the subject of aviation maintenance and the interrelationship between design operation and human factors as they affect safety and continued air worthiness. Since I don't deal in this area, first thing I did was say: Boy, what does that mean? And I went to the library -- went running to the library which is ten steps outside my door, got the biggest dictionary I could find and said: Let's find human factors in here and I would start with that as a basis.

I don't think it will come as a surprise to you that I didn't find anything in there on human factors. What's the next best thing? Who deals in that type of thing?

I went talking to various staff members -- Said what's this word: Human factors? I want you to fill me in. I haven't been paying enough attention. I am just dealing on a gut level with the members. And what should I -- how should I phrase this when I talk to the people at the FAA at the conference?

And so they told me -- People that were more familiar with it said looking at that title, basically all you have to do is talk about maintenance. Just get in there, use the word maintenance in there. You will be okay. And that's what they're talking about.

So please forgive me if I should miss the mark exactly what was intended, because it is a little confusing, and I am taking it from the position of a layman that has been -- not been involved in this. You are more experts in this dealing with these problems everyday. What I'm about to do is relate to you some of the problems and concerns that have been expressed by our members and also some of their suggestions.

Because I really don't think we have any new suggestions. Everything has really been worked over. If there's a common theme that runs through most of the letters that we get, it's the fact that the cost of ownership is just too high, and causing more and more people to give up flying and ownership.

And this is kind of scary. Not only does it mean my job, but it means a lot of workers and the manufacturers and everything else. Hardly a day goes by without hearing or reading about some key indicator, measure of aviation

activity that's on the down slide.

It might be aircraft registration. It might be sales. I mean -- You have all seen -- We can look at them all of the time. There it is.

The indicators seem to be going downward. While we certainly cannot blame maintenance for this particular fact, it is clear that a decrease in the activity and the cost of aircraft ownership are related.

Not the entire thing, but they're certainly related. Particularly in today's economy of rapidly climbing prices. Despite the optimistic prediction about a full recovery in the general aviation industry, we must recognize each incremental cost increase, wherever it comes from, results in more and more people turning from aircraft ownership. Traditionally maintenance costs were viewed as a small portion of the overall cost.

I'm sure in the big picture they still are relatively a small portion, but they are increasing. However, this traditional view, I assure you, is no longer being maintained by the members because of the letters that we're getting in, all of them are basically screaming about the price.

Let me give you a couple of examples. We all -- I think there are a lot of pilots out here, too and you fly -- and you fly General Aviation Aircraft and Airlines. There was a recent letter that I had from a guy who had a light twin, nothing fancy. He put it in for an annual inspection, and he came out $6,000 lighter.

And that's not the worse case, believe me. I am sure you have heard of even worse cases. There was the case of a -- Of course, this weight loss, it can put you into shock and I happened to know the owner and it did. And it also made him consider the fact he's going to have to get out of ownership because he can't afford to take an airplane and sink that much money into the maintenance.

There was a case of a single-engine aircraft which I recently had across my desk in which the aircraft, having an excellent maintenance history, the type you would want to buy, the one that had hundred hour inspections faithfully, everything looked super, it's a cherry airplane. It went in for an annual inspection and came out $3,000 as a cost for the annual.

Now these are only two cases, and I wouldn't want to imply that all of the costs were direct results of maintenance, but what I am trying to do is draw a strong correlation between the fact that when we go in there and pay for this -- this cost of maintenance has a direct relationship on the maintainability of aircraft.

In other words, the harder it is to maintain, the higher it cost and the cost continues to go up more rapidly. We do have to take this into consideration. So about this time you are asking yourself: Well, okay. What's this all about?

Economics. And it has to do with maintenance, and the answer is simple. The cost of aircraft maintenance is directly related to the ease of maintenance which is what I just said or put it another way: The higher the maintenance burden, the higher the cost. The more difficult or costly the aircraft is to work on, the more people -- and here I am specifically talking about the difficulty aspect -- the more people look for ways around the problems and this was something that was mentioned by several other people.

You design something. Even though despite your best efforts to, you know, to try and make it foolproof, it is possible that if it's difficult to get that, location, it's just not easy access, then the person's going to look for a different way to do it and the different way to do it is not always the best way. It's a faster way, but not the best way always.

So I think what we really need is a new approach -- Let me change that. It's not a new approach. What we need is a recommitment to the idea that maintainability should be built into all aircraft. And I believe that this will reduce the cost and encourage safety as a result.

Probably the easiest way to look at this -- look at the problem would be to divide it into areas. The major area that I have in mind would be the responsibility of the manufacturer, but I also believe there's also two other areas and that is the pilot's responsibility and the FAA's responsibility in the overall picture.

The manufacturers of aircraft have not in all cases designed aircraft with maintenance in mind, I think we're all very much aware of that. A part of the blame should be laid at the feet of the consumers because they have -- really haven't demanded it.

The cost was not that much of a factor. Therefore, it looked better, you know, with that nice paint job, but not broken panels and a number of different things that you can put on aircraft. But this is changing, and people are becoming more aware of it. Just to give an example of the type of aircraft I fly, it's a twin-engine, pretty typical. Not the newer ones.

So I don't again mean to imply that none of the human factors issues are being looked at, but this particular aircraft I have to fly around with a real long funnel, because I found out very quickly that the design was such that you really can't conveniently put oil in, and you can miss putting the oil in so that the oil goes all over the cylinders, and line boys have done that.

They pop their panel open and say: Boy, sure is far. So then they take that thing out and say: Okay. And stick it in like that, hoping it's going to get in there.

So for my own piece of mind, I can't let this continue so I have the line boy -- before the line boy does anything, I say: Wait a minute. I run back and get this big, long funnel, stick it way down in there and say: Now, go ahead and fill it up.

That's just one example and there are many, many, many other examples. Ask any mechanic and he will -- talking about the maintainability of an aircraft -- show you his battle scars, it you will. He'll point out his hand and say: Here's Mr. Smith's airplane, this gash right here. And this is where I got caught on Jack's airplane working on it. Just look at this hand. You can tell they're a mechanic, because they've been working around aircraft that are not easy to get into. They sit with their hands, you know, little inspection panels trying to inspect pulleys and cables and you have to hold a mirror up and get a flashlight up and look back in there, and it's way up in there.

This is how he's going to inspect it to determine whether that aircraft is airworthy. Let's point out again manufacturers do work somewhat on the human factors issues, and for the most part dipsticks are accessible. I don't know why, but they make them that way.

But again, in-large maintainability has not been a priority item in the construction and the design of general aviation aircraft. I think ease of

maintenance comes somewhere after the placement of the cigarette lighter. Make sure that cigarette lighter is right there where you can reach it. Then we'll worry about how you can work on it.

While all aircraft present a compromise and we all are aware of that. All too often the main compromiser has been maintenance. Ease of maintenance.

And I think this needs to be changed. In fact, must change if we are to reduce accidents which is the goal of the FAA and all of us. Reduce costs which is certainly what our consumer members would like to see and keep everybody flying, which is what all the sales people want to see. It's just plain human nature to avoid an unpleasant task. We all do it. In fact, my wife has suggested on numerous occasions that I hold the record in that regard. So it's not too hard to see why safety is compromised and is as a correlator why costs go up rapidly.

Whenever the components requiring maintenance are poorly designed or in locations requiring a circus acrobat to get at. As we see it, we need a firm commitment to the idea that the maintainability be designed into aircraft from the very beginning.

So standard arguments are that it's too costly, or that it won't sell. I think we're losing validity as the consumer becomes more educated, and his costs continue to go up; owners and potential owners are facing higher and higher costs and therefore when they go out to purchase an aircraft this becomes one of their considerations and it's becoming a larger consideration.

They no longer say how fast can it get me there, but what's it going to cost me after I finish? How much is that annual going to cost me? How many times do I have the oil changed? What's the failure rate on these things? I have faith in our engineers such that I believe that they can design an aircraft which is safe, fast, efficient, attractive, comfortable and on top of all that still easy to maintain.

I am sure there are probably people that would think those are all at odds with each other. I don't believe they are. These attributes are not mutually exclusive. Sure it does take some creative engineering. There's no question about it. But it can be done.

An American industry, I believe, has both the talent and the resources to do it. So that's one of the areas of responsibility, the manufacturers.

The other areas, the pilot, owners and here again in laying some blame, I'd like to spread it around so no one is taking the entire rap, because I don't think that's ever entirely true.

Pilot, owners share some of that blame when it comes to pointing fingers. They have traditionally ignored maintenance, the proper place of maintenance treating it more as an undesirable chore. Something that you have to do to meet the requirements and therefore, they can fly. And I think this is seen by the number of times in which the FAA and their field inspectors have found aircraft that are not properly maintained and needs to change.

However, the pilots are changing. They are becoming more aware as indicated by the contact that we have from all of the members. And again, economics is playing a more important part in their decisions to purchase these aircraft.

In fact, economics has a way of forcing the issue to the front in a very effective manner. Perhaps now is the time to interject a couple of other issues that other people have discussed and which are not directly related to the human factor but a side issue. That is a question of what kind of maintenance should be performed?

The issue of the mechanics about splitting, as they say, the certificates and rating so that there are different areas and perhaps even further getting into a very controversial area, one that I feel that the FAA doesn't like to talk about and mechanics don't like to talk about, and that is the possibility of having owners doing more of the maintenance.

I see it's a very strong connection, the concept that if a mechanic's certificate did have certain ratings, let's say you go with a basic A & P rating and then you have certificates that you can add to it. And if the training available was such that you could get in or enter into the field whether -- with a relatively modest amount of resources, then it is possible that we could get more pilots, more people interested in the maintenance field instead of having -- I'll take myself for an example.

I would love to get an A & P certificate. I can't find a school in my location there at Washington, D.C. in which I can do it around my work schedule. I would have to leave my position and basically go to school for two years, even with my background as an avionic's technician in the Air Force.

So it's difficult for me to commit myself to doing maintenance, even though I prefer to perform my own maintenance, and I think getting myself involved from the aircraft makes me conscious of what type of things need to be done. So I don't think it would be all bad we try and get the pilot into the maintenance field, make him more aware and more responsible for simple maintenance items on his aircraft.

In that regard, I think that the FAA has a responsibility to review the rules and regulations that they have on the books now. They've been there for a while and I think it's about time that we take a fresh look at it to see where the rules and regulations can be modified.

And I'm not proposing additional rules and regulations. Lord, don't ever have it that an AOPA would have additional rules and regulations. But I am proposing that we need to take a look at those regulations and see where they present barriers to maintainability to getting pilots more involved in the maintenance aspect.

So I really view it kind of as a three-way problem. There's a responsibility of the manufacturer. One that I feel at the present time the manufacturers have really not grabbed and run with. It's more like well, when the consumer complains about it or when this happens, that happens, then at the time we'll take a look at it instead of getting out there aggressively. It's a problem with the pilots and mechanics -- pilots being more aware of maintenance being performed. And I do find that -- you're aware of it -- pilots by and large really don't have a firm appreciation for what that mechanic goes through when he works on the aircraft.

And the pilots, I am sure you've all seen it, he drives in, jumps out and he said: Damn radio won't work, fix it and runs away. So then the mechanic sits there — the avionic's technician in this case said: I have to troubleshoot from the beginning. Instead of having the pilot sit there and take a few minutes to say: My radio frequency is out on 1223. I have a squelch problem. Every other indication seems normal.

You know, I think there is a responsibility on the part of the pilots and as I indicated with the Government to review the regulations and see where we can do better, where we can loosen those regulations to get more people involved.

So since in starting this whole thing I did not start out as my old speech teacher said: I want you to tell them what you are going to tell them, and you tell them what you told.

I'm -- I am going to complete telling you what I told you in summarizing this thing. First of all, it's evident that flying is getting more and more expensive. It's just a fact of life. There are a whole lot of factors involved in that, but maintenance accounts for one of those increases.

Aircraft designers need to do a better job of considering maintenance during the earliest stages of the design process. And in other words, don't design the airplane, sit there and say: This is what we want to go 200 miles an hour. We want to carry five elephants, fifty pounds of baggage.

After you do all that, you get the mechanic and say: Okay. Look at this. Do you think you can work on that? Maybe if we just tilt it a little bit. You need to involve the maintenance people from the very beginning.

I don't think a -- even though a designer will say: Yes, we're aware of it that he is aware of it to the extent the mechanic is. So it doesn't take a whole lot to upset a little portion of the office with people that have that kind of experience to review these plans, to get in from the very basic, even more that design it with the understanding that you'll design maintainability into the aircraft.

Okay. So the question then is really: What the title meant. I started out by saying: Okay. Maintenance. Can we afford it? Let me connect that to you if you haven't already. The answer obviously is yes. We must be able to afford maintenance. But we can no longer continue to ignore the importance of designing from the very beginning maintainability into aircraft.

If anybody has any questions I'll be happy to discuss it or any general comments about it.

SPECTATOR: AOPA helped put out a letter to one of the worst things, the pilots cannot write gripes. Many man hours you would save him.

MR. KORANDE: He's pointing out the fact many pilots do not know how to write up a discrepancy on an aircraft. As I indicated that you stumble out and say it's broken and that leaves you in a quandary about how to fix it, and I really believe that we, the Association, and a lot of other people do need

to take another look at our -- how we're approaching this.

I think there's a way we can get together and try to -- and get this type of thing across, you know, to the pilots. The manufacturers have a problem; maintenance people have a problem. They come to us and talk about it.

Maybe we can do something to structure an article or get that information out to the people. I've seen it from both sides. When I was an Air Force avionic's technician working on C5's and 141's, the lowest form of life was a pilot. You know, maintenance people, they say that guy doesn't know what he's talking about.

We run up there time after time and have a C5. They would have a write-up. We would run up there: Step aside, sir. Super mechanic is here. Sit down. And we look it over and say: Can't duplicate it. It's got a problem. We'd reset the circuit breaker or something and then go into the aircraft maintenance log, write as a corrective action: Short between the headsets. And then run out because the guy forgot to put in the circuit breaker or something like that. When you get on the other side of that fence, when you become a pilot or to gain these skills, you look at it and start to think: Those mechanics don't know what they're talking about. I have seen that thing screw up 15 times, you know, and I'm not going to take that airplane any more because those guys aren't fixing it.

There's both sides of the issues and we have to recognize that. Yes, sir, way in the back.

SPECTATOR: What the problem is AOPA knows what the problem is. Why don't you be -- (inaudible) --. I can give you an example why. Flying in World War II, German Air Force had this problem. They were training pilots by the thousands and how to keep these airplanes flying. They --(inaudible)--.

MR. KORANDE: I don't want to get you to repeat it. They couldn't pick you up here. Let me -- Can I paraphrase the question for you?

Basically, it was okay if we know what the problem is; why doesn't the AOPA take more action in order to try and resolve and set standards and things like that? Is that basically correct?

SPECTATOR: Establish goals that the manufacturer will try to meet and I began to give you an example. Prior to World War II in the Air Force Training --

(inaudible)-- keep from flying. And they showed me an airplane that where every major turnbuckle, the entire engine would be -- (inaudible)-- in 90 seconds.

MR. KORANDE: What was the last? Within 90 seconds. I take that as a very valid criticism and I would agree with you up to a point. There's a certain amount that we as an organization can do to set standards. When it comes to setting standards on technical matters such as aircraft and everything, a part of me wants to say: I'd rather defer that to the engineers who are more competent in that area. We have a valid input. In other words, AOPA should have somebody there or we should serve as the focal point to bring these people in to discuss these issues.

Say this is what should be done. I think we can do that there, but I don't think we can set standards as a consumer group. We don't have the technical expertise that the manufacturers do.

SPECTATOR: I'm not asking you to set standards. I'm asking you to set goals. Let the engineers determine what standards are. Things are -- (inaudible)-- examining every engine for example. That's what I mean.

MR. KORANDE: I agree with you again, and I think that that is something that we're going to be taking more and more of a look at. That's a very valid point. Anybody else? Yes, sir.

SPECTATOR: Part 43 allows extensive preventive maintenance by pilot. You make your people aware of that?

MR. KORANDE: We try to make people aware of that. We have that printed in several areas. I will disagree with you to a certain degree on the term: Extensive maintenance. When you read through that Part 43 section that allows -- It says: Preventive maintenance. Is that what you said?

SPECTATOR: Right.

MR. KORANDE: It does allow the things I would like to see and what's been suggested by a lot of other people is that more maintenance by individual owners be allowed, not necessarily under the direct supervision of a mechanic but say for example having been signed off by a mechanic to perform that operation. I think there's a debate here of whether or not if you have a mechanic there, does the person have to be there or have to be available or whatever.

SPECTATOR: Give us an example.

MR. KORANDE: For example, as I understand it you cannot change the brakes on an aircraft. You can remove the wheel, but you can't change the brakes. Now the disc brakes, they're usually very simple. There's a nut to pull them off. You can replace the entire unit or put just a pad on with some very simple tools. It's not something that's a complex operation. So the question is: Why can't the pilot do it if he's been properly instructed and supervised? So a lot of members are writing in saying: Why don't you suggest to the FAA or to the community or whatever that we get a sign off or some sort, be authorized to perform certain maneuvers after having met a testing requirement?

We go to the FAA, show them on our airplane we can do this. Maybe it's a written test or practical test or something. More and more people are becoming interested in this, particularly since the costs are going up higher and higher.

If we do have a mechanic shortage, and that's obviously a subject of debate, it's going to get to the point sooner or later where mechanics really cannot afford to be involved in just minor maintenance operations, things that can be handled by other people because mechanics are too involved in the diagnosis and major problems that pilots legitimately should not be involved in.

SPECTATOR: Could you maybe have an AOPA give seminars?

MR. PONTECORVO: We are having problems with the people in the back there.

SPECTATOR: Have AOPA address that point, and have training seminars like your weekend schools that you run very well now that would address specific areas of training that a pilot could -- he could be signed off, have a mechanic to check him out to expand it enough to where it would be a major point, some sort of training and expertise.

MR. KORANDE: A very good point. That's something that's been considered. Again, let's recognize the fact that it's a very controversial issue. I wouldn't pretend to sit here and think everybody sitting here agrees with the idea that maybe a pilot should be involved more in the maintenance of aircraft.

A lot of mechanics say: Oh, my God. You should have seen what came in yesterday. You want these guys to be working on airplanes? There's a real

problem. But yet there's a middle road there somewhere. There's a complexity of the operation that says the pilot shouldn't get involved. It should be somebody that has more background and more technical expertise. There is -- There are a lot of items that all mechanics do that really kind of -- you stick the screw in and take it apart, pull the nut off or place in, and the pilots are not allowed to do that.

Again, just as a suggestion type thing, come on up. Just as a suggestion type thing, more and more people are bringing that issue up and obviously it's being brought up here because of all the statements, the cost and everything about the splitting the mechanics' certificates and there are people on both sides of that issue, too.

SPECTATOR: You have access to a great number of pilots. Why don't you take and bring out the big drawback to what you're talking about. Maintenance as a mechanic and as an inspector. I go through log books page after page. The only thing in there is the annual or 100-hour inspection.

A maintenance man would like the pilot to take interest in what he's doing, but we would also like to see a record of what he did because when there's nothing in those log books that mechanic has taken all the responsibility for what Joe Blow did on the weekend.

You want the extra work. It's welcomed by the mechanics, but also take the responsibility for the work you're going to do.

MR. KORANDE: That, too, is a valid point. If people are going to perform the maintenance, this ties into the difficulty we have with enforcement actions. We could go all day on that. Enforcement actions on pilots; enforcement actions on mechanics. I get a few calls from mechanics who say: Boy, all I did was this and all of a sudden I have an FAA guy breathing down my neck. I've had a great relationship with them 20 years and now he's out to kill me. It's crazy. I don't understand what's happening. I did all that and something is wrong here.

If that type of thing occurs, then -- First of all, I would be in a position of saying that any item of maintenance done, you know, by an individual pilot or something or even a mechanic should be entered into the log book.

When you look at that log book, you know what has been done. We all know it's a fact of life not everybody likes to fill out the log books. That includes mechanics. We look at some of the write-ups of some of the mechanics. You, as an inspector, I'm sure have seen many times -- it's chicken scratching and you have to read between the lines and, you know, it's just incredible. But, yes, a pilot if he's going to do maintenance, he should put in an entry in the log book and be held responsible.

It's just not the mechanic. The problem right now from the pilot's perspective, strangely enough they are held responsible. They are ultimately responsible. If work is done on an aircraft such as -- (inaudible) -- or failed to be accomplished on a particular aircraft and the FAA inspects it because the pilot, the guy who owns the aircraft, they're going to go in most cases -- this is from my perspective -- they're going to take an action against that pilot and going to take an action against that mechanic.

Mechanic for failing to have done it; the pilot because he is ultimately responsible. And I have more letters from people saying: You know, hey, I'm just the pilot. I just take it into the maintenance facility and they have been doing a great job for me. And I trust them and everything, and now I find out the AD hasn't complied with it, and the FAA is trying to hang me. Why should they go after me?

The answer is you are ultimately responsible. Maybe that needs to be looked at, too. Any other questions?

SPECTATOR: How do the pilots go about selecting qualified or competent maintenance people to perform work on their airplanes?

MR. KORANDE: That is a difficult question, too. Right now we get inquiries from people saying: How do I go about selecting somebody; how do I know what his abilities are and the only thing we can tell them right now is to go take the time to talk to the mechanic, check with, you know, local consumer bureaus and everything to find out if there have been any complaints. Call us up. We do have a complaint file on FBO's and operations' schools and everything else, and if a person calls us up and says: Do you have any complaints on this organization we will tell them.

We'll say: Yes, we have three or four complaints. They're of the nature of this and if you're going to do business with them perhaps you may want to

consider watching out for this. We won't say: Don't go to them or they're bad or whatever. We will say you better be careful because you do have that. It's a very difficult problem. One we're trying to address. Hopefully in the future we would have -- an idea we're going to hook up a computer. At least this is an idea in the early stage that I've been trying to advance. We'll have a computer hooked up. We'll get right out there into the community to list the information about all of the different organizations and then lead that into the computer and then that would be available to people when they call us to say: Do you have information on this organization? Kind of like a single consumer bureau for what to do. Okay? Thank you.

MR. PONTECORVO: Thank you very much, Don. We've heard a lot of talk this morning and yesterday about avionics and we're now going to hear from an expert in this field -- Rich Charles, currently manager of Avionics Maintenance and executive secretary of the Avionics Maintenance Conference. Rick has been in the avionic's field for 17 years with the Air Force, Continental Airlines and also the Data Laboratories. And I think Rick is our first speaker in this area, and we will welcome Rick Charles.

MR. CHARLES: I'll try to run back and forth between the podium and the projector there. A number of the comments that Don made you'll find again as many other speakers have pointed out will hold true for airplanes in avionic's maintenance. When he refers to the consumer, that can be an airline organization as well as an aircraft owner.

And I found the parallel surprisingly exact. I do not mean to start off apologetically, saying once again I'm going to say things that have been said because I thing what comes out of that, what I see developing here is a number of recurrent things, and that's ususally one of the most productive outputs from a seminar or workshop like this. I'd like to also point out before I begin that my comments will be drawn mostly from experience with -- currently with the Avionics Maintenance Conference and those of you who aren't familar with that, -- Briefly, that's an airline activity that goes on year-round sponsored by AIRINC. It culminates once a year in a meeting. The attendence of the annual AMC open forum now is approximately 500 from airlines all over the world. And basically what they do is get together, the airlines on one side of the room, the manufacturers on the other and scream at each other for three days. It's a very effective forum and exchange of communications.

And we found that human factors in avionics maintenance is not so much, of course, a new item. There aren't too many new things that have been found about human factors such as people who wear red shirts on Tuesdays do a better job, but there is a need a lot of people feel for reemphasizing things that are pretty well known.

I happened to be reading an article from Fortune magazine on the way down here, and it has nothing to do with avionics maintenance. It's talking about how Intell, one of our leading chip manufacturers, tried to make its operation more efficient and in that area, as -- which interfaces with human factors quite a lot. The article points out Intell's technique for simplifying jobs is so obvious and elementary it's a wonder everybody hasn't always used it. No smashing breakthroughs or brilliant innovations lighted the way, and I expect that largely in dealing with human factors we'll be dealing pretty similarly in that kind of activity.

I also want to point out that I personally believe we have to draw a clear distinction between line and shop maintenance operations in airline avionics and in general avionics as well to a lesser degree.

As I mentioned before, line maintenance is largely carried out by A & P mechanics; shop maintenance is carried out by avionics technicians, for the most part in airline operations.

And there are differences in the perspectives from which those people operate. The business of avionics maintenance is currently on the threshold of a revolution in airlines. Airlines and in general aviation. Airlines are completing preparations to support digital bus linked, micro-processor based avionics oncoming new generation airplanes.

A number of industry activities are working to prepare airlines for the new generation avionics in several areas, including software certification, software support and configuration management, ATE acquisition and support and line maintenance interfaced with digital busses, thought memory and new built-in test concepts. Airlines are going to depend more and more on the skills of avionics technicians on the line and in the shop.

Incidentally, am I distorting back there, or is that the way it sounds back here? A little softer?

The roll of avionics on the airplane and an airline operation is continuing to expand. New technology systems are extending the capability of many traditional avionics functions and they're also adding new functions. Also, many parts of the airplane that have conventionally been mechanical or fluid devices are becoming electronic.

Operationally, airlines indicate that 40 to 60 percent of the delays are typically caused by avionics malfunctions. At this point we can safely say that the relationship between avionics and airworthiness has been consummated for sometime.

In the past it was just a question of: The radio was out and it was an inconvenience. That's not the case today. It would seem appropriate then to review the needs of avionics maintenance personnel. Technology trends and improved built-in tests, automatic testing and modularization have resulted in a deemphasis of concern with human factors in avionics maintenance.

These developments have tended to increase the role of equipment in the maintenance process and decrease the role of the technician in the maintenance process. It is generally perceived that as a result of that you can use lower skill level personnel.

Ironically, such an arrangement may produce a proliferation of maintenance people in some areas, such as the shops. The ATE operations, which are typically perceived as go, no-go operations may be able to use a lower skilled personnel. But since higher skill levels are going to now be needed at the component level, the result can be a number of people performing an operation that one used to be able to perform.

I want to quote from Jerry Farro (phonetic), vice president of Maintenance and Engineering with Flying Tigers. He commented at the 1981 AMC open forum in Los Angeles that: Avionics and manned aircraft should be viewed as a means to send the pilots' capabilities, not as a substitute for the pilot.

I would suggest that the same hold true for avionics technicians. I think it should be remembered that self-diagnostics and automatic testing provide the technician with indications to assist his decision-making process and those of you who might be familiar -- personally familiar with avionics, line or shop maintenance operations know that BITE (phonetic) and ATE don't give you a sign that says: Hands off procedure. If they did, the industry

picture on gate delays, and non-verified removals would certainly be different. Information from a variety of sources is combined by the technician in making decisions.

To maximize the quality of his decisions, we should examine the factors that influence his work and optimize them to whatever degree possible. Now I've shown a number of items here that I personnally believe are among the leading considerations in human factors in avionics maintenance.

And as I am sure you can see, most of them are not unique to avionics. Although I've listed them separately, they are, of course, very interdependent. Logistics, ability, attitude, physical environment, regulatory environment, communications, equipment and procedures all interplay greatly with each other.

Back to this one (indicating). I'm having a human factors interface with the projector now. The technician's ability is a fundamental consideration. It's largely a function of his aptitude, training and experience. The aptitude sometimes is one of those overlooked items. It's something that's taken for granted.

But we all know that there's a -- there are many people experienced in a certain function and trained, but they might have aptitudes that might better be channeled elsewhere. So it is something that I think is an important factor that should be considered. Training, we've talked about a lot this morning and it's of course, a paramount consideration with the coming new generation aircraft. The production oriented nature of avionics jobs and fast turnaround times on the line have made it necessary for avionics people to concentrate almost entirely on improving skills that are associated with existing systems.

ATE, mentioned up until now, in airline shops have mostly been analogue -- analogued ATE and has been limited in scope. It's usually an auto pilot test; it's often in the corner -- one or two guys may know how to use it. And it's magic to the rest of the people in the shop. That situation is changing. The new systems will require the acquisition of vast amounts of knowledge in areas that most technicians currently are unfamiliar with.

The quality of their work with the new systems, I believe, will pretty much reflect how comfortable they are with them. Airlines may provide general training in computer, software and micro-processors basics and draw heavily on

manufacturers' training programs for specific units or systems.

Most airlines have indicated that they will use audio-visual training aides for recurrent and refresher training only. They have shown a strong preference for the customary classroom arrangements in initial training programs.

Many people agree that in order to instill confidence and enhance the maintenance technician's decision-making ability, training programs should go somewhat beyond the bare minimum required to enable him to follow the instructions. A number of European airlines have demonstrated the cost effectiveness of thorough, initial and recurrent training programs.

William Salafee (phonetic) of Swiss Air. I don't know if we're talking about the same paper.

SPECTATOR: I don't think so.

MR. CHARLES: Noted again this was a 1981 AMC open forum. We must not underestimate the degree of knowledge our line maintenance technicians and engineers will have to acquire to cope with the new systems.

Shop technicians must not only be well trained on the digital avionics units, but on the automatic test units needed to maintain them. Now, technician's experience level, again, might appear at first glance to be something like aptitude to be taken pretty much for granted and observed as a part of the job performance. But the high reliability levels projected for new avionics for the new digital systems are presenting a new type of problem to airlines, and that is that it may be difficult for many technicians to accumulate enough experience on certain units to become proficient on them.

I therefore suggested a balance between rotating assignments and fixed assignments be sought by management. Assignments are generally rotated to provide a degree of variety on the job and widen the experience and proficiency of individual technicians to create a logistics safeguard. But if that isn't managed properly with new systems, this type of arrangement could create a broad base of non-proficiency in the shop on new systems and that's unconducive to effective job performance and happy technicians.

In talking about human factors, I only had cite 101, so I'm no psychologist but I do think we have to talk about attitude. While we have to give credit

to each individual for volition, either to his advantage or disadvantage, there are certain aspects of any position that will influence a person's attitude about a job.

While these factors may be somewhat elementary, again nothing new, I do believe they should be reemphasized in the avionics maintenance field. Since -- Because of the sophisticated technology of any system that I mentioned before has led some people to the mistaken impression there's little left for the avionic's technician to do and therefore little to consider on his behalf; the physical quality and conditions of the work area, the posture of management, emphasis on responsibility and professionalism will all reflect the quality of maintenance in avionics to varying degrees among different individuals.

Also, as a new generation of avionics enter service, a certain amount of caution may be advisable to see that actual responsibilities aren't diluted as a result of overspecialization which can result in highly modular, actual and redundant job functions.

Again, I point to this article in Fortune about Intell. They were looking at a background operation and the quote is -- goes like this: The backroom was organized by functions: All check and encoding was done in one place; all computer entries in another.

Responsibility was lost. Errors couldn't be corrected. So I think that's a good example of what can happen when we overspecialize. There really should be a balance, and the advances that we've made in modularization have oddly enough been somewhat counter to that.

In-line maintenance and again I stress most airline avionics line maintenance functions are carried out by A and P mechanics. There are a few considerations that are somewhat specific to line maintenance that affect the maintenance decision.

Proficiency in troubleshooting complex systems can be strained at the end of a shift on a cold, rainy night. We've heard that already today. Perspectives often change. It's a well-known fact that when it's raining, pitch computers fail. Elevator position sensors don't. And I think that -- that things just seem to happen that way for some reason.

Policies or arrangements by management to lessen the effect of inclement weather or extreme climate conditions can go a long way in enhancing his productivity and the quality of work. And then, of course, there's turnaround time. When a line maintenance technician has 25 minutes to troubleshoot, repair and retest a system, a knowledge of what's in stock and what isn't and an awareness of how delay factors are charged to each station and may be even some differences of opinion with the flight crew determining the nature of corrective action he plans to take, expediency can become attractive.

Another influential factor in the maintenance decision-making process is the regulatory environment. This seems to be an appropriate place to be talking about that. Line and shop technicians interface with regulatory agencies in a number of areas, including radio operations, FAR's, minimum equipment lists, airworthiness directives and occasionally directly with regulatory such as FAA personnel.

Experience has shown, as many airlines indicate, that the objectives of FAA are best served when the relationship between FAA and airline maintenance is one of cooperation and mutual understanding. Assuring that airworthiness standards are met in promoting aviation safety are primary FAA responsibilities.

An FAA posture that's too weak does not serve FAA objectives. An FAA posture that puts airline personnel on the defensive has proven many times to be thoroughly counter-productive. I had prepared a beautiful viewgraph of Leon Sphinx, but they wouldn't let me bring it. In acting out of necessity as a regulatory enforcer, while at the same time trying to stimulate cooperative teamwork, FAA's job is an extremely difficult one, I am sure we all agree. And such a balance might only be possible through good communications, uniform policy and a consistent demeanor on the part of personnel representing regulatory agencies.

There are few areas that have as direct an effect on the quality of maintenance decision-making as good communication. Communication in avionics maintenance generally begins with a pilot's report. Maintenance personnel are known, as Don mentioned, to complain frequently about the quality of pilot reports. And that, of course, one of the classics; as a result of that, some airlines have actually allocated a portion of time in pilot -- recurrent pilot training to a section called: How to write pilots' reports. But in all fairness, a pilot doesn't have any monopoly on the problem.

I can draw from one of my personal experiences to prove that out. On one occasion after everybody in the system seemed to be writing up every system as inop, radar inop, VOR inop, we put out a series of pilot bulletins that say: Please don't say inop. Please describe the problem. There is nothing -- It just gives the line and shop technicians nothing to go on.

So the pilot bulletins went out, but the problem only reduced a very small amount. It persisted. So we started tracing the paperwork and this is what we found: VOR No. 1 -- (inaudible) -- came into view and both -- (inaudible) --.

Their RMI -- (inaudible) -- to the right altitude. The recurrence was 350 ADM -- (inaudible) -- VOR No. 2 okay. And the No. 1 localizer is okay. Paragraph. Got all that; did you? Paragraph.

In this case, you know, the mechanic looked at the time. I'm not going to write that garbage. I don't have the time. VOR No. 1 inop. And that's what they got in the shop. So he just passed the problem on. And I think it is important to point out that there's more than just the pilot as I pointed out.

Further, on communications, communication between the flight crews, line maintenance, shop maintenance and I think most important the feedback among them can be and indeed is a primary element in the quality of many maintenance actions.

If the line maintenance technicians knew that four radar transceivers have been changed on an airplane during the past five days for an antenna stabilization problem, he might not be so quick to change another one.

More so, if we know that only one out of fifty transceivers returned to the shop for -- (inaudible) -- problems was a confirmed failure but forty-seven out of fifty antennas returned -- (inaudible) -- problems were confirmed, he would have to have no conscience at all to change another transceiver. Broader dissemination of such information throughout the maintenance system can improve the decision-making in a number of levels.

Pilots might even squawk more effectively if they received appropriate feedback from maintenance personnel. In the case of that example of the radar antennas, that shows the interrelationship, I think, of these factors. It sure would play on his conscience, but he still has the pressure of turnaround time which is not conducive to changing radar antennas.

To improve communications, a number of airlines have implemented maintenance information systems on line interactive systems, such as septor (computer) system that Republic has. It's an IBM-based system. Some of you may be familiar with it and the OSIS system, which has just completed the phase 1 implementation at Eastern.

With systems of this type, line or shop technicians can have a wealth of vital information at their fingertips, such as the history of a specific unit by serial number, reliability data for a certain type of LRU or system and performance information such as pilot's report or maintenance actions on a certain airplane for specified period of time.

These systems have been reported to have significantly improved many areas in maintenance operations. As with the design of any data processing system, the user interface should be kept as simple, efficient and straightforward as possible. Industry activities such as the avionics maintenance conference where equipment users and suppliers meet to compare notes on operational and maintenance-related items provide reliable communication link to the industry for individual operators.

One of the leading benefits of AMC and other activities like AMC has been that the chain of events between discovering a problem and implementing a solution has been greatly streamlined.

It's very difficult for somebody to tell United or TWA or Continental: You're the only one having that problem. I can't understand why you have that problem when 500 people from 30 countries are in the room. If there's any misunderstanding, I'm not saying that's a malicious reaction. If there's a misunderstanding that leads to that kind of conclusion it gets cleared up in a big hurry at AMC.

Looking on the machine side of the interface, we have been looking at people, but as a manned machine interface, one of the leading considerations is reliability. The industry trend is beginning to shift in the military and in commercial aviation from equipment capability to equipment reliability.

Manufacturers responding to user pressures and are beginning to concentrate more effort on designing reliability into equipment from the outset.

Now what's the consequence of reliability as far as human factors are concerned? A known unreliable unit tends to build frustration in technicians and maintenance actions often become more automatic and less thoughtful following a reported malfunction.

Corrective action in this area, of course, begins as many have said before me today with equipment design. Built-in tests is another important equipment consideration in the maintenance decision process.

Lack of confidence in built-in tests can be a major source of frustration with avionics maintenance. In a recent paper entitled: Diagnostic errors and Human Factors in Built-In Tests by -- (inaudible) --, T.M. Miller and -- (inaudible) -- of the Air Force Human Resources Laboratory, authors commented: It is not equipment such as built-in tests that makes decisions but people.

We talked about that a little earlier. While the technicians-error rate can be uncomfortably high, it's not nearly as high as the error rate would be if the built-in test indications were taken at face value.

The authors noted further that high built-in test error rates have caused many false pulls of LRU's and this resulted in delays in aircraft turnaround, overloaded intermediate repair shops and the employment on the flight line of guess what? High skill level technicians to resolve the many false and ambiguous built-in test indications.

It's not uncommon for the built-in test to essentially be ignored by maintenance personnel due to its high false alarm rate. The built-in test for the coming digital avionics is quite a bit more sophisticated than -- (inaudible) -- balls we have had up to now.

There's ram memories for in-flight diagnostics, recording intermittents and ARINC and industry activities have been dealing with how to standardize interfaces to down load that information; how to make it most useful to the line mechanic.

And we have a number of -- of alternatives. The initial idea was the -- red light and green light. And that's where it stops, but maintenance people decided they wanted more information than that because they know from experience that when the light says: Pull box A and the mechanic pulls Box A, gets another one out of stock and plugs it back in, he often gets another red

light, and he doesn't know if he has a bad unit out of stock. He doesn't know if there's something wrong with the circuitry. He doesn't know if there's something else wrong with the system somewhere.

So we will be looking forward to more complete BITE diagnostician and indications rather than just red and green lights. You know there's always been a running rivalry between A and P mechanics and avionics technicians anyway and we've heard a number of suggestions in the past that are somewhat analogous to the red and green light, such as putting animals -- pictures of animals on the boxes and then you can publish a book that says: If the VOR needle goes to the right, change two giraffes and a hippo.

But that kind of thing just isn't working. So -- Additional equipment characteristics that affect a technician's decision-making process and the quality of maintenance include as was mentioned before today: Maintainability, and Don covered that more thoroughly than I could ever cover it. The consequence of maintainability is cost and airworthiness directly.

Testability. Accessibility on aircraft. And the integrity of the installation design. It's human nature to take the path of least resistance whenever possible, and it can be frustrating when there's no alternatives available.

There are a number of avionics units. Again, the human factors consequence of that. There are a number of avionics units and systems flying today that technicians simply hate to work on. Relationships of that type of equipment are not conducive to quality maintenance.

These features again should be designed into the equipment; not added as an afterthought. The procedures provided by manufacturers for maintenance on the airplane or in the shop should be understandable, consistent and most of all correct. The technician should be comfortable with the maintenance procedures and have confidence in them.

Special procedures such as requirements for non-magnetic screws in the vicinity of a flux valve should be kept to a minimum whenever possible. Again procedures as well as reliability, testability, and maintainability should be developed from the ground up, beginning in the initial design phase.

There are a number of new DOD documents that point to reliability, testability and test procedures being developed from the ground up. The

coming new generation digital systems, however, are presenting interesting challenges in the area of test procedures.

Many line and shop replaceable units such as those that are micro-processor based cannot be tested manually and must therefore be tested ATE. That's going to result in a rapid proliferation of ATE in avionics' shops and somewhat of an inversion of -- It plays -- ATE plays in avionics maintenance.

Test procedures for these devices are computer programs on -- (inaudible) -- tape, an arrangement most shop technicians are currently unfamiliar with.

Airlines and the military have taken a major step toward preventing the uncontrolled proliferation of test programming -- (inaudible) -- by specifying the use of Atlas. As in any software application, it's imperative that test software and support software be well-written, properly documented and above all proven.

So what's the human factors consequence to that? Well, in avionics maintenance, the consequence of pure quality software is somewhat unique. A technician is asked to sign his name, his personal certification that a unit is airworthy. The trouble is that a compile test program executed from a storage medium is a string of ones and zeros, is invisible to the technician and something over which he has little, if any, immediate control.

So if his experience tells him that a particular piece of test application software is deficient, he's going to lose confidence in the software and he may be justifiably somewhat reluctant to sign his name to vouch for its integrity.

A final consideration is logistics. The availability of spares we talked about being a major influence in maintenance decision-making. Technicians often find it necessary to find alternatives. Alternative courses of action due to out of stock conditions. Paperwork, of course, is always an important consideration to the extent that forms are poorly designed or contain superfluous information, people don't -- simply don't fill them out or sometimes worse yet they fill them out incorrectly.

Much of the basis for good communication rests in good paperwork. Well, I have attempted today to list some of the items that I consider, even considerations regarding human aspects of avionics maintenance and to briefly comment on some of the things I think might be done to improve them and on certain things that are already being done.

As I mentioned earlier, there aren't too many human factors that are unique to avionics maintenance. The opinions of A and P mechanics not withstanding. I don't imagine I've said anything too surprising, but I do hope you're provided a rough checklist as a starting point in recognizing that at least in the near future no matter how sophisticated BITE and ATE get, the machines aren't going to do it all.

As we continue in our ever increasing quest for advance built-in tests, automatic test equipment and in ever increasing variety of flying guides in missiles, we shouldn't forget the poor guy sitting in the rain with a -- VOLT OHM -- meter in his hand or the poor guy at the bench staring down at a smouldering mess because we still need them to make it all work. Thank you. Any questions?

SPECTATOR: How do the current BITE functions -- Are they working well on the INS systems that are self-diagnostic?

MR. CHARLES: No.

SPECTATOR: What was the question?

MR. CHARLES: The question was: How are the existing -- the current BITE systems such as Inertial NAV working? Are they considered good?

In my considered opinion it's no. The BITE systems we have, really suffer from an extreme lack of confidence almost universally. What we're trying to do with the BITE, not only to make it more dependable and inspire confidence in maintenance people, but as I mentioned earlier to give them a bit more to go on such as an alpha numeric display or something that can lead them to the source of the problem.

They get redundant BITE displays.

SPECTATOR: You talked a lot I think about the need for more training. You talked about the need for more training I think with the digital systems. I guess one question I have: Aren't there some digital systems now where people are working on satisfactorily and I guess the other question is: How much more training are you talking about?

MR. CHARLES: Well, the amount of training -- I don't know if that mike picked up back there -- It has to do with how much training are we talking about for the new digital systems? It, of course, varies from airline to airline because different airlines are on -- different levels of support at this

time. With the Boeing Airline or the Air Bus Airline or whatever new generation digital airplanes they ultimately wind up with them. Large -- We were talking about the Salafee (phonetic) paper from Swiss Air. In his paper he described what Swiss Air is doing right down to the number of hours required for each function.

And he talked about on -- some -- Well, I better not quote the hours, I don't remember, but -- Do you have that?

SPECTATOR: The basic of the line level is 40 hours of classroom.

MR. CHARLES: Forty hours of classroom.

SPECTATOR: They're looking for different levels, 40 being the basic among 40 more and 40 more.

MR. CHARLES: So for line maintenance troubleshooting we have 40 hours of classroom. And again, this is just a reflection of what Swiss Air is currently planning.

And then there are blocks of 40 hours that advance beyond that to a point where you get a shop technician at the component level of troubleshooting and repair.

But I think that the main thing is that if you are looking at a Level 3 maintenance support program, then a lot of the existing digital systems that are -- there weren't a lot of airlines right now that are maintaining the current digital systems to Level 3.

Most airlines will go to the card level and ship back to the manufacturer. There aren't that many around. I think to a great extent that's going to change and will require knowledge of micro-processing theory, computer theory, programming languages too, before you get too - before you get to the specific pieces of equipment.

SPECTATOR: Just some of the data from his report, they're looking -- Swiss is looking at 40 hours in elementary computer training for digital, 40 for computer basic.

MR. CHARLES: Forty for what computer?

SPECTATOR: Elementary training. Then they go to computer basics for 40 more and then they consider the person that has the foundation. That's what they call Level training, Computer Level 1. Then Computer Level 2 is --

expects to be taught by the vendors.

MR. CHARLES: Right. Again, that's when we go from the basic computer or micro-P theory into the -- either Level 2 or into this specific piece of equipment. Then the airlines seem to be looking toward the manufacturers for that sort of training.

I think I'm cutting into lunch time here.

MR. PONTECORVO: That's fine.

SPECTATOR: In regard to getting the mechanics to fill out their paperwork they can be induced to do it if it was explained to them that they're very vulnerable legally in the event of a lawsuit following an accident if they don't have their paperwork down to perfection. Every lawyer will take advantage of that. The second thing has nothing to do with human factors is that avionics equipment is very subject to malfunctioning by highly charged atmosphere. If you're on the ground and lightning strikes the airplane, check out your avionic equipment. It only takes about a half volt to cause a lot of disturbance.

MR. CHARLES: On the point of the paperwork, that's ultimate -- in the personal experience that I was relating, the ultimate action that was taken was to put out a bulletin to mechanics and discuss with certain specific mechanics the liabilities involved in changing paperwork in that way as well as, of course, as the problem's created in-hours.

On static discharge, there's a lot of work being done on anti-static protection for the micro-processor and various chips that are coming out in the new avionics now. And, of course, the worst problem -- widely perceived to be the worst problem were electrostatic discharge damage as the latent failure.

If it blows the chip, you are in good shape. The latent failure is the thing that creates an intermittent or will fail eventually, but you don't know when and a lot of people perceive that as the worst problem.

MR. PONTECORVO: Rick, thank you very much.

(Whereupon, a lunch break was here taken.)

MR. PONTECORVO: We can come to order once again. Everyone should be wide awake which is typical after eating.

Now we're going to have -- Is Dick Bennett here? Okay. We're going to have a presentation by Dick Bennett. He is with Upjohn Corporation and he's a Purdue graduate and aviation technician and employed by Upjohn Flight Department as an A and P technician. He's going to talk about factors involving the aviation maintenance technicians.

MR. BENNETT: Good afternoon, gentlemen. I'm here on behalf of the Professional Aviation Maintenance Association, PAMA as we call it. I am the acting vice president of the Association. And I'm very pleased to be with you here today.

I'd like to give you just a little bit of background into my aviation maintenance experience, which actually started at Purdue University. And I've been going to school ever since, some 23 years ago.

I am employed as an A and P technician for the Upjohn Corporation's Flight Department in Kalamazoo, Michigan. And my presentation today will be a little bit different from what I've heard. It will be physiological factors realting to the A and P with regard to human relations -- or human whatever.

First of all I regard the A and P technician as a very, highly skilled professional. A tremendous amount of responsibility rests on his shoulders for the safety of our aircraft today. There's a very high degree of pressure and stress that goes with the job. You must work odd hours, weekends, holidays and nights. Often in inclement weather.

His job is very demanding physically and mentally. I'm going to talk about basically four different things today. They're going to be stress, pressure, job attitude and morale. Stress and pressure are two very real human factors concerning the A and P technician.

And I consider them coming from two primary sources: family related and job related. Family related stress and pressures, of course, come from the wife and children. Some good examples -- I'm going to tell you a few things that's happened to me and maybe some friends of mine, typical examples of stress and pressure concerning the A and P technician today.

Obviously the working hours of the aircraft technician are irregular, to say the least. Oftentimes, I have to call up my wife at 5:00, tell her I won't be home for supper because an aircraft needs my attention.

At last minute notice an aircraft broke down. I have to stay two or three hours additional to get the airplane fixed. Sometimes that creates some problems with the family atmosphere. Often times A&P technicians are required to go to different service schools, seminars, workshops and so forth.

Sometimes flight duty requirements. He could be away from home long periods of time. This creates tension within a marriage or can create tension within marriage and the family. He can't always attend Johnny's baseball game. He usually can't coach a football team or basketball team, and he misses many school activities as a result of his job which creates pressures and tension from the family point of view. An incident that -- Just to use a typical example, an incident that happened to me a few years ago.

We had a fuel-boost pump to change on a Grumman Gulfstream I, which is about an eight-hour job total. And it was no particular problem because the aircraft was down for two days of maintenance, had plenty of time to do the job.

However, about two hours into the job everything was opened up, the airplane had been defueled and so forth. My boss comes out and says the airplane is scheduled at 5:00. Can you get it done?

And I assured him that was no big problem, and with some additional help we could finish the job. So we proceeded with another man on the job and were coming along quite nicely, and I got a telephone call from my wife that said that the water pump at home was out.

She had a washerful of clothes, couldn't wash the dishes in the dishwasher, the toilets woldn't flush and, of course, the A&P technician -- you're supposed to fix everything in the house, keep all of the mechanical things running plus all of the neighbors' equipment besides.

And I think she found it hard to understand why I couldn't just drop what I was doing and come home and fix the water pump. It was about 7:00 or 8:00 that night that we got the water back at the house. But these are typical examples of stress and pressure that come -- can come from the family relating to the A&P.

Job related stress and pressures come from many different sources, but by and large they're time, quality and quantity factors. Again, they give you -- to give you a typical example, many years ago I was changing my second fuel con-

troller on a Grumman Gulfstream I, and having been to all the necessary service schools and so forth, I had the proper schooling and training, but I didn't have a lot of experience.

I was quite young in my profession at that time and only the second controller that I had ever changed. It was a nice job, a technical job which I liked. The manager of maintenance about two hours into the job came out and asked me how long is it going to take to do the job because he had a schedule for the aircraft, and it was to fly that day.

Not having a lot of experience in changing fuel controllers, only changed one previous to that, I estimated my time to be anywhere from four to six hours. He didn't seem to understand that, not being maintenance oriented.

He was an aeronautical engineer. He was in a different part of the company, not servicing in aviation capacity, but when the opportunity came about to make a maintenance manager, the company figured that since he's an aeronautical engineer, I think he would be a good man for the job so they promoted him to that position.

But not knowing aircraft maintenance, he couldn't understand why I couldn't say it's going to take four hours, five hours, six hours, three hours. This frustrated him quite a bit and as a result of this and several other instances with other technicians and with the same problem, not being able to tell him exactly how long it was going to take to do a certain job, he ordered time-study people to the operation and proceeded to put the clock on technicians that were doing different jobs like changing wheels.

How long is it going to take to change a wheel, a brake, a tire? How long is it going to take to do a phase 1 inspection? How long is it going to take to change an engine?

Needless to say, these time-study people didn't know what they were in for. After about a week of frustration they gave up and went back to the company with no particular results. Obviously they got very little sympathy from the aircraft technicians doing the job. In fact, all of us took about twice as long to do the job as we normally would have. All it did was create hard feelings, poor attitude and lower morale among the aviation people.

Needless to say we're working on light aircraft. They put excessive pressures on us to get the job done. If you never had any time-study people around

you, you can't really realize what kind of pressure it does put on you. Everytime you're out there, there's an individual sitting there with a time clock, logging all this stuff.

So after losing well-trained good aircraft technicians, the operation -- or the company decided to replace the manager with a maintenance-oriented manager, promoted the Chief of Maintenance to that position, moved the engineer into another area, and since that time the operation has improved immensely.

But that's a typical example of things that happen. And the ignorance of companies and managers to do some of these things that are utterly ridiculous. Poor supervision is a job-related stress. Poor pay, benefits, et cetera.

And in a lot of cases the A&P technician himself put excessive pressures on him by not being able to do the job that particular day. Aircraft technicians have no business in the cockpit of sophisticated aircraft, starting engines, taxiing and so forth if he's not in a good mental state or not physically capable that particular day.

He could have a cold, a flu. He might be sick. He has no business in an aircraft at that point. Often times, however, he will not tell his supervisor, foreman, lead mechanic, whatever that he doesn't feel well. He might have been on cold capsules or pills for a week trying to get rid of a cold or the flu or something of this nature. He is not mentally capable of doing that technical job that particular day. The two to three seconds or longer reaction time that it can take him to shut an engine off when it heads for a thousand degrees or so or the couple of seconds longer that it takes him to put the brake on, close proximity to the terminal, hangar, building, ground equipment, could mean thousands of dollars.

Not just ten or fifteen thousand, all of you know what jet engines cost today. I mean hundreds of thousands of dollars. The guy has a couple of years schooling, the company says: You're qualified. You can taxi aircraft. Got a million dollar airplane -- may have a 747, 20 or 30 million dollar aircraft. The A&P may not physically and mentally be able to do that job that particular day.

It's important that supervisors try to observe their technicians before they come to work very closely, try and get a feel for how the individual feels that particular day. Maybe he has a hangover. You think he's going to do a

good job trimming an engine if he's been out drinking all night? Obviously, no.

Alcohol and drugs, I would like to merely mention. I really don't have any scientific data to back any of my own personal feelings regarding alcohol and drugs. I would like to think it's not a major concern at this time with our profession. I am sure, and obviously there are cases, but I've talked to aircraft technicians throughout our nation and I know there are problems in that area; however, I don't think it's major at this point.

The divorce rate of aircraft technicians, I would gauge to be higher than the national average because of some of the factors that I've mentioned previously. It would be interesting to see, and I don't know of anybody that has a gauge on the relationship between divorce, alcohol and drugs as far as the aircraft technician is concerned.

Our aircraft technicians are employed in six general areas. Each is unique and each area has its advantages and disadvantages. Areas being airlines, FBO's or general aviation. I would like to make the distinction between general aviation and corporate. I heard some comments about the safety factor of general aviation being sub-par compared to airline type operations.

And I would like to clarify, if I may, a point that general aviation and corporate actually should be two different areas. And I think if you'll look into the facts that actually corporate is equal to or better than airlines as far as safety is concerned. But the airlines, FBO's, Government, corporate, manufacturing service centers and the IA running his own business is where the bulk of where our aircraft technicians are located. There are stress and pressures in all of these areas. As I said, some of them are unique. Some of them have advantages and disadvantages over others. And in the last two or three years we have been hearing a lot of conversation about liability.

I know as being an officer in PAMA, we've had several requests that we offer our members liability insurance because we've had a lot of IA's that will not renew their certificate because of the liability factor. It seems like today everybody is out to sue somebody for something and although a lot of technicians work under a shelter of a certified repair station, if there's a fatality involved or accident involved, the FAA will not stop at CRS.

The airline, whatever, they'll come right down and get the individual that actually did the job in the first place. He's going to get sued along with everybody else. Seems like they're suing everybody now.

Engine manufacturer, component manufacturer, airplane manufacturer, the individual doing the job and so forth. Job attitude and morale are two -- what I consider the two primary human factors that are of extreme importance in our profession. They must be maintained to the highest possible level. They're primary factors within the individuals tnat can be influenced by external sources such as your boss, management, the company. I'd like to give you an example.

Typically, I think the airlines pretty much set the standards for well-maintained equipment, good policy, good practices. They have the latest and greatest of equipment, usually offer the best of schools and so forth. And then on the other end you have the small FBO that's scratching to make a buck.

All too many times we find that they take a good technician off the floor, promote him to foreman or manager, but yet they don't send him to human relations' school or leadership schools. They just assume that he's a good A&P technician, he's going to be a good manager. It's not so. You certainly wouldn't go to your practitioner and have him perform open heart surgery on you.

Obviously it's erroneous to think that you could put an A&P technician in a supervisory capacity, either as a lead mechanic, foreman or manager without giving him adequate training and leadership and human relations skills. But yet, we find this happening everyday, and you wouldn't believe how many leaders -- or supposedly leaders that are in FBO's that have never been to any kind of management training, leadership training whatsoever.

I think since the A&P has his own integrity and license to protect, he will not knowingly jeopardize aircraft safety regardless of his attitude, but he can make life miserable for everybody around him.

A recent survey conducted by researcher, M. Scott Myers, at the Texas Instrument Corporation, showed factors that workers -- and when I say workers, this includes really everybody in our profession, only as an example -- found most objectionable -- our company policies, administration, lack of good supervisors, poor working conditions and inadequate payment of wages and training benefits.

These items tend to dissatisfy rather than to motivate, but these items are -- these items are important, but are not primary motivators. Things which tend to motivate people are opportunity for advancement, greater responsibility, promotion, growth and achievement and interesting work.

Therefore, the supervisor or manager who wants to obtain better performance is well advised to utilize strategies which will contribute to the satisfaction of the employees' social esteem and self realization needs. This is very appropriate for the aircraft technician.

If we had those six factors or most of them present in the A&P technician's job, I don't think we would have too many problems as far as human factors, physiological human factors are concerned.

Isn't this what all of us want? We all want these factors involved in our job no matter where we're working. I have some suggestions here for decreasing stress and pressure and improving job attitude and morale. And a summary of my recommendations are as follows: For A&P technical schools, they should better prepare their students for human factors, teach a course on human factors. Let the student know what -- what he can expect as far as working hours, where the best opportunities are, how to cope with stress and pressure.

And how about a course on human relations? And a biggie here is how about appointing an industry advisory board for curriculum input? I talked to a lot of school administrators in my travels across the nation and find that there's very few schools that want the input, or maybe nobody has even asked them.

I don't know. But very few of them have an advisory board made up of people in the industry for their curriculum input. I think if they have that, they would know what industry wants.

What does the FBO want out of an aircraft technician? What do the airlines want? What does the corporate want? What kind of people do they want and what kind of education are we going to give them?

I think the young 18, 19-year old kid that comes to school doesn't really know what he wants. He knows that he likes airplanes, but he doesn't know if he wants to work for the airlines, corporate. He has no knowledge of the difference among the many different facets in jobs that are really there in aviation today. He only knows that he likes airplanes or he might like to work on airplanes.

Therefore, I think in a lot of cases students are not necessarily misled, but are not properly informed about what he can expect in the industry that he's chosen. And there again, I'd like to point out a typical example in Kalamazoo, Michigan.

We have a fairly good aviation program. It's a four-year program offered by Western Michigan University. It has many different options which a student can go to. One of those options is an aviation management technology. They actually offer a Bachelor of Science in Aviation Management.

Well, at our operation at Upjohn, we employ on a part-time basis three co-op students that do primarily our cleaning, janitorial, fueling of aircraft and so forth. We had one individual a couple of years ago that graduated with a Bachelor of Science in Aviation Management. I asked Mark what he was going to do, where he was going to get a job. He said, "Well, I want to be a manager of airline maintenance. I want to be the chief of maintenance for a corporate operation." I don't know where he got his counseling, but, you know, airlines, corporates or FBO's just don't go to the school and say: Hey, we want an aviation manager. Send me out a 21-year old. It just doesn't happen.

Obviously this individual had been misled in his counseling, and as far as I'm concerned the whole curriculum was improper because the individual didn't even have an A&P license. After a year of trying to find a job as being an aviation's manager, he gave up and went back to school and got his A&P ticket and was hired as soon as he got it.

So it's very important not to think that schools have a curriculum that -- a realistic curriculum and advisement to the student on where he's going to seek employment. What does he have when he graduates? I think, too, the aircraft manufacturer, they must improve their maintenance and parts manuals and microfiche systems. This puts a tremendous amount of stress on the A&P technician in the school or in working on a job if he cannot interpret the manuals, if they are difficult to read. Especially warning diagrams. They must be accurate and concise. They must be easy to get information from. They must be quick references.

All too many times I've had to take an hour of my time to look up a specific maintenance procedure. It was difficult for me to find because every manufacturer didn't follow the same procedure as far as coordination of the material was concerned.

They must also improve their technical data regarding service bulletins and service changes. And again, I'd like to draw on my personal experience. Recently I put in a service bulletin on a Thrust reverser system on a corporate aircraft which is a fairly complicated service bulletin. You get these in a kit form from the manufacturer, they have all of the necessary instructions, parts, relays, wiring and everything you're supposed to have to do the job. So the technician sits down. He reads the instructions, and, of course, the manufacturer has a recommended timetable. It's going to take a hundred man hours to do the job, so we know about how long to pull the aircraft out for this specific procedure.

So about four hours later, after trying to interpret the instructions, I more or less gave up in frustration thinking there's no way it can work like this. I conferred with a fellow technician. He agreed. We called the service rep and after a half hour on the telephone and him saying: Well, the first thing you do is throw the first 15 pages away.

This is about a hundred-page service bulletin. And on this page, strike out that and on page this -- no, it won't work like that. On the line diagram, change this to that and that to this and -- and we were very frustrated to say the least. It was obvious that the service change could not be installed as the manufacturer suggested and, in fact, we had to have a service rep come into our facility and try to interpret the instructions themselves.

After all of the instructions were changed, he had put the bulletin in several times or assisted. We proceeded to do the job and everything worked out all right. But the job -- what I'm trying to say is the kit we got would not work on our aircraft, and this is where the manufacturer could really do a lot better. He's very faulty in this area.

Some are better than others, but I think all of them could do well to make sure that when they send a kit out that it's been tried in every possible aircraft. I mean every model of aircraft. And that it will in fact work -- maybe even give it to a technican such as the type that's going to install it in the field.

If this individual can do the job, probably more than likely the technician, the customer in the field can do the job also. But if he has trouble reading the instructions, reading wiring diagrams and so forth, it's obvious

you're going to be in trouble when you get that kit out in the field.

The manufacturer must also offer quality schools for maintenance personnel, both for insurance and recurrent training. Let's keep the schools to a minimum, but yet to a very high quality degree. I know of a lot of service schools that I've been to that involved two, three, four weeks of my time away from home, time away from job, nonproductive time so to speak that I feel that if it had been very professionally run it could have cut quite a number of days off the school itself.

They must also make better access to components and in specific business-type aircraft or smaller airplanes, and some familiar with the airlines and I think the manufacturer or larger aircraft have realized this quite a number of years ago that maintainability is a big factor in the cost of maintenance on an aircraft.

And if they would only use that same concept on smaller aircraft. You see in most of the smaller aircraft, -- (inaudible) -- jets, we have all of the same systems that the airlines do except they're only one-tenth the size, but we cram all of the systems in the same airplane.

So what they do, they make the access panels one-tenth as large and sometimes it can be frustrating, very difficult to change a component in the field. The typical example is a fuel boost pump such as I mentioned before on a Gumman Gulfstream that requires about eight hours to change the unit.

You have to work through a small-access panel about six by eight inches, an oval access panel. You can -- The normal man can only get one arm in that area. He has the safety with one hand; he has to look in a mirror, read things upside down, safety upside down and so forth to do the job.

Definite area for product improvement as far as the manufacturer is concerned. I think for the airlines in general aviation, they must carefully select the best possible managers and supervisors and train them in the area of human relations people. I think a good -- I'll use a good example or what I consider to be a good example. My brother's situation with Delta Airlines. He has been with Delta 23 years, worked up through the ranks, started as junior mechanic right out of school, mechanic, lead mechanic, foreman and is now general foreman in charge of his own station.

And he told me once he made the rank of foreman that he no longer had air-trap problems. He had people problems. He locked his toolbox up, and he hasn't used a ratchet or wrench since. But Delta, being a well run, efficient airline, recognizes that people that they pull off the floor and promote must be schooled in the area in which they want them to do the job.

He goes to leadership schools, supervisory schools, staff meetings, human relations schools, schools of this nature that are related to people and not related to aircraft. I think also that the quality control and inspection departments must maintain the highest possible standards.

I know inspectors must be immune to pressures that would decrease safety standards. The FAA Flight Safety Foundation and PAMA and other organizations should hold similar workshops as we have here today. And they could distribute more information on human factors relating to stress, pressure, job attitude, job morale and how they interrelate to this profession. I would maybe not directly relate it to -- it is somewhat related to human factors. I would like to commend the FAA on their recent IA refresher course. This is just an excellent course I recently attended. I think that's what we needed as far as Part 91 operators. We needed this for quite some time. As you know, there are certain criteria for IA renewal.

The Part 91 operators, at best, found it difficult to meet the criteria for IA renewal. The FAA just recently initiated a refresher course, an 8-hour course, that says if you've attended this course your IA will be renewed. I appreciate that and in a lot of ways this takes the pressure off of a certain amount of our industry.

In conclusion, the thousands of A&P's across our nation handle these human factors problems very well, but it's encouraging to me to know that the FAA now recognizes and is taking steps to educate personnel in this area. This is a big step forward and I'm very pleased with their action.

Thank you very much. And I'll answer any questions anybody has. Thank you very much.

SPECTATOR: One question, Dick. That area on the manuals and the fiche. That's concerned me also. Do you see improvements there? That is the most frustrating thing in the world to track down and read and understand bulletins, instructions and -- of other types of written verbiage we see in the industry now today. Is there any hope for this?

MR. BENNETT: There have been improvements in manuals and technical literature recently; however, they are far from being solved at this time. And I would say that, you know, having 23 years experience as actually doing the work on an aircraft, performing the maintenance, your manuals are really an area which could be improved on, and as of yet, I have yet to see a really good manual.

I've worked on a lot of different -- mostly corporate jets in-fleet, but very sophisticated. Most of the corporate jets I've worked on -- some of them -- some of the manufacturers are better than others, but they are improving. They know what we need.

They have our input. The maintenance field has come a long way as far as workshops and industrial input in the last five years. They're asking us, you know, you gusy are complaining. What do you want? How should we lay these out and so forth?

We're giving them that input and they're slowly changing their manuals to make it better adapted to our needs in the field. So people are improving, but it's taking a -- it's a long, slow process. But improvements are coming.

SPECTATOR: You say it cost you money then, whereas if you had a good written instruction you could send a less experienced man out to do it?

MR. BENNETT: Very definitely. Especially for a young A&P that maybe has been in school, but he doesn't have a lot of experience in doing a particular job. He has to either go to the microfiche system or get the maintenance manual out. If the procedure is long and lengthy, misleading and not to the point, you know, obviously it's costing the company he works for time.

It's nonproductive time and it would behoove the manufacturer to write up the activity more concisely and organize it in better form which we could understand. Anybody else? Thank you very much.

MR. PONTECORVO: I mentioned we were going to have one or two additional people. Now, I'd like to bring up Ed Koziatek from the International -- TWU. I'm sorry.

MR. KOZIATEK: Thank you for squeezing me in on the agenda on short notice. Before I begin, my background in the industry has been 29 years as an aircraft mechanic, 25 of which have been primarily in air carrier operations. I would

like to make a couple of observations based on comments I've heard from several of the participants at the workshop.

One interesting point was made on whether mechanics should occasionally or once in a while be reevaluated as to their qualifications to work in their particular field. I'd like to note that there was a comment made by a participant this morning that an engineer who is five years away from a school is not up on current technology and it's interesting, we don't hear any kind of an interest raised by the engineer fraternity that the engineer should be reevaluated for what they know or whether they can practice in their particular field of expertise.

Another area of commentary was whether we should consider the industry setting up training based on specific qualifications or certain fields of expertise, rather than an overall power plant and air frame concept.

I believe the United States Air Force, which has pursued this specialization to a high degree, has as a bottom line an overabundance of manning to do the job that is required and is done everyday by well rounded-out mechanics in the industry right now that are certified in primarily the carrier operations are well-trained in their particular field.

Since my primary area of expertise lies in the air carrier operations, my remarks are aimed primarily to that category. I'm not ignoring the rest of the operation, which was certainly vital to what we're talking about, but the comments I have are primarily air carrier-type notations.

The airline industry that has transformed the burden of long distance travel to the commonplace experience we all know has succeeded in doing so through the contributions of many participants. With the combined efforts of all airline employees, from the highly visible flight crews to the thousands of unseen workers required to maintain and service Air Transport Operations, the traveling public has been provided with one of the safest and most time-efficient modes of travel known to man.

Upon review of the key elements directly accountable for the industry's outstanding safety record, the airline mechanic is in the forefront. Years of training and experience in complex technical skills serve to develop the unique pride of workmanship that identifies the mechanic among the highly trained workers common in the industry -- an individual who is dedicated to providing

the quality maintenance required by sophisticated aircraft presently in use and fulfilling that responsibility with the integrity and commitment of the career professional.

While a mechanic's function is of necessity dependent on judgment and skill, a number of outside factors inevitably influence the maintenance environment. The dramatic impact of airline deregulation has prompted the industry to increase cost control efforts and one of the major areas subject to reduction is the high cost non-revenue producing maintenance establishment.

Air Carriers' expansion into newly opened markets has been paralleled by their contracting out of maintenance work previously accomplished by their own trained mechanics.

Concurrently, the use of such alternatives has created increasing numbers of non-maintenance stations where vital repairs required for flight are subject to the priorities and questionable experience of contract operators. New regulations have also created a vicious circle whereby computer operators are permitted greater latitude in areas of required maintenance than trunk operators, which in turn promotes further reductions in maintenance operations as a self-defense measure by the affected carriers.

Among recent innovations in maintenance practices allowed by the FAA, the least justified is the new restriction placed on mechanics assigned to carrier line operations by FAA approval of general maintenance manual changes, which now requires their relying on verbal assurance via headset communication with flight crew members as to the maintenance status of an aircraft rather than personally reviewing log book entries.

Such continued short-sighted planning by Government Regulatory Agencies responsible for these activities will unfortunately have long term effects. We all know the unforgivable sin is the avoidable accident which could have been prevented if we were more cognizant or responsive to the danger signals which should have been recognized. It is, therefore, our recommendation to this body that, although human factors encompass many subjects beyond our control, our combined efforts are destined to fail if we do not stop the obvious trend for the elimination of the aircraft mechanics' surveillance role by excluding him from vital segments of an air carrier's operations. The Transport Workers Union of America believe the flying public has the right to expect the safest means of transportation it is within our ability to provide, and the

airline industry and its designated overseer, the Federal Aviation Agency, have an ultimate obligation to the air traveler that disallows any acceptance of marginally maintained aircraft and the attendant reduction in passenger safety.

I would like to add to that what I consider experts in their particular fields in the industry comment about improvements being made in the designing and maintainability of aircraft.

The type of training that has been given to people that are entering the industry and will ultimately work as aircraft mechanics, some phases of a mechanic's role especially pertaining to human factors have not been addressed.

Now, I would like to just comment on two particular areas that we have a concern about that really have not been addressed specifically. The airline mechanic, regardless of how well-trained he happens to be, or how well-designed a particular piece of equipment he's working on is, if he's under pressure because of an air carrier's scheduling activity that provides him with minimal ground times or is pressured because management, who's responsible for -- scheduling -- departures requires him to do a significant job in a shortened period of time or shortened time frame, he has to respond in the best way he can.

Ironically, one of the best concepts that we have evolved from discussions with the FAA, and I've heard this comment from a number of FAA representatives that the airline mechanic or certified mechanic is the eyes and ears of the -- maintenance -- engineers at the Federal Aviation Agency. That's interesting, and I hope that objective role put on the mechanic by the FAA is continued off into the future.

It's difficult to be able to relate to all the problems that we face as mechanics trying to fulfill the responsibility that we have to under the Federal Regulations. However, we ask that you realize we do not work in vacuums. We work under varying conditions, under a lot of pressure, which stress it may be difficult to relate to indivduals that have not been doing this directly in the industry or recently.

We just ask that you work with us to provide the ultimate consumer, the airline passenger, the product he's paying to get. Thank you.

MR. PONTECORVO: Thank you very much, Ed. Any questions or comments?

SPECTATOR: Could you expound a little bit on the pressures that airline

mechanics face, particularly in the light of what the gentleman from PAMA said earlier about family pressures and so on? Do you face those kinds of pressures in your years in the industry?

MR. KOZIATEK: Well, there's a number of factors I would have to consider that do possibly apply or provide stress more so in some cases than others, but the 24-hour type of operation that we face certainly has an impact on family relationships.

The type of frequency schedules that have evolved -- that have been common in the past, but have been accelerated as a matter of competition now in the deregulated climate tend to have the minimum time frames that we as mechanics are allowed to have our hands on type input into the operation of an aircraft.

This latest change, and it's not a change necessarily in FAR's, but a change in general maintenance which is approved by the FAA, which now does not allow mechanics to go up and sign for an inspection, does not allow a mechanic to have hands on the log book to see if all of the complaints have been verified or responded to add to that stress problem.

It will depend on specific factors. Those are a few of the most visible ones.

SPECTATOR: Could you expound on the verbal review of the log book? I never heard of that.

MR. KOZIATEK: In the past and I don't want to single out specific areas or even regulatory agencies for criticism. That's not our intent. I think we want to raise issues that I think a body like this should be addressing itself to. In the past when an aircraft -- this is an air carrier-type trunk operator -- has arrived at a facility, they would be required by general maintenance manual procedures to have a mechanic walk around the aircraft, sign for a turnaround inspection if there was a change of flight numbers. This is no longer the case.

And when they raise the issue about the PMI, in particular, to this carrier who's responsible, he said this is a temporary operation. The FAA intends to spot check to see that the regulations are complied with as far as the FAR's are concerned.

What regulation he told me that triggered this change in general maintenance manual procedures was, I believe, 121.563. That was changed in September of last year, whereby, the pilot in command is now required to enter logbook discrepancies on every segment of a flight.

By a mechanic walking up to an aircraft and asking that flight crew whether they have complaints that have to be responded to, it disallows him any access to that pilot log book or to doing an in-depth review that he ultimately can sign for and insure it's been accomplished properly.

The level of activity we have in the airlines now precludes a lot of what we used to be able to do in timing. It's not a major time problem now, but they effectively restricted the airline mechanic from getting his hands on an aircraft and unless we're called in, which is a -- something we're sensitive to right now, we have to have some way of communicating, some way of getting access to what we feel that we ultimately are responsible for by direction of the FAA.

If we're going to fulfill our role under the FAR's, we have to have more access than they are now providing us with.

SPECTATOR: Going back to your comments on outside contract work, another operator doing some of your line station work where you had no mechanics, are they required to have the same type of aircraft operations -- example 727 -- experience in operating 727's in order to do your work?

MR. KOZIATEK: The technical requirements by the FAR's as they must be trained to fulfill whatever their designed role is for the particular base operator. Unfortunately, we found in a number of cases that people move out of a job, or the people that have been trained have moved on, and the operators are not assigning all flight mechanics to do that type of work.

I raised the issue -- I'm not going to comment -- I'm not in a criticism role here now, but I've raised the issue in a local level or regional level on occasion, and I've been less than satisfied with the response from the FAA.

In dealing with this level of the FAA Organization, we've had excellent response so there's a big gap that has to be addressed. The concern that we basically have is the FAA is not manned or funded to provide a surveillance role, and we would like to see whether it's in the general aviation industry

or in the airline industry. And we do feel responsibility predicated on our licenses that we should serve to some extent that role. And we don't feel we're being allowed to do that with the change in general maintenance manual procedures.

SPECTATOR: Who's signing the log book for the airworthiness of the airlane at base operation?

MR. KOZIATEK: A couple of cases that we found on occasion to arise, a mechanic has signed for; however, we find upon delving into the records that they have not maintained their qualifications to do that type of work on that particular aircraft. In some cases, a mechanic or individual, while not even a mechanic, has signed the name down by putting an AA license number in the log book.

A number of these items have been picked up by the FAA and I assume responded to them in some way.

SPECTATOR: Perhaps I misunderstood you. When you mentioned about the mechanic not having access to the tech log. If you're sending -- If you are -- working -- on a particular aircraft, sure you must have access to a tech log. If they're -- the operators are -- (inaudible) --.

MR. KOZIATEK: The known procedure, like I said, had been approved by the FAA was a mechanic is not required, nor is he allowed to go on board the aircraft unless the flight crew tells him that they have a complaint they want a response to. So in years past we always had that right. That's now been taken away from us.

And as I've stated, I have been a mechanic for a long time and I can't recall when I lost the right to ground an airplane because -- (inaudible) -- I felt was a reason for doing so.

But in any event, it's a tremendous problem. We're not going to address all of the phases here. We have a growing concern about what we see as a developing trend. We would ask that the FAA take our comments objectively and attach a priority to them we feel should be attached to them.

MR. PONTECORVO: Our schedule now shows Mr. Musser for giving a presentation, but we have a substitute, B.J. Sanders, who is in the Air and Examination Branch here, and he will tell you a little bit about some of the things that go on here at Oklahoma City.

MR. SANDERS: Thank you, Joe. We appreciate the opportunity to get to tell you something about our programs that we have at the Aeronautical Center. I'm part of the regulatory portion of the national field office, the Examination Standard Branch and last, the Airworthiness Section. My responsibilities deal with the technical portion of the Airworthiness Airman's Written and Oral Practical Tests.

Also in the same section we deal with the standardization training or designated maintenance examiners and inspection authorizations. Up under the airworthiness airman, this involves A&P mechanics, IA's, parachute riggers and under the standardization training we deal with designated maintenance examiners.

For you that don't know what that is, that's civilians that the agency has designated to carry out one of our larger functions. That's administering the oral/practical tests.

Some of the program activity that we have going on right now we'd like to tell you about. Over in the written test area we, some one year ago, sat down and Branch Chief Larry Musser and myself and started trying to identify areas that we probably had problems in and we felt like we had a couple of major problems.

One of them we could deal with immediately within our own house. Another we would probably have to have some help on. The first one being that our turnaround time editorial wise was way too long. We get a test ready technically and it takes us six months to type it, edit it and when it gets finished, we have three different typewriters that it's been typed on and it really doesn't look professional, so we started coming up with ways we could eliminate this and cut the time down. And we finally settled on going to a word-processing system whereby we could store our test questions on electronic record.

A flexible disc. Let's give us some flexibility in that it provided us with a tool whereby we could retrieve a test question. It also allowed us to, if we wanted to add a smaller or larger diagram to one of our test questions, it prevented us from going into the marble down the tube effect.

If you use a big one here, you bump one off the end of the page. It provided flexibility to handle that. It also gave us a good situation with our test guide. Our test guide came along when we were required to put out the information to the public, and almost doubled -- in fact it did double our editorial workload in our written test area.

So it gave us a tool whereby we could, with a little bit of a scrambling process, we could print a test guide without any extra work. And to deal with human factors in this area, we got into this because when we have a stem of a question, we don't want to write something that will trick somebody because anytime you trick somebody in a stem of a question, you put them under pressure. They're more interested in reading it right than they are trying to select the correct technical data in the question. We also ran into problems in the area of the format. The question format. We have maybe 1,000 questions in a booklet. We're only going to examine the airmen on approximately 100 of them. We tell them which questions we want to ask them. We need to lay this format out so that the guy won't spend half his time worrying about getting the right answer, again putting him under pressure.

And we're also concerned in human factors area in getting him a chart or something that's clear enough and large enough so he can read. And the written test area we are and we do take a look at human factors very deeply. We get over into the standardization area and we get into it again in the same area. We feel like or we teach our designated examiners that we train in the field when they get ready to administer an oral/practical to an applicant, if it takes 30 minutes to get that man down out of the clouds when he comes in; if he's jacked up, just like he comes in for a check right or whatever, he's jacked a mile high worried. We teach our designated maintenance examiners, and I have two that we have in our class in here, so I have to be correct here. We teach them to spend as much time as necessary to get this guy relaxed so you can -- the man can hear your question and answer you without being under pressure.

We also use the input from -- the human input from the designated maintenance examiners to improve our program. We started this program about -- approximately three years ago where approximately one area into the revised cycle.

And not only do we teach the designated maintenance examiners to spend as much time as necessary to relax their applicant; we spend a lot of time -- our instructors do learn how to deal with the designated medical examiners when we teach a seminar in order to have a good rapport with those people where we can transfer the information.

Sometimes we noticed in our first -- initial training which is a three-day cycle that sometimes it was into the second day before we had the guys relaxed enough that they would start to feed back information to us, start to ask ques-

tions. They come in and they are uptight. They're not comfortable as we want them to be. They're going to be around FAA people. They're a little uptight, but we so far have been able to turn them around within the second day and get them loosened up and start getting down to business and start having a real good course.

We have another problem in the area of inspection authorization. We're also doing some standardization training in that area. And that really presents a human factors problem in that usually we have anywhere from 60 to approximately 100 in every meeting and you know how that is when you try to stuff a bunch of people in a small room that's available to lease at a motel facility. You have a problem getting them in and out for coffee breaks. You have a problem in getting enough lighting, proper seating et cetera. We have a real big factor there. We also have a problem in the area of the amount of distance that they have to travel.

We spend a lot of time trying to locate these meetings where a guy will have the least amount of distance to travel. I sometimes -- some of the people don't think we spend very much time doing that, but we really do. We try to look at that area real hard.

We also -- Again the same area -- in the IA area, we spend a lot of time, our inspectors do, trying to develop a good rapport with the inspection authorization people. And sometimes it's a little difficult because we will have them eight hours, but we feel we do a pretty good job and get them relaxed and information flowing back both ways.

And according to our feedback, we are being well received in the field and we're really pleased about that. And I think one of the reasons why we're getting good feedback is I think we're doing a good job.

And also some of the feedback that's being used to improve our program and we also pass this feedback on to our Washington counterpart, Leo and Joe's area. That's about what I have to present today, and I'll attempt to field any questions you have in this area.

SPECTATOR: Do you see an increase in the number of repairman certificates, or is that part of your organization?

MR. SANDERS: No, I don't see a reason for having an increase, no. Personally I don't. I hadn't thought about it, but I don't. Anybody else?

MR. PONTECORVO: Thank you very much. We appreciate you taking the time to come over.

MR. SANDERS: I would like to give the guys an idea where -- our people are in Helena this week -- our travel team. We're going to Anchorage next week; Minnesota next; Denver next; Rapid City next; Cleveland, Spokane, Pittsburgh, Farmingdale, Rochester, Wichita, Houston, Jacksonville and San Antonio and that will finish up our first year on recurrent training.

MR. PONTECORVO: I would like to introduce at this time Ed Yamada from McDonnell Douglas and Ed is going to try to tell us what human factors is. We've been having discussions outside this meeting, and we haven't really come up with a definition yet. You've heard several people say they tried to find it. Ed may be able to help us out a little bit.

MR. YAMADA: I'll try. Since I haven't made a prepared speech, I'll -- this is kind of off the wall, but I'll try to define human factors. What is it?

The definition is sometimes kind of hard to come by, because there are so many specializations involved within the area. In all of these presentations we've talked about human factors and around human factors and under and over. So I have tried to explain human factors and it's -- as I say, somewhat difficult to do. And I've explained it to my wife, and she's always coming back and says: What do you really do?

So I'll try to, without baffling you or insulting your intelligence, try to give you a definition of what human factors is. I guess a common misconception is that we're a bunch of guys running around in white lab coats with blinking lights and a bunch of white rats running around in cages. That's not quite true.

So, what is human factors? One of the problems in defining human factors is that the people that practice this profession tend to speak in tongues. And they use words which are not very understandable to most people. And I think in defense of those people, they are so involved in their specialization that that's just the way they talk, but you've heard words like, oh, we deal in psychophysiological factors and man machine interfaces and wonderful. What do you really do?

Okay. Fine. Basically what we're trying to do is to define and apply the limits that people can operate, can do things. Okay? That's easy enough. You say: Well, what do you really do? So let's start with quantifying people in finding out what their capabilities are. One of the things that we found out -- I want you to write this down -- is there really is a difference between men and women.

Okay. You say: Oh, well heck. Everybody knows that. But when you get to the quantification of the differences, then it becomes more significant, especially in maintenance because we're talking now about getting more women into the armed forces and those women will eventually -- many of them will show up in the aviation maintenance field.

And so what's the complication?

Okay. Another obvious fact, women are generally smaller than men. So what? Well, let's look at a few fairly simple examples. Standing eye height. Looking into access holes to see -- to read gauges.

Obviously, if the standing eye height of a female is several inches shorter than the so-called average male, that entails more maintenance, because you have to have a stand or something to climb up on to look.

Another big area is in the area of strength. And the military is quite concerned about female strength. Okay. What are the differences? Well, females generally tend to be more equal to men in their legs and lower body strength, but tend to be weaker in the upper body strength, such as: lifting, applying torque and -- what's the difference?

Well, you could say generally that women are about sixty percent as -- have about sixty percent the strength of men in their upper body and perhaps seventy-five percent in their lower body.

And these all have a tremendous significance on the maintenance operations, because you may say that a task only takes five minutes using two men to pick up a cowling to install or whatever.

That's no longer true. And the problem in dealing with humans is they are so highly variable. There's such a tremendous range in capabilities.

It's not like a mechanical system where you pretty much know from the laws of physics and thermodynamics and aerodynamics you can predict what hard-

ware is going to do for you after you design it because that's the way you design it, obviously.

But when you get into the area of human factors, and people are so variable, and so people often ask: Well, just use the average man. But there is no such thing as an average man.

None of you here are average in all respects, either in height, weight, in the distance you can reach, the amount of weight you can lift. And you're talking about a certain population of people.

When you are talking about maintenance of aircraft and you sent it, say, to the Far East, Middle East, you're talking about another -- different population. If you are talking about using women, that's another population.

So, to apply human factors to a design, that's the problem. You've got such a tremendous variation in the amount of lighting, vision, smell, taste, all of the senses, memory, motor capabilities -- excuse me. I'm trying not to get into the jargon again, but when you begin to realize all of the things -- the differences between all the people in this room and try to design a piece of hardware that can be maintained by all of you efficiently, then you begin to see the problem.

And so you say: Well, what is a human factor specialist? It's not one person. Within that area you have psychologists who are concerned about how well you can see, how well you can hear, what are the limits?

How fast can you react to things? You have anthropologists or physiologists that are more concerned or are concerned with body size, strength capabilities.

You have M.D.'s. You have toxicologists that are concerned about toxic hazards in maintenance. So that field doesn't consist of individuals with -- all individuals to not have the same background.

So how do we implement? First of all, we have to define what the limits of the human action are in terms of the user population. You guys say: Okay, now, how do we implement these human factors' considerations?

First of all, you have to quantify them as best -- or we have to quantify them as best we can to obtain data. And initially in the design of any system, we have to take these criteria or these elements and apply it to the design of that system.

That way that system can be operated and maintained by the widest range of people that we expect to use that system.

And once we have these requirements into the basic design of the system, what we should do or would like to do is to do what's called a functions analysis and say: Okay, a man is going to do this part of it, perform this function in the system.

And we're going to get the machine to do this part of it -- this function in the system. And that's based on human capabilities again. If you have to depend on someone to rapidly detect a whole lot of changing things all at one time, obviously -- not so obviously sometimes -- the human is not capable of doing that, so we'll assign that function to a piece of hardware.

And all during the layout stages of the system we made up mock-ups and talked about accessibility. I am sure that's a big bugaboo in the maintenance area. And it always has been.

But if you know how big -- let's say your hand is not only bare, but with a glove on or whatever conditions this system is going to be used, we'll incorporate those requirements.

And so -- I'm sorry. I didn't mean to run on this way, but I guess the point is: Human beings are extremely variable and we have to quantify what they can and cannot do and incorporate those limitaitons into the design of any system.

And the reason why many things can't be maintained is because -- simply because it was not designed that way. So I guess the point is: Let's design the hardware and software so people can most efficiently and effectively do their jobs based on what people can do best.

That's it. Any questions?

SPECTATOR: Can you tell us something about what it is you do at McDonnell Douglas? Your responsibilities, some of the things you've worked on?

MR. YAMADA: What are my responsibilities? I'm to cover both sessions both days and attend all of the sessions involving cabin safety, evaluation -- inaudible --. Seriously, I guess I'm king of -- not the average guy.

My background is and my education is medicine. And I ended up being a design engineer as well as doing some work in product support on operation and

maintenance manuals, doing manufacturing shop liaison. You name it.

So I think fortunately for me, I've had some exposure to many of the aspects of the industry that some of these people have not had that are more specialized than I am.

But what I do is basically -- basically involved in hardware design. Okay? And incorporating those factors that I discussed. And this field has so many areas -- it really does -- that it's difficult to try to explain all of them. And I'm not trying to evade your question, but basically I'm concerned with hardware design.

SPECTATOR: I have a question as far as components' accessibility is concerned. You are obviously responsible somewhat in that area. How do you determine the placement of components that are, in effect -- put a unit here and determine the size and the access and do you actually get somebody like a technician -- A & P technician, say: Okay. Here it is. Can you get a component out through that hole?

Can you safety this with one hand? Do you have to use two mirrors and a magnifying glass to do this? I mean, how do you determine?

MR. YAMADA: The question was: How do we determine the accessibility of the component or part that's to be removed and replaced at a later time? I'd like to be able to tell you that we have a full crew systematic method where we totally assure you anybody can remove and replace it without a problem.

It doesn't work that way because the design of anything is a compromise between a design technology, cost, weight, et cetera, and et cetera.

It sounds like a cop out, but it really isn't. What we have to do is early on in the design stage, what we would like to do is to mock up the area. And here we are dealing with various technologies.

We've talked about power plants people and hydraulics and pneumatics and the wiring people and the interiors people.

Okay? So it's hard at a later point in time to define what all is going to go through that area. But what we do -- what we try to do is to, at the earliest possible time, to find the total environment of that area and certainly we apply those criteria: the hand size, the tool that's in the hand and the direction and location of the tool and the visual access, the manual access.

We try to apply those criteria to that design and fight like crazy to keep the design from encroaching on that area.

SPECTATOR: Next time I'm out in Podunk, I will think of compromise when I'm changing the unit, and it's 2:00 in the morning and about zero degrees temperature. I'll think of compromise instead of saying bad things about you.

MR. YAMADA: Let's put it this way: We don't end up being the most popular people. We don't end up being popular at all because we have to sometimes bring about the compromise because the engineers don't want to budge.

SPECTATOR: Who do you compromise: the mechanic's point of view or compromise the ---

MR. YAMADA: If you're asking me what my allegiance is: I'll take the Fifth Amendment on that one.

SPECTATOR: There are different ways to do a job; you said that you try and determine what you can and can't do. There's a lot of things you can do, but there are certain ways of doing that job that's a heck of a lot faster.

Do you get into the relative speed?

MR. YAMADA: Here again, we sometimes get into the ideal situation and then the practiacl situation, where ideally you can take this LRU and mock it up and mock up the access opening and space and work out in detail a task anslysis of the maintenance function and say: Oh, heck, you have to do this and this and have to have certain tools, have to have a light and the ideal outcome of that is a beautiful maintenance manual that will tell you how to do it thoroughly.

Totally with no misunderstandings. But that doesn't always happen either. So we do the best we can. I don't know how else to answer that.

SPECTATOR: Have they done studies on trying to make the maintenance manuals maybe simpler, quicker to read? I find a big problem with most students or most Americans is we'd rather do the job first.

When all else fails, get the damm manual out.

MR. YAMADA: You think that's bad. You can imagine the problem a foreign carrier that picks up a manual that is written by the manufacturer in English and try to interpret that.

Yes, there have been efforts to make maintenance manuals more understandable, but you have to realize that there are people that write the manuals and if you really and truly want to make a full-proof manual, that will involve maintenance technicians and giving them the manual and say: Here, do the job and see the effectiveness of that manual.

I don't know of anyone doing that. The manuals are written and put out in the field. I don't know of any method -- consistent method that's used to verify the adequacy of that.

SPECTATOR: Why not? When you make a product, you put it out in the field; you test it; you find out what the faults are; and you come back and redesign a product so that it comes out better. Why not do the same thing with a maintenance manual so that there are a lot of faults and I know some companies request feedback from the maintenance people. Say: Hey, the manual is all wrong or whatever and to go back and revise the manual.

MR. YAMADA: Who said we live in a perfect world? And certainly the feedback unfortunately is sometimes the only method that manuals get changed. Here again, we're talking about -- a couple of different worlds.

One, talking about in a military world where the military defines what specifically a systems requirement, and they're pretty specific in how things are to be done and unfortunately the methodology that is specified by the military is not in toto carried over to the commercial side of the field -- side of the business, mainly because of the cost.

Because, as you know, military weapons systems are very expensive, but in defense of that I have to say that it's expensive for a reason because that system is designed to very exacting requirements.

And that's in a large part cost of a system, but when you go to the commercial side of the business, there are a lot of accountants up there that are questioning engineering hours and saying: Why do you need umpteen hours to do an analysis of maintenance manuals?

We've lived without this analysis for forty years. What are you guys going to do?

SPECTATOR: You know what my answer is? Take them out to the field in Podunk and let them change the unit. They'll find out.

SPECTATOR: I'd like to vent an editorial point. In the design process, one of the things that is accomplished is rigorous failure analysis of the given system or component wherein every possible failure is examined.

Now, I don't have the data, but I would guess that fewer than one percent of those failures ever materialize in airplane service and in your experience. But the failure -- inaudible -- and the tedium that you see in the maintenance manuals reflects in part the fact that the design engineer sits down and laboriously goes through all of the things that could possibly fail.

Most of them don't. But you have to read all that junk anyway because it's there, and we have to provide those manuals before we deliver the airplane.

That's generally a contractual requirement. I don't think we really know how to judge ahead of time what the failure modes of the pieces of equipment are going to be.

If we did, believe me we would try to avoid them. You find out about them and say: Boy, that's a bunch of junk in that manual. Most of that stuff never happens. Sure it doesn't.

That's a dilemma I don't know how to avoid. We try. If anyone has suggestions, I'm sure open for them. End of speech.

MR. YAMADA: That brings up another point within the design technologies with an engineering, which have various groups that do reliability analysis that punch a whole bunch of numbers -- a whole bunch of nines out that say this thing is going to fail once every ten thousand hours or whatever.

And then we have another bunch of guys that do a failure modes effects analysis. If this thing fails, these are the things that are going to happen. Nobody ever does a failure modes effects analysis on what happens to the failure of the human being of the pilot or the maintenance man.

I think one of the problems in industry is that these various groups within companies have to talk to each other a little bit more. That's one of my main crusades.

Any other questions?

MR. PONTECORVO: Thank you very much, Ed. I appreciate that.

We're running a little bit behind schedule. Not too bad, but I have one more speaker I'd like to put on and that's Dick Hall and then I'd like to have Leo Weston speak to you for five or ten minutes and Bill Gaffney has the answer to some questions that were asked yesterday.

Why don't we take about a five-minute stand-up-and-stretch break and then bring Dick Hall on?

(Whereupon, a recess was taken.)

MR. PONTECORVO: Gentlemen, come to order now. I'd like to bring Dick Hall up here now. Dick is from this facility right here. Dick is going to talk to us a little bit about our data system here, the collection of mechanical problems data.

MR. HALL: My name is Dick Hall. I am Chief of the Safety Data Branch here at the -- center --. Our primary function is the processing analysis of various reports that are routine reports filed both by industry and by the inspectors out in the field. And the FAA offices. We have three primary problem areas that we concentrate on.

The first one is our Accident and Incident Data System and that system that we have there captures information from general aviation accidents and air carrier and general aviation incidents.

These are routine reports filed by FAA inspectors -- inaudible -- personnel. We receive copies of them and using operation and airworthiness personnel and engineering, we analyze, process that into data system which is -- it is analyzed.

Second system, one that has been in place and been a very substantial system for us is the Service Difficulty System. That particular system is fed by reports from general aviation, the malfunction or defect reports that are submitted, small cards and by the service difficulty reports filed by the air carriers in accordance with the 121 and 135 requirements.

Those reports come into the office -- into my office, where they are processed into the system and analyzed from that point.

The third system we're involved with is a new system we are putting up at this time called the Enforcement Information System. As most of you are probably aware, in July 1 of 1980, a new enforcement and compliance program was

initiated within the FAA to consolidate all efforts to enforce the Federal Air Regulations from that or a spin-off of that system was the Enforcement Information System, which had many purposes. One was to capture the types of regulations violated and the type of penalties and such so we could analyze to see if there is obviously a regulation that's in error or an area that needs attention.

In those systems we keep them up on a time-share computer system, a commercial time-share computer system. We keep five years for analysis purposes and keep the remaining data on tape for historical purposes.

Each one of these systems is maintained separately, although in the analysis we do, we extract information from each one to see if there's any relationship among mechanical discrepancies, accidents, incidents or enforcement actions.

In our general aviation accidents system, we process approximately forty-five hundred reports a year. This is a figure we use. It runs between four thousand and forty-five hundred.

In our general aviation incidents, we run approximately forty-five hundred reports or an equal amount. In our air carrier incidents, approximately fifteen hundred reports a year.

In our enforcement system, we are running approximately seven to eight thousand reports a year. At the present, under the new concept where we have taken up the responsibility for processing security-type reports, filed by the security field offices around airports, screening points and all, we've now -- that figure has grown almost eighteen thousand reports a year.

The Services Difficulty program has been pretty steadfast over the last four or five years, and there's approximately twenty-five thousand reports a year that come into that system.

Processing analysis, the handling, the filing, distribution of those reports all occur there in our branch. A little more about each one of these systems possibly. In the general aviation accident system, a carrier -- inaudible -- we process those two types of documents the same, extracting similar information from each one of them, so that they go into a single computer, electronic records.

They're identified in there, naturally, as to whether they're air carrier incidents or general aviation incidents or an accident. They're processed into a record that has some hundred and sixty-two elements of information in it.

And all those elements are accessible directly by the analysts who key on various factors to see if there's a relationship between these various events for which they can identify.

We have in work, due to a technical difficulty, I could say, we don't have the functions right now. We do have a medical accident system which takes the information coming through the medical group, which is the counterpart to this group, and electronically attaches that to the accident record that we have already established into the system.

So this right now -- we have a setup. It's not quite functioning yet, but it is in place and we should have it going by the end of the year.

So now when you look at an accident, you can look at your crashworthiness factors, which are provided by your medical examiners out in the field, and you can look at the environmental factors we have that's in the accident record.

The operational factors. You can look at the mechanical factors involved and these various relationships between -- these various events and factors can be analyzed electronically. Which there's no other way that we can see to handle the volume of data we get in, unless we handle it electronically.

Next system, the Service Difficulty Report System, as I say, has been in place for several years. This system supports or provides us with a way of monitoring the appearances of mechanical events that happen both in general aviation and in the air carrier fleet.

We have an automatic red-alert system that takes a look at the number of events that occur by the ATA systems and using flight hours that we capture through another means.

And we analyze the rate which we receive the reports and spread that over a calendar year basis and have this system alert if there's a particular area on a particular aircraft that gives us a problem.

The system has some problems. It's about eight years old and we're working on modifying it. But right now, it's done a pretty good job for us up to the present time.

We do at this time retain the data we received in these systems indefinitely. We only keep five years on them for analysis. If something is indicated or if there is a problem indicated, then we can go back and load the tape data up or the old data and include it into the present analysis to see if there's a long-term trend.

Again, we do have these systems commercially on a time-share computer we operate out of Kansas City, Missouri, and this provides each one of the regions and headquarters with the ability to access this data should they have a need for information out of the system.

The system provides analytical data and information from which to respond to requests or questions that are generated by various people, the industry, the various groups or management.

An enforcement information system -- we're presently in -- this system is not totally operational. We're presently processing information into it, bringing it up to speed, but we have -- the way we have it set up, we have high hopes this system will tell us something about the FAR's and whether or not they are effective and indicate changes that may need to be made.

Additionally, we're trying to provide more access for the inspectors out in the field to information that he may need when trying to enforce the regulations.

To substantiate our design efforts on this enforcement system, we have a test set up in the Southern Region to be centralized out of Atlanta, Georgia.

Some of their field offices are participating, and we're looking for a direct field entry of data in order to accelerate the velocity of this data moving through the system, such that we can now have something that's closer to the real time set of data to operate on.

And by that I mean we experience two, three, four months lag time in the mail system sometimes when documents get lost. And we're trying to improve that. Not only that, but we'll improve the other floating back to the field so the regions have a better idea of where to place their efforts.

Also, in the branch we produce a document called Airworthiness Alerts. It comes out once a month. It goes out to most IA's. It goes out to a lot of organizations. And we have a system set up now where we can produce that on

word processors, although the reports are selected and written by hand by one of our senior specialists back there, trying to get the best word out.

Additionally, we produce the Daily Summary, which is information come out of SDR system. It goes out daily to some fifteen hundred recipients. We select certain general aviation events that are submitted to us on the -- inaudible -- cards.

Those that are highly significant or called into us from the inspectors from the field. That's priority events that come in on the phone. We select them and put black borders around them if they're highly significant and send those out daily.

Every report that we get in on the air carrier -- from air carriers are printed in that daily report and distributed out through the system. There is a major effort underway right now in the agency to consolidate what we call our Safety Analysis System, pull them together and make them more effective and continue the operation of these systems that we now have that's in operation.

There's been major improvements made, I feel like, in the systems and in the amount of analysis we've done and the way we're looking at the data. And goodness knows, we're not any different from anybody else. We're subject to staffing adjustments and trying not only to continue looking at the data, but look at more of it.

So we're looking very much towards automation as to the way to analyze the reams and volumes of data we have coming into the system. And that's pretty much of a picture of what goes on in the branch.

We do have several other type functions, I think, but if there's any questions on any of these systems or what we do with the data, I would be happy to answer it.

SPECTATOR: Could this be accessed by all of the computer users? Can I access your --

MR. HALL: Yes. Two of the systems: AIDS AND SRD's are -- inaudible -- other users. We do restrict certain pieces of information. In the AIDS where there's a certificate number of an airman involved, that's restricted and not released.

SPECTATOR: Can I contact you or is that published or easily accessed so I can find out how to do this?

MR. HALL: Probably the simplest way would be if you wanted to contact us at the branch. We notify the local contractor, who we obtain the computer service from and advise him to have his man get with you and turn a number on.

You would be issued a user's number with this time-share vendor. You have a contract to sign with him. You have direct access to the same data that we look at. So the best way I think would be to come to us, and we start the ball rolling from there.

SPECTATOR: If you restrict some of your information like the certificate number, why then would the enforcement information be available, or as I understand it's going to be available?

MR. HALL: The enforcement information, that's one item right now again is not operational system. It's in development. We're taking it to general counsel, our lawyers, to determine the releasability of that. Now, we have in the past not released names, certificate numbers, date of birth, those privacy -- pieces of privacy data that are restricted, but the enforcement system, without that information, still provides you with the ability to do analysis of various regulations, geographical locations of the violation of the regulations, the penalties, you know, the various things associated in there, the more -- the generic-type analysis, but not looking for individual people.

We're not as much interested in that at this point with that system as we are -- because we have another system that identifies the individual airman. That's in-house totally in a very total secure system. It's called the Comprehension Airman Information System.

So as far as the airman's personal report, that's in-house and is a closed system. So this -- the enforcement information, the EIS, has other basic purposes there.

SPECTATOR: Does the Civil Aviation Authority have access to your -- does the Civil Aviation Authority in Great Britain have access to your safety data banks?

MR. HALL: Yes, they do at this time. It is assigned on to the system, and they do have access to it.

SPECTATOR: So I could go through that, say, instead of having to see you?

MR. HALL: Yes.

SPECTATOR: Could you explain why they discontinued the Summary of Airworthiness Alerts and why it is being limited to -- all of this information is being limited to about six percent of the mechanic population?

MR. HALL: Okay. Your -- you say the Summary of the Airworthiness Alerts?

SPECTATOR: Right. Under the old inspection AID's they had a summary each year.

MR. HALL: When they dropped the inspection AID's we dropped the Summary. Maybe so we should go back and summarize the Airworthiness Alerts. That could be a valid requirement. The restriction of the Airworthiness Alert -- actually we had expanded it when we released it to all of the AI's in the field as a free-issue type document.

Now, as you can appreciate, and we get quite a few of these back each month with address unknown. In fact, we have a stack back today which was about a four-inch stack where when our addresses were wrong, we've lost the genelemen in the system. But cost is primarily the reason that we don't send it to all licensed mechanics or operators, through the system.

And right now it was felt that getting them to the AI's and to the operators that qualified, it was the best. Those certainly can be obtained through the GPO or anybody else.

SPECTATOR: Are they for sale?

MR. HALL: Yes, sir, they are. They are available through the GPO now.

SPECTATOR: What's the current cost if I wanted to access to call up for access data based on a particular product, history of service report difficulties? What's the present cost for that?

MR. HALL: For you -- mean access yourself or have us run your report or ---

SPECTATOR: Have you run the report?

MR. HALL: Okay. Our present cost on that, which I'm sure you'll recognize our way below market values is two dollars a search, plus a dollar per line items. And that is specified in Part 7 of the CFR.

So I haven't been able to stay up with inflation on that one, I'll tell you.

SPECTATOR: Is that still available? I was under the impression that was no longer available through the FAA. In other words, that you had to go to a commercial such as --

MR. HALL: No, it will be -- there are commercial concerns which will produce that. What we're doing now, we're looking into having this provided by commercial concerns. As our staffing continues to diminish, these twenty-five hundred requests a year that we get in the branch from private industries for data out of these systems is quite a workload to us.

As we process these all through the system and clerical, handling and all, we're looking at people like -- I think there's a group called Capital Systems Group, AOPA, and Aviation Data Services. There are some commercial entities that are looking at providing this information out of these systems directly to the public.

And this is something that we're looking at fostering in a sense for the day when we are no longer able to supply it.

We don't want to say six months from now we'll send you data when we get to it. We're trying to find other means of distributing this information.

Okay. Thank you, gentlemen, very much.

MR. PONTECORVO: Thank you very much, Dick. Now I'd like to bring up Leo Weston, who is Chief of the General Aviation Branch and the Aircraft Maintenance Division in Washington, D.C.

MR. WESTON: As Joe said, I am the Chief of the General Aviation and Commercial Branch and the Aircraft Maintenance Division Office of Airworthiness in Washington.

I think his primary reason for wanting me to get up here, I wasn't prepared to make a speech, but to let you know there was so much conversation on FAR-147, it's my branch to be handling any changes made in a FAR-147.

To give you a brief resume as to what we're responsible for, we're responsible for the certification and surveillance of airmen and air agencies. The airman agency includes the certification of mechanics and repairmen, and the air

agency includes the certification and repair station, mechanics schools and parachute laws.

We are also responsible for the continued airworthiness function of general aviation, which involves the inspection programs that are required by general aviation aircraft, whether it be -- it be the small aircraft, large aircraft or in the case of the commercial operators that's aircraft that are required to operate under the FAR-125, which is basically the old commercial operator, large aircraft over six thousand pounds payload.

Attached to the human factors workshop -- and I'll listen to the NTSB talking about specific accidents and maintenance involving on this thing, I want to relate to you a situation that happened to me when I came to Washington.

When I came to Washington, the FAA was very much involved in the accident prevention programs, but these primarily involved the accidents as they revolved around pilots.

Nobody made a strong effort to bring the mechanics in as far as providing information to prevent aircraft accidents. The response we got -- they didn't think it was worth putting effort into providing learning information to mechanics because when did you ever see a mechanic in an aircraft accident?

When was he in the aircraft when the accident was caused? He wasn't in there because he wasn't a pilot. The position we took in the general aviation branch there's a lot of cases where a pilot is put into an environment for an accident by a mechanical defect in an airplane.

We had to prove our point. We couldn't prove our point by using NTSB accident statistics. We had to go out and hand-hack accident reports and primarily where we got our information was incident reports, which was really a fine record as to what was causing particular instances to happen.

We found out that about one-half of one percent of the aircraft accidents that were maintenance-related -- when I say maintenance-related, I'm talking about mechanical malfunction.

About one-half of that percent was really due to human error on the part of the mechanic. The mechanic actually doing something wrong. And part of that maintenance error was also due to pilots performing preventative maintenance in the wrong way.

So we decided that the other twenty percent we're talking about was due possibly to -- either the lack of maintenance or the lack of technical information to the general aviation mechanic.

So we said if it's lack of technical information -- it's not like an air carrier mechanic who has a company to provide information for him. He has a regulation that says he must be trained. So how does a general aviation mechanic get the information -- current technical information?

We worked with industry, private organizations and decided to kick off the program of aviation mechanic refresher clinics, which for the first two or three years went real well.

The attendance at the mechanic refresher clinic was very well received. Especially in the fact these were mostly on weekends. We found out that the general aviation mechanic really wanted to learn, so we developed procedures to try to provide this information to them.

But the point I'm trying to make here is that if the information is available, the mechanic will use it. This is the experience we found from the mechanic refresher clinics.

A lot of these changes are still going on today. Things are being provided by professional organizations such as PAMA or AMF and still being continued by AOPA. I think that the human factors for gaining maintenance information are still there, and we still haven't really evolved a perfect system or any decent system to get the information to them.

The one program that the people in Oklahoma City here, that they're performing is the Mechanic Examiner Refreshers, which have been very well received.

In conjunction to this with the AI program has also been very well received. We plan on pursuing it even further if we possibly can. And the area of mechanic schools or aviation technician schools, we're also looking into see what can be done in that area.

At this time, we can't make any promises, but we will be looking into these areas. And I do not want to take up too much time. If there are any questions I can answer, I'll try to field them.

SPECTATOR: Leo, you might point out to the group that the refresher courses that you've offered have been free of charge to the individual. I know I recently

attended the IA refreshers course, which was an outstanding eight-hour refresher course that I needed and at no cost to myself.

MR. WESTON: Yes, they are free of charge. When they're in your area, I recommend that you take advantage of them.

MR. PONTECORVO: If there's nothing else, no other comments or questions relative to what Leo has to say, let Bill Gaffney have a few minutes to answer questions.

MR. GAFFNEY: With respect to the forty-seven nose landing gear doors and with the door safety system, there is a service bulletin, if not released in progress or very nearly released, that places a restricter in the doors closed circuit on the gear-down selection side, such that the rate of the doors is cut down by a factor of about three.

Normal door operating time is in the order of one to one and a half seconds and that will cause the doors to close in like four to five seconds. The idea being that if the door safety valve isn't where it should be, that the additional time should give somebody a chance to get out of the way, hopefully.

There are additional design efforts going on to relocate and redesign the basic door ground release system, but that is a more difficult task and that's going to take longer, so I can't tell you any more really about the status of that, other than it's under study.

I have no specifics on that as yet. With respect to the ICAS system on the airplanes with two crewmen, the ICAS system is set up presently to store -- to store one event per system on an automatic basis, and by that I mean if there is one warning on, say, the flaps system on a flight that will be stored automatically.

There is the capability to insert additionally per flight a single event. There's a button that is accessible to either crewmen and it will read out on the -- or store on the ICAS system all of the information and in its current state.

In other words, whatever EGT and N2 and all that is, in that point in time, it will be recorded. On the versions of the airplanes with two crewmen, the information is not accessible in flight.

It's being accessible only on the ground. The airplanes with three crewmen, there's more flexibility to the extent that the maintenance pages can be entered in flight by the third crewman and he can enter data into the maintenance pages.

They cover hydraulics, pneumatics and so on and so on. There's additional flexibility there. Information is not retained from one flight to the next or at least for an extended period of time.

There is no long history retained. As I indicated, that was in our planning early on, but apparently one of the fellows said we ran out of memory in the computer, and I guess we did.

In talking to fellows this morning, there is a capability to store two events per system. Okay. Any additional questions that maybe I can answer?

SPECTATOR: Well, it's different for the autopilot than the navigation?

MR. GAFFNEY: They have interfaces with these warning systems.

SPECTATOR: I think its capability is greater; is it not?

MR. GAFFNEY: I'll get myself in trouble, because I really don't know.

SPECTATOR: I think it's tied into all of the flight control -- inaudible -.

MR. GAFFNEY: The ICAS system is purely an indicating and recording system that's not an active system. It doesn't do anything. It doesn't monitor the other systems so that it records warnings or indications of travel.

Any others?

MR. PONTECORVO: I want to just mention there will be a tour of the aircraft services base tomorrow morning and anyone that's interested, should be in front of the main building, the one where you registered yesterday, across the street at 8:30. There will be a bus tomorrow morning at 8:00 from the hotel just as there has been for the last two days.

I think we've heard from everyone except Jack Harrison, who will make some closing remarks. -- Before I ask Jack to come up here, I'd like to say just a few words.

I'm not going to bore you too much, but a couple of months ago when I was asked to conduct this workshop -- asked isn't the right word. When I was in-

structed -- that's not even the right word. When I was told to conduct this workshop, I said is this really necessary? And I wondered just what we were going to talk about and what kind of speakers I would get.

And I found this to be a real pleasant surprise. We may have wandered a little bit away from human factors in some cases, but as far as I am concerned, the lectures that we have heard here have been excellent.

They've been some -- I would like to say some outstanding ones. I also left here with a few jobs to do. At least Leo has. I think we have a better feel now for some of the problems that we've got.

We've heard from a lot of people that we just don't ordinarily have the opportunity to hear from. We don't have an opportunity to get such a mixed bag and that's the best description I can think of in a group like this.

Our meetings are always very specialized either with a small segment of the air carrier industry or small segment of the school people, very special groups, but this has been a real mixed bag. Been an enlightenment. The papers have been good. And I want to thank all of you who have taken the time to come here and especially those that have taken the time to give a presentation.

Once again, thank you.

Jack, you might say is responsible for the putting on all of the workshops. Jack is Director of the Office of Aviation Safety, works directly for -- Walt Luffsey. Jack has the responsibility for all of the work associated with the workshops and setting them up.

MR. HARRISON: Well, I certainly would like to add my thanks and gratitude to that which was just expressed by Joe. I heard a couple of things here. One of which was that there wasn't any definition for human factors. And I thought I'd tell you when we started out scoping out this program, one of the first things we decided to do was define human factors and we weren't able to do it.

And so we decided that one of the major jobs here was to deliver to you the task of defining human factors. And for that reason, while Joe mentioned that perhaps there had been some digressions, I don't think we're going to see that when we tread out the record made here because what we're really trying to do is encompass within a program the solution to all of the problems that can be associated with it as human.

And we're planning a program that's going to cover a number of years. It will involve a good deal of research, a good deal of work, most of which will be done by the industry and academia, your schools.

I suppose schools like Embry Riddle will be deeply involved in these programs as they have in some of the pilot programs. And as a session here, this isn't the end.

We look to a series of continuing sessions where we can get into dialogues in order to assess the progress of the program which will be undertaken.

What's going to happen after this is we're going to shred this record after having it printed and edited, and it will be available for distribution probably in something like six or eight weeks.

By that time we will have developed to a pretty good extent our program proposal. In addition, after we have all of the transcript analyzed, worked on, shredded, whatever you want to call it, we will be publishing a report on the entire proceedings.

And each participant in each session will receive a report, which covers the entire proceedings. The pilot sessions, the controller sessions, et cetera. But as I say, we look to the continued assistance of people like you in helping us with this program, and we're very deeply gratified by your participation here.

I apologize for not being here throughout. I had to divide my time so I could make some closing remarks at the other session as well, but I'd like to say on behalf of the Office of Aviation Safety, Aviation Standards, FAA, thank you very much.

I forgot one point. The record will remain open for thirty days. If any of you have any suggestions or late items to suggest to us as issues for resolutions or suggestions as to how to go about the solution to the problems, we would be glad to have you submit them in writing.

Thanks again.

MR. PONTECORVO: For that purpose, don't forget the form that I mentioned the first day. Jack, do we have any more of them?

MR. HARRISON: I can't say.

MR. PONTECORVO: The form to write down the issues to send in. If we

haven't got forms, we'll get some. If anyone has anything to say at the last minute speak up or if not, we can all leave and wait for the bus. Thank you all very much.

(Whereupon, the proceedings were concluded.)

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Sixth Human Factors in Aircraft
Maintenance Workshop

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JULY 1981

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