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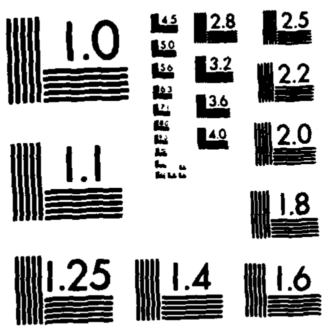
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THIRD HUMAN FACTORS WORKSHOP ON AVIATION

TRANSCRIPT

Sponsored by the
U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration

March 18 & 19, 1981

Presented at the
Transportation Systems Center
Kendall Square
Cambridge, Massachusetts

REPORT NUMBER: FAA/ASF-81-5

DOT/FAA
THIRD HUMAN FACTORS WORKSHOP
ON AVIATION

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FORWARD

This document is a verbatim transcript of the proceedings of the DOT/FAA Human Factors Workshop on Aviation held at the Transportation Systems Center in Cambridge, Massachusetts, on March 18-19, 1981. Additional workshops/symposiums are scheduled to address Human Factors safety issues in the coming months. The Fourth Human Factors Workshop on Aviation will be held on May 13-15, 1981. Another workshop is tentatively planned for July, 1981, at the Civil Aeronautical Institute in Oklahoma City, Oklahoma.

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LIST OF ACRONYMS

ADF	Automatic Direction Finding
ADOCS	Advanced Digital Optical Control System
AFA	Air Force Academy
AFC	Air Force Communication Service
AIDS	Advanced Integrated Display
ALPA	Airline Pilots Association
ALS	Approach Lighting System
ALSF	Approach Lighting System with Sequenced Flashing Lights
AOPA	Aircraft Owners and Pilots Association
ASI	Airspeed Indicator
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
BALPA	British Airline Pilots' Association
CAADRP	Civil Aircraft Airworthiness Data Recording Program
CAB	Civil Aeronautics Board
CAI	Computer Assisted Instruction
CAR	Crew Station Assessment of Reach
CAT I-II-III	Category of Minimal Landing Requirements
CDTI	Cockpit Display of Traffic Information
CGI	Computer Generated Image
CPS	Central Processing System

CRT	Cathode Ray Tube
CUBITS	Bits of Information, Criticality and Utilization
DARC	Direct Access Radar Channel
DME	Distance Measuring Equipment
ECOM	Electronic Communications Command
EMMAD	Electronic Master Monitor and Advisory Display System
FAR	Federal Air Regulations
FEIA	Flight Engineers International Association
4-D-NAV	Four Dimensional Navigation
GAMA	General Aviation Manufacturers Association
GPW	Ground Proximity Warning
HOS	Human Operator Simulation
HSI	Horizontal Situation Indicator
HUD	Head Up Display
IACS	Integrated Avionics Control System
ICA	International Civil Altitude
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Airline Pilots
IFR	Instrument Flight Rules
ILS	Instrument Landing System

INS	Inertial Navigation System
LOFT	Line Oriented Flight Training
MDA	Minimum Descent Altitude
MET	Meteorological
MFD	Multiple Function Display
Mmo	Maximum Operating Mach Number
NAVAID	Navigational Aid
NAVSTAR/GPS	Navigation System using Timing and Ranging/Global Positioning System
NBAA	National Business Aircraft Association
NTSB	National Transportation Safety Board
OMEGA	Low Frequency Global Navigation System
PATCO	Professional Air Traffic Controllers Organization
PERT	Program Evaluation Review Technique
PLATO	Computer Language, Computer Assisted Instruction
PNVS	Pilot Night Vision System
RDP	Radar-Data Processing
REILS	Runway End Identification Lighting System
RNAV	Area Navigation
RVR	Runway Visual Range

SAS	Scandinavian Airlines
SFL	Sequence Flashing Lights
SID	Standard Instrument Departure
SSM	Subsystem Status Monitor
TCA	Terminal Control Area
TICKETT	Computer Language, Computer Assisted Instruction
TRSA	Terminal Radar Service Area
TRSB/MLS	Time Reference Scanning Beacon/Microwave Landing System
TSO	Technical Standard Order
VAM	Visual Approach Monitor
VASI	Visual Approach Slope Indicator
VAT	Velocity at Touch Down
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	VHF Omnidirectional Range Station
Vso	Minimum Steady Flight in Landing Configuration

SESSION 1
(March 18, 1981)

MR. ANDERSEN: My name is Jim Andersen and I am the Director of Air and Marine Systems, Transportation Systems Center, and I will be the Workshop Coordinator for the next two days.

And it's now my pleasure to introduce Jim Costantino, the Director of the Transportation Systems Center. Jim.

DR. JAMES COSTANTINO: Good morning ladies and gentlemen and welcome to the Transportation Systems Center and to this two-day workshop on Aviation Human Factors. This workshop is sponsored by the Federal Aviation Administration and is the third in a series to address aviation Human Factors issues. As in the previous workshops, when we speak of aviation Human Factors here, we will be concerned with all aspects of human behavior which are considered in the design, operation and maintenance of aviation man-machine systems.

The first workshop out here at TSC last November, we took the initial step first to establish a common frame of understanding as to ongoing efforts in the Human Factors area. Secondly, we tried to develop a dialogue throughout the International Aviation Community on Human Factors problems and issues. And thirdly, we tried to gather information to form the basis of a Human Factors research agenda for the future. At that workshop, the first one, Panels representing the Government, airline pilots, commercial aircraft manufacturers and commercial airlines presented and discussed a broad range of important Human Factors issues based on their wealth of experience and knowledge in the aviation field. I believe that workshop was successful in achieving its intended purpose. Many of you that are here today participated in that particular workshop, and we appreciate that.

The second workshop in this series was held in conjunction with the Second Annual FAA/Commuter Airlines Safety Symposium in Arlington, Virginia, this past January. At that one-day session, the emphasis was on Human Factors considerations in the design of modern-day equipment for the commuter airlines. Three panelists representing the aircraft manufacturers gave informative presentations on their companies' design philosophies, the principal Human Factors criteria which are applied, and some specific examples of problems and recommended solutions.

At this third workshop we are starting today, our aim is to continue the process of defining and discussing the critical Human Factors issues in aviation and what further should be done about them. We want to give particular emphasis to gathering inputs from additional segments of the aviation community not formally represented at the previous workshops.

This workshop has been organized to address Human Factors issues in five areas: General Aviation, Helicopter, Air Traffic Control, Airline Operations and Metrication. We will begin today with presentations by representatives of various aviation organizations primarily concerned with one or more of these areas. Then tomorrow morning, five individual workshops will convene, each of which will address the Human Factors issues in one of these areas in greater detail. The conference will conclude tomorrow afternoon with a plenary session beginning at three o'clock at which time the results of the individual workshops will be presented.

So our work is cut out for us, and I am sure you are all anxious to get on with it. Your presence here today confirms your interest and dedication to assuring the continued safety, reliability and efficiency of the world's air transportation system, and your recognition of the critical role of the human element in that system. Thank you for joining us here at TSC today for this important conference.

And now it is my pleasure to introduce to you the FAA Associate Administrator for Aviation Standards, who will set the stage for the next two days - our friend, Walt Luffsey. Walt.

WALTER LUFFSEY: Welcome to the third workshop on Human Factors as related to aviation safety. Our goal, as it was at the first workshop held here in November of last year and the second workshop which was held in January at the Commuter Airline Symposium in Arlington, Virginia, is to establish a common perspective on Human Factors problems and to identify the issues that when resolved through our common efforts can lead to the greatest improvements in safety. These improvements are possible in both the operating and design phases of the flying business.

We view this open process of Human Factors program planning as a key move in our certification process. Many who have spent virtually their entire professional careers in aviation have urged that we take advantage of their experience in opening up the certification process. While I don't think, and I'm sure you agree, that this meeting is an appropriate forum to discuss the specific pros and cons of open certification, I believe this meeting does represent a real move in that direction. As I understand it, the goal of those who would open the certification process is, fundamentally, to have an influence on the way aircraft are designed and equipped and through this influence to contribute to everybody's goal of accident avoidance. Whether you wish to call it a part of the open certification process or not, this is what we are here to do today. The collective experience of professionals in this room is being brought to bear on one of the most promising areas for safety improvement. Your help in the planning phase, in the execution and the analysis of the results for our Human Factors studies will clearly have a positive effect on the certification of future aircraft. Put simply, our mission in Human Factors is to investigate the "Why" of human error, the interfaces between people and our complex systems and to mitigate problems or hazards at such interfaces in both existing and future systems. We must deal with elusive and sometimes abstract considerations and assess in an objective manner the pros and cons of a number of issues aimed at safety improvements. FAA has recognized that human performance in the activities of men and women who operate and maintain aircraft, the air traffic control system and navigational aids is of paramount importance to aviation safety. This is evidenced time and again in accident investigations which reveal that a large percentage of causal factors are attributable to human performance, or putting it less positively, to human error or lack of adequate performance.

We also recognize that a large number of reports in the aviation safety reporting system show the involvement of human error. Our conclusion that human performance enhancement deserves an elevated priority is supported by nearly every element in the aviation community. NASA, NTSB and DOD all have highlighted the importance of gains in safety that may be attained through increased understanding and better applications of present knowledge in Human Factors areas. Concerned groups have called for more attention to the root causes of so-called pilot error. The simple logic is that blame provides neither a remedy nor prevention of repetition in the future. If we can find out why, we have a clue to avoidance next time by changing methods, practices or application of complex systems and hardware. I believe, then, there is general concurrence that improved reliability of engines, airframes and avionics must be paralleled by comparable improvements relating to the human elements in aviation. What we see happening in the coming years is the melding together of Human Factors knowledge - that already existing and that produced by new programs such as aircraft design advancements and ATC and aeronautical aids improvements, all integrated into a technically advanced national aviation system that, in turn, will achieve improved safety. The FAA's primary responsibility is improving safety in the national aviation system. The work associated with this responsibility is continually changing as this aviation environment continually changes, manifested by increasing traffic congestion, more sophisticated equipment, more complex operational procedures, all of which impose new demands for maintaining safety in the present and future system.

Our safety programs can be divided into three major categories: The first is mechanical. These programs deal primarily with the aircraft itself, the landing systems, the technological enhancements that manufacturers and industry are making every day, and computers which continue to make more and better decisions for us. Our statistics indicate that we have adequate programs working in this area.

Second, we have the environmental category. These programs deal with the operating systems or those relating to meteorological matters. Wake turbulence, wind shear, bird strikes, near midair collision and all of the weather-associated problems, all of those fall into this category. There are many active programs within FAA in these areas and other agencies also.

The third, of course, is Human Factors. True, we have many programs which might be placed in this category such as biennial flight reviews, continual evaluation of certification standards, increased utilization of certification standards, increased use of improved simulators; but the facts still point to the large majority of our safety problems occurring in this category. Landing at the wrong airport, flying into reported bad weather, inadequate preflight preparation, improper center of gravity calculations, fuel exhaustion, gear up landings and human error in maintenance are but a few examples that are at least contributing factors to the aircraft accidents that are occurring today.

Our new technology with more complex and automated equipment, operating in an ever increasing congestion of air traffic will require our airmen, both pilot and nonpilot, to be alert to the environment they are operating in. They must be knowledgeable of changes to the system and physically and mentally capable of performing their respective functions.

Basically, the success of the FAA programs has been highest where most data on accidents and nonaccident-related information are available. When the problems can be adequately described, the prevention can be developed. This approach has resulted in diminishing the accidents caused by the mechanical failure and, to some extent, weather.

I firmly believe we must get out from behind the power curve in Human Factors and get into the posture of accident prevention rather than reacting to accidents and reporting after the fact. I am also of the opinion that as we gain more of the appropriate kinds of information in a more timely manner, we will be able to identify trends and be alerted to areas requiring attention prior to the occurrence of an accident. To this end, we are conducting this series of Human Factors workshops to help us identify the safety issues and chart a proper course of action.

Before turning the podium over to Cliff Hay, let me simply welcome you again and tell you that the FAA needs your cooperation and your participation. It's one thing to see a need for advances in knowledge and for changes in rules but another to lay out an effective program to attain those goals. To do that, we seek to coordinate the efforts of existing government, industry and university research teams so that results focus on our specific needs in aviation. We can succeed only if we have the participation in both the planning and the execution of the knowledgeable people already engaged in aviation Human Factors work.

We believe the group assembled here today is representative of a significant part of the community of interest, and we earnestly solicit your active efforts.

Our assumption is that our efforts will produce an avoidance of human tragedy. The program will be expensive and it will be challenging.

Success will be important to all of us in aviation. I now turn to Cliff Hay.

Cliff is our Chief of the Special Programs Division, Office of Safety in the FAA. Cliff.

MR. HAY: Walt, your comments only serve to underscore the very, very significant charge that all of us have placed upon us in this particular field and we thank you for those.

I would like to focus some attention on one aspect of this that all of us consider very important, and that is the very fine support and environment that have been established for us by the Transportation Systems Center and particularly Jim Costantino. And to make sure that that continues to run along smoothly, I want to provide a few minutes here for some administrative details by Ms. Les Foster. Please, Les, if you would.

LES FOSTER: Good morning, everybody. I just have a few things that I want to say; and if you all will just be patient and listen carefully, I'll run through them. They're in no particular order, but I think it will make the conference run a lot more smoothly.

First of all, there are telephones just to the right of the doors as you go out across from the coat racks, public telephones. There is also one at the registration desk.

Now we will be selling meal tickets today for lunch during the break and also right before lunch, both at the orange registration desk when you go right outside of the door and at the circular information booth when you first came in. The tickets will cost $3.50 and we would like to encourage everyone to buy them because it will make starting the conference this afternoon easier. If everyone has lunch together, we will all try and start on time. There is also a menu out there.

Tomorrow everyone is going to be more or less on their own, and we will sell lunch tickets tomorrow morning also; but if you would like to eat out or eat at different times -- you are all going to be breaking at different times, so you are free to do as you like.

Now if anyone has any travel changes or problems, there is a travel office here at the Center, and it's just as you walk out the hall here and go into the main lobby. It's just before you enter the main lobby on the right. If you have any ticket changes or anything like that, they will be more than happy to help you.

For the people who are bringing their luggage with them tomorrow morning, we will have a space provided, so just bring it with you on the bus because the bus will not be returning to the hotel in the afternoon.

Now one important thing; when you go out each time, during break, before lunch, during the afternoon break, please try and check. There is a round column sort of message board right outside the door here. And we'll -- if you have received any messages, what we'll do is we'll tack them to the board, so just please try and glance and see if your name is up there as you go by.

This evening there is going to be a cash-bar reception -- I guess most of you know that -- right after the conference. And if any of you have guests here in the city, they're more than welcome. It will start around 4:30 to 5 o'clock depending on when you all break.

Now about the bus. There will be a bus leaving directly after the conference tonight going to the hotel. It will then drop anyone off who doesn't want to go to the reception and will return here and stay here until the reception is over, about 6:30, quarter of 7. And then it will take everyone else back to the hotel. Tomorrow morning it will leave the hotel, and I think most of you have gotten the bus schedule. It leaves 8:30 and 9 o'clock, I believe, and will bring people here. And then tomorrow afternoon after the conference is over, it will go directly to the airport from the Transportation Systems Center.

I guess that's all. Thanks a lot.

MR. HAY: Thank You, Les.

Now it's a great pleasure for me today to be dealing with and introducing 12 very distinguished speakers, both national, United States and international in character.

It's planned the following way: That each will give his presentation and we will move on through the day in that fashion. This will mean no questions and answers at the end of each presentation. Later on in the day, I will introduce Guice Tinsley, who is the Chairman of the Human Factors Task Force now in the Special Programs Division, the FAA. And he will discuss with you the individual discussion sessions and workshops tomorrow. This will be the place for the questions and the discussions to take place.

One final note before I move into the introductions, the transcripts of the previous workshops, one and two, are outside and are available to you free of charge. We encourage those of you who do not have them to take them as background and review material.

The first three speakers today will cover two discussions from the helicopter side and one of the two discussions that will take place on general aviation. At the conclusion of the third speaker, we will have a break.

The first individual I would like to introduce this morning is Walt Rossbach, Director of Communications of the Helicopter Association International. His discussion will be Human Factors issues in helicopter operations. Walter.

WALTER ROSSBACH: Thank you very much. Good morning everyone. Actually, Art Childer was to deliver this presentation, and it is his presentation. Art was called to Mexico at the last minute on a very, very crucial safety issue that developed down there, so I'm standing in for him this morning and delivering his presentation.

Just one word about his being in Mexico. The Helicopter Association, as you know, was called the Helicopter Association of America until only a month and a half ago, and has changed its name and scope to reflect the international character of its members, which are basically commercial operators since approximately one-quarter of those members are outside of the United States. So the name of the organization and much of its activities now are reflecting the international scope of helicopters in the commercial sector, which is a very rapidly expanding field, which I'm sure you are all aware of; and we are very happy to be here, gentlemen.

Man's interest in flying is as old as recorded history but older still is his interest in himself. His pains, his pleasures, his desires and disappointments, his fears and fantasies have been subjects of speculation and theory for centuries.

If the first flight of the Wright brothers can be considered to mark the beginning of the science of aviation, it is of great interest to all of us here to note that the birth of scientific psychology was less than 25 years earlier than the first flight. The science of aviation has concentrated effectively on the physical problems of flight. Structurally and mechanically, great strides have been made in man's conquest of the air. We know now how to appraise some of man's strengths as well as his limitations and we know that certain limitations have very important bearings on his operation of modern aircraft, to say nothing of future aircraft.

Helicopters are radically different from fixed-wing aircraft. It's important that we say that up front. They do not fly the same way nor do they react the same way in any given situation. The main thing that helicopters and fixed-wing aircraft have in common is that they are both modes of air travel. That is where the similarity ends. They both provide transportation by air for passengers and cargo; but for much too long, individuals and government agencies have tried to apply fixed-wing rules and analogies to helicopters and their operations. They don't fit. There has been a failure in the past to recognize the rapidly expanding civil helicopter fleet and now it is predicted accurately, we believe, that the number of civil helicopters will more than double in the next 10 years. This growth will bring on stream larger and more sophisticated helicopters and its related systems. We already have several helicopters that are IFR certified, with mutliple-type displays and ever greater complexity. It has to be recognized that the success of these unique machines, the helicopter and their systems, is dependent upon the human beings who must learn about them, operate them and maintain them. Many of our present-day helicopters are limited by the limitations of the people who fly them, and without a doubt many of our present systems could be made better if we had more complete knowledge of that human behavior.

New techniques and improvements have been developed from experiments that have proven to be very valuable. Proceeding in the proper direction to perform the necessary experiments and research has been a problem because the cues from which we receive our guidance are, for the most part, drawn out of results from accident investigation. Through investigation we have been able to determine the exact number of meters, for instance, by which a pilot missed a landing, but why he misjudged is invariably attributed to those two convenient words "pilot error."

Can I have the first viewgraph, please? (Slide.)

Statistics from the NTSB "Briefs of Accidents Involving Rotorcraft" U.S. General Aviation, the year 1978, showed that 64.49 percent were attributable to pilot mistakes, which is rather glaring when compared to other cause/factors: terrain 26 percent; power plant 23 percent, approximately; material failure/ malfunction 14 percent; other personnel 14 percent; and weather approximately 12 percent.

Could I have the next viewgraph? (Slide.)

During the calendar year 1978, the following statistics on rotorcraft were also compiled by the NTSB:

2,227,651 hours flown, a total of 322 rotorcraft accidents, of which 56 were fatal accidents with a total of 84 fatalities.

(Slide.)

The total number of helicopters in that universe reported in 1978 was 6,448, of which 3,800 were reciprocating and 2,648 were turbine type.

(Slide.)

From the 322 total accidents reported in 1978, there were 94 cases involving engine failure. Of those 94 cases of engine failure, 21 involved turbines and 73, reciprocating engines. Of the 21 turbine engine failures, 8 listed fuel exhaustion as a causal factor. Of the 73 reciprocating engine helicopter accidents claiming the engine as a causal factor, 22 listed fuel exhaustion as a reason. You can deduce, therefore, that out of the 94 reciprocating and turbine engine failures, 30 were due to fuel exhaustion; and because of the way statistical data is complied one would think, according to the earlier chart, the engine failure, that engine failure is the causal factor in almost 23 percent of the grand total of 322 accidents in 1978. If we take out the engine failures due to fuel exhaustion, engine failure, as a causal factor would actually represent 19.8 percent of that grand total. I hope you understand some of the misinterpretations that can occur when trying to deal with and decipher statistical data.

Many times the accident report does not address the actual cause of the accident or go deep enough to find out what actually caused the accident. Another problem arises in comparing accident statistics containing different variables. Unless the samples have been equated or equalized for exposure rates, types of aircraft, kinds of mission terrain, weather conditions and numerous other variables, comparisons will be inaccurate or possibly meaningless. And unless the values of these variables are known, it will be hazardous to generalize from these samples. These problems do not make it impossible to study accidents by means of statistics. On the contrary, better statistical techniques must be developed and used. These techniques coupled with accurate and thorough investigation will insure valid accident statistical data.

The FAA has done an exceptional job in conceiving and implementing safety programs in areas where hazards have been identified, especially with respect to mechanical and environmental factors. The lack of substantial progress, in the area of human error, if you will, is linked to our current lack of insight into the nature of the problems in this regime. Human Factors data, as currently collected, is inadequate in defining the "why" of pilot error. The terminology and classifications give no insight into corrective measures. More attention should be focused on the human error aspects of accidents, near-accidents and incidents. Then and only then, will the progress we're looking for be made.

We feel that a normally successful flight becomes an accident when accompanied by a series of one or more "accident-enabling factors," conditions which have to be present and without which the accident would not have occurred. This approach de-emphasizes the phrase "pilot error" and focuses attention on the factors that prompted the pilot's actions and decisions.

Some areas that should be looked into are: pilot workload; integration of controls, displays and visual requirements; pilot comfort and physiological factors, controls, display location, environmental factors such as pollution -- in the helicopter operations, that's a serious problem at times -- and temperature extremes. Also the long-term effects of vibration upon the pilot and noise problems.

Pilots of helicopters have been continually exposed to an environment that is conducive to serious back problems because of long-duration exposure to high vibration levels. Additionally, the growth of external-load operations increases this problem because of unconventional positions required when viewing sling loads under the helicopter. Noise and environmental factors also contribute strongly to pilot discomfort. It is necessary for display and control research to define cockpit layouts that minimize strain on the pilot. We need seat research that identifies seat structures that will provide proper support for pilots in unconventional positions. Of course, the reduction of noise and vibration levels is certainly something we all are pleased to see being constantly improved.

Specific research activities need to be completed on the integration of cockpit functions utilizing advanced control display and communications technology in a manner that allows the pilot to give maximum attention to the outside environment.

Pilot error accounts for over 60 percent of all helicopter accidents. The high workload level, environmental, physiological and psychological effects that are inherent in many helicopters and in connection with their unique missions are certainly contributing factors in many of these accidents. We cannot expect to reduce our accident rate by always attempting to change human behavior. If there were a hole in this floor, here in this room, we could not reliably expect to avoid all accidents by training everyone that possibly might walk by it to walk around the hole. We must improve our accident reporting and investigation techniques, then concentrate our research in priority areas that are properly identified. By improving and expanding work in these areas, we can relay to the engineers what they need to know so designs can be changed to help prevent future accidents. In the past, finally, we have overemphasized the ability to change human behavior. We cannot continue to rely solely upon training people to walk around the hole in the floor. Let's concentrate on removing the hole.

Thank you very much.

MR. HAY: Before we move on to the next speaker, one thing that Walter has drawn to my attention both in speaking this morning and in his presentation is one of the more active examples of work that Walt Luffsey has established within the FAA and that is the Helicopter Operations Task Force that is supported by, literally, the entire industry in the way that I must say is very, very complimentary to them and their interest. Dr. Bertone, Dora Strother and Walt and many others are active, very active, in that area and that is handled by Harlan Hossler out of our Special Programs Division.

Our next speaker, Dr. Bertone, of Sikorsky Aircraft Division will speak on Human Factor issues and helicopter manufacturing to further underscore the helicopter programs. Please, Dr. Bertone.

DR. C.M. BERTONE: Good morning. Sikorsky Aircraft on behalf of the U.S. Helicopter Manufacturers - Bell Helicopters, Boeing Vertol and Hughes - welcomes the opportunity to join the distinguished members of this panel in presenting what we jointly feel are the Human Factors issues in our business. We are enthused by the FAA's continued interest in holding workshops of this nature and providing a platform from which they have been both praised and criticized.

Upon accepting the opportunity to represent the Helicopter Manufacturers, I immediately called my contemporaries and polled them on the issues they wanted me to bring to your attention.

These can be broken down into several categories including displays, visibility, controls, standardization and anthropometry. Of course, from a Human Factors manufacturer's point-of-view, we are concerned with the design features of the vehicle and, therefore, will address those areas specifically; and we are especially eager, at this point, for the FAA to take an active role in evaluating and establishing criteria for the certification of advancing cockpit technologies.

Of major concern to Human Factors personnel are the pilot role and cockpit information issues. What can we do to anticipate the information requirements of the future, and what is the best method of displaying this information to the pilot? This whole area of the design and development of the so-called "advanced cockpit" is critical to Human Factors personnel. As a result, studies are continually being generated to determine the medium that will be used for cockpit displays. Will it be cathode ray tubes, plasma displays, flat panel units? Which is best? Is there a combination of electronic and conventional displays that will do the better job? Once the display issue is resolved, a whole host of questions are then generated in terms of the kind of information that must be presented, the type of information required or desired by the pilot and the safety issues implicit in advanced instrumentation.

At the present time, the military are making major advances in the research and acceptance of new systems. For example: the development of a Subsystem Status Monitor (SSM) system, which reduces pilot visual and decision-making workload during the monitoring of helicopter subsystems by automatically displaying only what the pilot needs to know, when he needs to know it.

(Slide.)

This is an example of the Subsystems Status Monitor Display installed in the UH-68 Helicopter. This is the Army's newest helicopter. This is what the present instrumentation looks like, vertical display of instrumentation here (indicating). And this is the same cockpit with the SSM installed. You can see a radical improvement and an addition of real estate. And real estate is very, very important in the helicopter. We have very limited space in which to put things, so any improvements in that real estate is important to us.

Other advances are the Aircraft Performance Indicator System, which is an on-board computer that provides the pilot with detailed information on lift margin, fuel management, cruise capability and many other aspects of it. There are many other programs along these same lines that the civilian industry and the FAA should be concerned with. A major one is the development of Voice Interactive Systems. These systems would provide the pilot with the capability of talking to his helicopter and having it respond either by displaying information he requested or turning on and off switches or in warning him of pending problems and out-of-tolerance conditions.

(Slide.)

The goal of the cockpit voice interactive systems is to reduce manual workload, provide the pilot with more outside visual contact and crew size reduction, improve system monitoring, reduce visual display area and improve information transfer. All of these goals are being met by systems using voice. We now have very, very good voice systems, and we are experimenting with these continually. And they are getting ready to be installed in vehicles.

Some of the functions that you could use voice for in the helicopter: communications, radio selection and tuning. The pilot could actually ask for the particular frequency that he wants and it will automatically be dialed for him. Navigation. To update the positions, request position, request steering, voice position and voice steering. He could actually tell the helicopter which direction he wants to go, what flight path he wants to take, which way point he wants to go to and have automatic direction.

Instrumentation, mode selection for altitude and SB callouts. He could actually have a display by exception, the cathode ray tube, which would have no information on it. When he needs this particular information, he would call it up merely by saying "fuel" or by asking for altitude, and it would be displayed to him.

Subsystems Status Monitoring, of course, we talked about. AFCS for mode selection and voice status; and finally, the voice warnings and emergency procedures. This is where the helicopter would actually tell him when he had out of tolerant conditions. When things were going awry in the helicopter, a voice would come into his headset with a priority message telling him exactly what was wrong with the systems.

In the area of controls, Human Factors has addressed the issues by investigating two, three and four axes, both force feel and displacement-type controllers. These systems will provide the pilot with a more comfortable seat. He will now be able to sit back in the seat instead of having to sit forward holding both the collective and cyclic as he's now required to do. This is the four axes side-arm controller which reduces pilot workload and frees one hand and both feet. The pilot merely has one handle now instead of both the collective and cyclic. He has roll left and roll right merely by moving it sideways. He has pitch down and pitch up by pulling back and forth. He has your left and your right by twisting, and this is collective up and down motion. This system has actually been flown in the Canadian variable stability helicopter, and it has been flown very successfully.

(Slide.)

One of the pilots that flew the system is General Stevens of the United States Army. Here he is sitting in the variable stability helicopter with the side-arm controller which is here (indicating). This whole armrest comes up in the air for ingress and egress so that it's very easy to get in and out of the helicopter with that system in there.

Under a study sponsored by the U.S. Army, this system will also be flown next year in either a Black Hawk or a Bell UH1N Helicopter in the evaluation of what is known as Digital Optical Control Systems. The Digital Optical Control System is a fly-by-light system. What I am depicting here is a fly-by-wire system. The fly-by-wire system eliminates all of the controls, the linkages, the bell cranks and everything else that you need to control a helicopter. By putting in an electronic system, you have very, very little control. Side-arm is over here (pointing); digital process, redundant channels, so that you have a very simplified system without all the mechanical linkage that is now required to fly a helicopter. So these are two of the major advances that we see in the helicopters, but we're concerned with other things also in the Human Factors area. We are concerned with visibility and reach in the cockpit. As a result, the area of vision plotting and over-the-nose visibility is a major issue.

In many cases, we again go to the military standards to establish our path. Lately, we have gone to computers to assist us in demonstrating how to improve visibility by changing window size and location. It saves a tremendous amount of drawing-board time. The Navy has developed a program called CAR, C-A-R, for Computer Assessment of Reach. This program assists in determining the optimum position of switches and controls in the cockpit. More sophisticated computer programs permit the specification of arm size, body length and so forth as inputs, and then they plot graphically exactly what the individual pilot and co-pilot can reach either with his right hand or his left hand.

(Slide.)

This slide shows a typical instrument panel, and the overlay to that shows what the computer would generate, indicating the Zone 1 reach, the Zone 2 and Zone 3.

Zone 1 reach means that the pilot is totally restrained in his seat. He cannot lean forward, and you can see that the pilot has a very limited reach area. This is the only area of the instrument panel that you could put switches for Zone 1 reach.

In Zone 2, the yellow area, he has released his seat belt so he can lean forward to a limited degree. And then of course, he has a greater area of reach.

And in Zone 3, he is totally unrestrained, and he can reach the centers. Of course, the reach is very, very important for safety aspects of flying, so we've very, very concerned with this kind of thing.

We must, however, become more aware of anthropometry. Anthropometry is the measurement of the human body. And there are more and more woman pilots coming into both the military and the civilian sectors. Unfortunately, anthropometric measurements are lacking, and they must be developed in order to assure that vehicles can be flown by both male and female pilots. This also brings up the design of seats, the amount of travel required so that the pilot is comfortable and can fly safely. The side-arm controller mentioned previously will do a great deal in settling the anthropometry issue.

A compilation of issues would not be complete without addressing those of noise, heliports, standardization of labels, controls and air traffic control.

Briefly, in referring to noise levels, the utility and executive helicopters have a significantly reduced cabin and cockpit noise level. We are now approaching the large wide-body fixed wing aircraft. This is due to new treatment in transmission technology and new soundproofing and lightweight material.

On labeling, today there is no standardization either in placement, size and/or color among manufacturers. The same with the control heads for the collective and the cyclic. Each of these depends on the individual manufacturer and the kinds of buttons, coolie hats and switches that he wants to put on there. I feel sorry for the poor pilot who transfers from one vehicle to another. The learning task can become overwhelming and hazardous.

Now, for the Human Factors issues directly relating to the FAA. We are concerned with air traffic control. Helicopters require lower minimums than fixed wing aircraft. Their approach speeds are one-half of those of airplanes or less. They don't require an airplane type glide slope, and, in effect, are never committed to land. They can approach an airport at much steeper angles of descent.

I have presented a wide variety of specific issues pertaining to Human Factors in helicopter manufacturing and what specifically they have to do with the DOT and FAA. In order for the manufacturer to apply the Human Factors research they are committed to do, in order to make their product meet the advancing technology and stay in competition, the FAA must be prepared to be able to certify the new instrumentation, the new displays, the systems that will inevitably find their way into the modern helicopter. I bring these points forward to challenge the FAA to look at their requirements to be sure they do not interfere with the safety benefits of this new technology.

The growth rate of this industry is phenomenal. General aviation has a 4 percent increase per year. Helicopters at the present time, 12 percent. We have 6,000 today. We are estimating double that by 1987. I will not attempt to read all of the numbers on all of these slides. You can see them for yourself; but basically this shows the civil production through 1987, and you can see the number of helicopters that are going to be available, both the dual pilot and the world-wide total helicopter sales.

(Slide.)

This is strictly the Northeast Corridor along in the IFR operations for helicopters. You can see the number of IFR operations, 178,575 by 1987.

(Slide.)

Now there are several near-term solutions that have been generated and are working. These are through 1982 in order to meet these objectives. These are various things that the FAA is working on, various things that the industry is working on. Again there's no need to go through these individually. We can go through them at the question and answer session and at the workshops tomorrow.

The progress on these by FAA is considerable. You can see that the FAA is working in a wide variety of these areas and doing very well in them.

Long-term solutions, of course, through 1987 to meet these objectives. Again specific things for helicopters that must be done by the FAA in order to meet the criteria that have been established.

(Slide.)

And finally, some of the progress to date on these long-term items.

(Slide.)

The FAA must also renew its commitment started under the previous administration to support work in the area of rotary wing aircraft.

The Human Factors projects I spoke of this morning are not dreams, they are reality. The helicopter manufacturers continually invest their own funds and obtain military support to bring these concepts into fruition. The four major manufacturers in the United States all have very small Human Factors groups working on major changes that will affect the industry for years to come. I propose that because this group consists of only four individuals, each representing a major company, they should unite with representatives of the FAA in forming a task force to work cooperatively on developing certification procedures, advisory circulars and the necessary FARs to be prepared for the future.

In summary, then, there is a brief look at some of the major Human Factors projects the helicopter manufacturer is concerned with.

(Slide.)

This is a very brief list of some of the things that are going on right now in advanced cockpits: the display system, side-arm controller, visibility, workload analysis - which you will hear much more about during the course of this conference and which we heard about at the last conference. A lot of work is being done in this area, again sponsored mostly by the military.

Terminal area approach, exterior lighting, helicopter lighting and so forth. Voice interaction system, communications, passenger comfort, seat comfort, perceptual blocking, review of FARs for helicopters and finally, emergency procedures.

(Slide.)

And here, ladies and gentlemen, is a look at not only the present but also the very near future. This is the 53E, which is the navy helicopter. It's the largest helicopter built in the free world. You see on the righthand side the existing 53E cockpit; on the lefthand side, you see the proposed 53E cockpit. This is the cockpit we are working toward developing right now. You can see a tremendous change in the information presented to the pilot. In the new helicopter we have the CRTs and the side-arm controllers. Again the Black Hawk helicopter. This is the present Black Hawk helicopter on this side (pointing) and this is the advanced Black Hawk helicopter. Again all the boiler gages are removed and replaced with the vertical instrumentation, and we go strictly to CRTs side-arm type controllers and multiplexing systems.

And finally, the ultimate in the advanced cockpit. This is what we see as the future for helicopter cockpits.

Thank you very much for your attention.

MR. HAY: You've raised some issues this morning for us, Dr. Bertone, that we see coming up in the helicopter operations task force regularly in the safety issues that you all have been recommending to us. This is another aspect of the work that goes beyond just the Human Factors work into the operations itself that Walt Luffsey has established in the Safety Resumé Program that we're putting together. You will hear more of this tomorrow related to the Human Factors area when Neal Blake, the Associate Deputy Associate Administrator Engineering and Development has some closing remarks.

It is always a pleasure for me to introduce the next speaker, who is Russ Lawton of the Aircraft Owners and Pilots Association. Russ will speak on pilot error and general aviation aircraft.

RUSSELL LAWTON: Thank you, Cliff, especially for putting Walt on first.

It's a pleasure to be here to discuss a problem that's familiar to all of us. I guess anyone who blunders around first thing in the morning before the first cup of coffee knows the severe implications of human performance, but I'm going to be bold this morning, unlike the first two presenters, and risk giving this presentation without the aid of slides or viewgraphs.

Human Factors for some reason seems to be a new buzz word this year and the last two years in covering a variety of topics depending on what you want to lump into that area, what just happens to fit at the time. Nonetheless, both FAA and NTSB tell us that pilot error is cited as a factor in 88 percent of general aviation fatal accidents and a significant factor in aviation incidents. Now I don't know why that should surprise anyone in this room, since anybody that looks through the accident literature for years - especially people like Heinrich tell us that it's accountable in over 90 percent of all industrial accidents. What I would like, since our purpose here today is to provide some sort of stimulus for the working groups tomorrow, is to present a couple of ideas for consideration.

A good working definition of human error is often difficult to find. I have one that I'd like to present for your consideration this morning. Human error according to at least one source has been called "That point where the assumed omnipotence of the participant failed to meet the expectations of the reviewer." While that may seem a little absurd, it does point out the high degree of subjectivity when evaluating aircraft accidents, or in other words "dead men tell no tales," or Monday morning quarterbacks always have a field day after the big loss." Conclusions such as "improper use of controls," "failed to see and avoid," "failed to obtain/maintain flying speed," just simply do not address the fundamental problems which contributed to these accidents.

The most significant cause/factors contributing to aircraft accidents are listed by NTSB each year in its summary. We all get the telephone book and leaf through it. But interestingly enough, if you go back through the years at these ten percent most significant cause/factors since NTSB has been accumulating the data, you'll find that the percentages don't vary more than five percent at the most between individual years. And it seems to indicate that maybe these descriptors just aren't very accurate to take the necessary steps to eliminate these particular contributing factors or maybe we've reached the point of diminishing returns with respect to preventing these types of accidents. Assuming that the latter is not the case, I'd like to focus the attention on the nebulous area of pilot error and determine if there are still practical means of preventing these types of accidents.

I would like to get very basic for a minute and suggest as a basis for gathering the data, since a lot of the data presented today does not do this, to follow three classic areas in Human Factors for consideration in the groups tomorrow and that is: the data should specifically be designed to help us design the machine to fit the human operating it; design the machine to protect the human as an end result; and design the system to serve the human operating in it. And I don't think this is too far afield since some of the basic premises in accident investigations where we talk about; one, removing the hazard; protecting the person from the hazard or warning the person of the hazard are other fundamentals.

Well, I think we probably all agree that a lot of improvements have been made in cockpit standardization in recent years. And while we've made great strides, we're not there yet. It's especially critical for the general aviation pilot flying light aircraft, since the general aviation pilot operates more than one make and model of aircraft. And even though Part 23 describes relative control, shapes and sizes, there are still variances between different makes and models of aircraft. And we're still increasing the exposure of the individual to make a mistake through the incorrect operation of a control which still varies in direction of movement, shape and size.

Great strides have been made and are certain to continue in avionics and controls and displays now coming into general aviation aircraft. It is a naturally, rapidly evolving segment of the technology, but it doesn't have the set of standards for displays. Last October at the annual Human Factors Society meeting, it was pointed out and great concern was expressed over the variation in the presentation of Head Up Displays. And if we don't pay attention to it now, we're going to be exactly where we were 15 years ago in the area of cockpit standardization.

Along the same lines, NTSB expends the bulk of its resources investigating fatal accidents. In general aviation accidents, this is unfortunate since in many instances there's little information to be gleaned when all that remains is a big smoking hole. It would seem to us that resources would be better spent investigating fewer accidents with a greater emphasis on the quality of the investigation instead of investigating each fatal accident. We would like to see a group to at least establish a new set of criteria to select those accidents which would be investigated, especially the non-fatal accidents.

A couple of years ago, a year or two ago, a good paper was written by Dr. Alan Diehl who is now of the Office of Aviation Medicine, then in the Human Factors Branch of NTSB, wherein he addressed four human performance areas which he suggested for review in investigation. Those were: medical factors, operational environment factors, equipment design factors, and behavioral factors. If we are really sincere in our effort to examine the broad area of pilot error, these factors must be given more thorough consideration. Now the only thing we fear in this, in making this recommendation, is that most of the resources, of course, are put into air carrier accidents and they only receive cursory attention in general aviation accidents. We simply need to wean ourselves from the conclusive, pronouncement of "probable cause" in the back of every blue cover report.

Nonfatal accidents hold a far greater wealth of information for preventing future accidents. We should continue to use as much of this information as possible, especially through sources such as the NASA Aviation Safety Reporting System, which has proven to be of invaluable assistance already vis-à-vis the problems in the study of TCAs and TRSAs. The ASRS program has matured, but simply doesn't receive the attention it deserves as an accident prevention tool. We hate to admit it, but a lot of the problems faced in using the data and the problems in coordination seem to be in the defense of empires between government agencies. And as long as we continue to do that, we'll never advance the cause.

One other area in the data collection arena that should be mentioned is that of exposure data. At the present time when you go through the NTSB annual phonebook, you see a listing of pilot total times by the various accident percentages; but what you do not know when you look at those total time requirements is anything about the pilot. They're absolutely meaningless. When you find out that 49 percent of the accidents are occurring with pilots that have three thousand hours total time, you simply have no way of knowing whether that three thousand hours was accumulated over ten years, 60 days, one week, whatever. We need to get a handle on this type of information by going out and doing the sampling of exposure data and come up with a representative of both the accident and the nonaccident pilot population.

No matter how hard we try to prevent accidents, we all have to agree that we'll never reach the point of zero aircraft accidents unless we just stop flying altogether. We would like to see the necessary steps taken to ensure that aircraft occupants are adequately protected in aircraft crashes.

Accident studies dating back over 40 years have concluded that at least 50 percent of the fatalities in general aviation aircraft would not have occurred if adequate crashworthiness design (such as stronger cabin structures, energy absorbing seats, improved restraints, shoulder harnesses, delethalized interior, etc.) had been utilized. There is a conservative probability that at least 60 percent of the aircraft manufactured will be included in an accident during a 20-year service life.

We believe that many of these accidents could have been prevented, or at least the severe injuries in these accidents, if the crashworthiness standards had been periodically updated in FAR 23 through the years in order to reflect state-of-the-art crashworthiness design. AOPA tends to publish in the near term an evaluation of FAA safety standards for protection of occupants in crashes under the authorship of Dr. Richard G. Snyder at the University of Michigan. The purpose of this study is to review the pertinent sections of FAR 23 related to crashworthiness requirements and evaluate how effective the present requirements are within the state-of-the-art. Particular attention will be devoted to those sections of Part 23 with respect to "emergency landing conditions," "seats, berths, safety belts, harnesses," "fitting factors," and in the TSO requirements pertaining to safety belts, aircraft seats and belts and proposed TSOs for child restraints.

Our objective as a result of this study is to petition FAA to amend the appropriate portions of FAR 23 to more adequately reflect the state-of-the-art for a newly certificated aircraft.

I mentioned a moment ago that the NASA ASRS program has presented the problems with potential near midair collisions and other related incidents within TCAs and TRSAs. Many of these problems are the result of a failure of two human beings to communicate for whatever the reason. Unfortunately, the result was not catastrophic. The problem is not limited to just general aviation pilots but all pilots, for I think we agree the system has inherent dangers for communications errors and carries many misconceptions among pilots. Consider some of the following situations which we know have already been factors in accidents, which it would be interesting to address in our discussions later on: Pilots operating either IFR or VFR upon hearing the magic words "radar contact" assume separation and traffic advisories on all traffic will be given by ATC at one point. Pilots operating in VFR conditions but on IFR flight plan simply do not understand the responsibilities that they have for traffic separation. Or pilots who believe they are receiving separation service in an airport traffic area or traffic pattern and are surprised to learn after a midair collision that it wasn't the controller's responsibility to provide that separation. Controllers who aren't trained or qualified to understand the capabilities of pilots or aircraft. Finally, our system of weather collection and dissemination, which I'm not going to go into a great deal of at this point but simply to say it leaves much to be desired.

Two years ago at Ohio State University, AOPA and GAMA in cooperation with FAA sponsored a general aviation safety workshop which came up with a number of recommendations in the weather-related accidents. A second workshop was held at the FAA Technical Center the last week in January. We talked about these types of problems enough. We need implementation now, not further discussion and groups such as these.

There were a number of good recommendations. However, all we hear is, "Well they're probably ten years down the road."

Now I realize that I have presented many problems in the last few minutes without solutions for all, but I would like to stimulate discussion in these areas anyway because we perceive them as major stumbling blocks to aviation safety in general aviation of Human Factors.

And I would also like to make clear that we do not intend to cover or make excuses for indivduals who willfully engage in unsafe practices. But we hope to reduce the number of pilots who fall victim to this type of accident. And we need more implementation and not continued discussion of the many ideas presented as a result of some of our past workshops. Thank you.

MR. HAY: Russ, I just would like to mention, the workshop that you brought up at the Technical Center in the last week of January, we are working right now with you very closely in that area to bring those recommendations into focus in the way of aviation safety issues that we will be reviewing. And again this is the ability to do this and having the material to work with is in a large measure a credit to you and to your organization in assisting in putting that together with us in January, and we thank you for that.

Now I would like to ask all presenters today if you would be sure to leave us with copies of all your viewgraphs and other related material so we can enclose these in the record, and that can simply be in the form of a hardcopy and be quite satisfactory.

We have a key time that we shoot for here at TSC, so what I am going to do is give you a longer coffee break and more time for personal exchanges here after these first three briefings this morning. We will come back at 11:10 and that will be approximately one hour from now. The reason for that is we will take advantage of this extra time this morning because we have a specific lunch period that we must hit at the appointed time in your schedule. So if you would all relax here for a short period of time, we will see you back at 11:10.

(Coffee break taken.)

MR. HAY: Let me just ask, is Mike Simons here? I tried to find you in here today. Do you have anything that you want to put up for viewgraphs or anything such as that?

I think we're fast approaching the time to reconvene. Take just a moment. If we can all come in, please.

I never know how I come out after Russ has spoken, and it's probably taken me this long to figure out, but again we want to thank him for always an interesting and direct speech.

The next three speakers, one will be on general aviation accidents. Mike Simons from PATCO and the Human Element in Air Traffic Control and Derek Ruben of the British CAA on Civil Aircraft Airworthiness Data Recording Programme, certainly a stimulating area, one that none of us over here has had any experience or engaged in at this time to the extent that the British have. I would like to start out by saying again a great deal of pleasure on my part to introduce Gerrit Walhout from the National Transportation Safety Board, and his presentation will be on Human Performance Aspects of General Aviation Accidents. Gerrit, if you would, please.

GERRIT WALHOUT: Good morning. I would like to talk to you about the human performance investigations that we've tried to organize over the last couple of years or so. From my personal viewpoint of having had the role over the last five years or so of administering the investigative efforts of the NTSB's human factors area, it has been, to say the least, an interesting experience. Human Factors has become the catchall phrase of the decade, so to speak, of things we sometimes cannot explain, and sometimes I am not sure we are all talking about the same thing.

By way of introduction, let me explain briefly the traditional role of the NTSB's Human Factors investigator since this particular field of expertise came into being in accident investigations conducted by the Civil Aeronautics Board (CAB) in the mid-1950's.

There had been considerable research conducted by Cornell University beginning shortly after the Second World War on the crashworthiness of aircraft and the ability of the human body to withstand forces. The need to investigate the adequacy of occupant protection in airplane accidents in as detailed a manner as possible and as detailed as were the mechanical circumstances of the accident was pointed out quite forcefully at that time, and therefore, the CAB established the Human Factors speciality.

The name Human Factors, in the context of what we were doing at that time, of course, was a misnomer in that it had little to do with the academic speciality embraced by most psychologists. We were merely interested in and documenting the mechanics causing injury and death in accidents. And I might add that CAB contributed enormously in those days to the understanding of human survivability factors by supplying the Flight Safety Foundation with its investigative results, who, in turn, used these statistics in their research efforts on this subject.

Over the years, the Human Factors specialist's task expanded to include the physical and physiological conditions of the crewmembers as a possible causal factor in the accident; the cabin environment as a source of injury to passengers; emergency egress problems; post-crash factors such as fire, ditching, etc. and finally the external human survival factors dealing with firefighting equipment, rescue capabilities at airports and disaster preparedness of communities.

Thus, what I have outlined here as the progression of the Human Factors task at the Safety Board is an indication of the response the Board has made over the years, as it perceives its investigation and oversight responsibilities to the public in this area.

In the last five years or so the Safety Board has been criticized in more or less regular fashion after each successive accident that the Human Facotrs investigation has not been performed properly, had been incomplete or faulty. These criticisms have stemmed from the fact that the Board often cites the crew for faulty judgment, disregard for procedures or inadequate supervision of flight, to name just a few.

I suppose we deserve some of the criticism because, after all, the Safety Board is the Federal agency responsible to determine accident causes through its investigations and to determine the best means of preventing accidents from happening. If the Board determines that the crew was to blame, it should indeed indicate the reasons for crew error and recommend ways to prevent recurrence of these errors.

In defense, let me state that we haven't exactly been sitting back and waiting for someone to give us a good idea, let alone a scientific approach towards the investigation of the human performance aspects of accident causation. We have looked at different methods and approaches over the years, and we have talked to a number of agencies, such as the Army and the Air Force. We've approached ALPA and asked for suggestions, and we've attempted a few analyses in-house on past accidents with a measure of success.

A good example of such efforts is the Board's analysis of a 1976 accident in St. Thomas, Virgin Islands, which is available for anyone who is interested in this particular analysis.

While we don't always have a clear understanding of all the factors which cause professional pilots to become involved in critical errors, we believe that with the proper tools and appropriately qualified participants, specific human behavior can be identified as it applies to accident-enabling factors and that this human behavior can be put in the context of the operational and environmental conditions in which the pilot operates.

With the help of several analytical models available from various sources, the Board has recently put together rudimentary human performance protocol which takes into account the following factors seen on the first slide here. Can I have the first slide.

(Slide.)

They represent the psycho-physiological, the environmental, and the operational/workload factors in an accident.

(Slide.)

The next slide gives a breakdown of these broad areas of investigation. For instance, on the behavioral and psychological side, we would want to examine those factors affecting the fatigue-arousal state and those producing stress levels which could affect performance. And on the medical side, we would be interested in the past and present general medical condition of the crew; their rest/sleep cycles, as well as their general physiological condition including reliance on such items as alcohol, drugs and medication.

(Slide.)

The next slide covers one of the environmental factors which we would investigate, which deals with the man-machine interface, if I may use that word, as it pertains to the equipment and design of displays.

Another environmental factor which is on the next slide concerns the cockpit environment pertaining to noise, temperature, humidity, contaminants and what have you. And it also may include other environmental conditions such as noncrewmembers in the cockpit, activities, distractions and other constraints that you can think of that may have played a role and influenced the crew.

(Previous slide.)

On the operational and workload side of the picture, we are looking at the training of the crew, their selection process, company operating procedures and management practices.

(Slide.)

Regarding workload or task, the task could be recreated in actual flight or in simulators. We could recreate the accident or the activities of the crew just prior to the accident. The familiarity of the crew with the particular task is of interest, and the sequence in which it was performed. The reception of information and the processing of this information in order to reach decisions is of interest. Specifically, we would examine the activities of each crewmember in a specific period leading up to the accident and time taken by each individual to perform each task relative to a common time base.

We believe that this approach to the investigation of the human performance aspects of accident causation will allow a rational analysis of the underlying "why's" in human performance failures.

Only recently, the Board established its first human performance group during the investigation of a Beech 99 commuter accident in Spokane, Washington.

The aircraft was being vectored for a particular approach when a wind change dictated an approach to a different runway. The airplane was vectored to intercept a localizer approach with a collocated DME.

(Slide.)

A VOR with a DME was located almost on the centerline of the localizer at about four and a half miles from the runway. The final approach fix was a 4.2 DME location from the localizer DME. The following slide shows the subject approach plate. Note the terrain or obstruction heights at the VOR and the straight-in MDA for this approach, almost identical. The aircraft impacted the ground at the final approach fix.

The aircraft was equipped with a DME/navigation mode selector four months prior to the accident which featured four push-button functions. The functions allowed selection of the DME and navigation frequency of the No. 1 navigation radio, the No. 2 navigation radio, and there was a RNAV function and a DME hold function, which is located between the No. 1 and the No. 2 NAV button.

(Slide.)

The outside environment was 400 feet scattered clouds with two miles visibility in fog. The cockpit environment was not determined regarding temperature or humidity, but we measured sound pressure levels in a sister ship which reached as high as 111 decibels at a frequency of 125 HZ in the cockpit in flight, a rather noisy cockpit.

The workload of the pilots was evaluted by actual flight tests in a sister ship after we did a time-line analysis of the ATC tapes and the conversation that had to do with this particular flight.

An exhaustive background investigation was conducted on both pilots which included all the persons with which the crew had been in contact for the last 24 hours, and their activities in the previous 72 hours were traced. The human performance group did a personality profile which included their interests, hobbies, family relations and their attitude towards flying.

We did a complete medical profile which included an extensive medical/psychological evaluation of the captain at a major airline where he had applied for a job some two years ago.

Well, since we didn't find any mechanical problems with respect to the airplane, the attention of our investigators, of course, was directed -- there was a question of why a highly experienced crew would descend to minimums in apparent violation of the final approach fix crossing altitude, which the crossing altitude, of course, is clearly depicted in the profile view of this. Some interesting aspects came to light during the investigation when several local pilots voluntarily came forward and told the investigative group about the potential for error with this particular approach when one is not familiar with the DME equipped localizer. Each of these pilots identified the final approach fix as 4.2 DME but received the DME indication from the VOR rather than from the localizer DME. Therefore, they had started to descend prematurely.

A search of NASA's Aviation Safety Reporting System revealed four incidents at various other locations in the country where confusion was reported with respect to distances from approach NAVAIDS.

Since this accident is under active investigation at this time, I am not able to discuss with you the implications of this accident. We're going to have a hearing on it early April, and for those who are interested, it's going to be in Spokane, of course. However, the issues from a human performance viewpoint are evident in the factual information I just presented. They deal with ATC system's capability to correct known potential hazards; and they deal with the human factors aspects of approach procedures specifications; and the design of approach plates; and the stress and the distractions which may unknowingly have been built into these systems, for example.

So we are rather encouraged with our first systematic attempt to delve deeper into the "why" of pilot error accidents. The task overview that I have shown for a human performance group has proven that it brings together all the elements from the Operational Group, the systems group, the ATC group and the medical group in one document which amplifies the preponderance and the direction of the evidence.

This investigation has shown that the composition of the human performance group also may be an important factor. In this case, the group was headed by an engineering psychologist who was aided by an operational specialist on the Board; and the members were the Regional Flight Surgeon of the FAA, the Director of Operations of the airline involved and an Accident Prevention Specialist of the local FAA Flight Standards District Office.

The group was purposely kept small and each member was selected for his specific expertise and specialization. And it appears desirable that the human performance group be headed by a professional who has an academic background in aviation physiology and/or psychology and who has a strong organizational talent so that the integrity of the evidence to be collected will not suffer from misplaced biases of group members.

Finally, the analysis effort of the available evidence is of the utmost importance. It cannot be an individual effort of the group leader as is the practice in other areas of the Board because the evidence is gathered over the entire spectrum of the investigation, and most if not all individuals involved have had an input into the human performance package. Therefore, it may well be necessary that the Investigator-in-Charge perhaps convene a conference of the human performance group after sometime when all the data is in in which the evidence can be discussed openly and inputs from other specialists can be solicited, so that the best interpretation of this evidence can be reached by consensus.

It is our intent to pursue this outline of investigation vigorously in the future. And we have finally gotten this program off the ground, and we would welcome any suggestions you may have to refine our efforts to reduce the human error potential in aviation.

Thank you.

MR. HAY: Now in introducing the next subject and the next speaker, I would like to preface this with one statement. The National Airspace System is a cooperative system. Up to now, we've talked about the air crewmembers. Now we have the other side of the coin, an equally important one, and the second half of the partnership in making this system operate.

In presenting the views today of the Professional Air Traffic Controllers Organization, we have with us Mike Simons. Please, Mike, if you would. The subject will be the Human Element in Air Traffic Control.

MICHAEL J. SIMONS: Thank you. Good morning. On behalf of PATCO, the Professional Air Traffic Controllers Organization, I appreciate the opportunity to speak to this Human Factors workshop on aviation. I will address myself to some of the principal issues involving the human element which are directly related to safety in the skies.

Our membership, though known primarily for its involvement in traditional labor relations issues, has always sought to focus attention on the scientific and technical aspects of the air traffic control profession. I realize that's not what you've seen a whole lot of on TV the last few days, but we are active in this side of the business as much as we are on the other side of it.

It should be stated at the outset that the United States Air Transportation System is one that every one of us in this room -- in many cases the people who make that system work -- can be proud of. A passenger airliner takes off or lands somewhere in the United States on the average of every three seconds, around the clock, every day of the year. In 1979, 318 million passengers flew a total of 256 billion passenger miles, which is some one million times the distance from here to the moon. The number of passengers carried by domestic airlines has risen 75 percent in the past decade. Virtually every one of those flights was guided from take-off to landing by highly qualified air traffic controllers and pilots.

Yet this record should not be interpreted as a commendation of the Federal Aviation Administration. That organization is charged by law with maintaining rules for the use of airspace and the operation of the air traffic control system. The airspace system functions as well as it does much more despite FAA than because of it. The present state of the system allows no room for complacency and much room for improvement.

PATCO believes that a critical problem in air traffic control today is air traffic controller staffing.

Let me try to shed some light on this from the controller's perspective. We're a low budget operation. I don't have a bunch of viewgraphs here. If anybody wants all these numbers, see me afterwards and we'll lay them out.

The FAA has done very little to cope with the rapid increase in air traffic. Air traffic control equipment has not been updated in all cases to the extent technologically feasible.

In 1974, 22.9 million en-route air traffic control operations were handled by 8,347 controllers, which is an average of 2,743.5 operations per controller. In fiscal year 1980, 30.1 million en-route operations were handled by fewer controllers: 7,785, about 400 less. This computes to an average of 3,866 operations per controller, the increase of 41 percent - number of airplanes handled by each controller in a system: 41 percent increase.

In the terminals, air traffic control towers, 8,234 controllers handled 24.1 million instrument operations in 1974, an average of 2,926.9 each. In 1980, 8,788 controllers handled 38.2 million instrument operations. This is an average of 4,347 each, an increase in per controller responsibilities of 49 percent over 7 years.

Using FAA's own numbers, the increased traffic vastly exceeded efficiency gains due to automation. In 1979, we believe en-route centers were understaffed by more than 1,500 controllers, while terminals were understaffed by more than 2,500. These figures are based on a 40-hour work week. FAA has requested funding for less than 200 new air traffic controllers for the next fiscal year. They claim to account for that difference by imposing revised staffing standards; that new standard does nothing but give the status quo an air of legitimacy.

The FAA has chosen to deal with the increased air traffic in a rather curious manner. On the one hand, they simply ignore the problem, trying to deny its existence. On the other hand, they try to make the existing controller workforce put in vast amounts of overtime, a choice which greatly shortchanges safety.

The problems inherent with overtime are obvious. The longer a controller works, the less alert he or she can be to respond to the air traffic control situations that will arise. The FAA uses this identical reasoning to restrict airline pilots to 80 flying hours per month. Yet, a pilot is responsible for the safety of several hundred lives, while at any one time, a controller at a major facility may be responsible for as many as 2,000.

Most industrialized Western nations restrict controllers to less, way less than 40 working hours per week. For instance, the scheduled controller work week is 29 hours for Euro-control, the high altitude European Air Traffic Control Service; 34 hours in Canada; 36 hours in Denmark; 37-1/2 hours in Belgium; 38 hours in Switzerland.

During fiscal year 1979 -- the most current data we have available -- the FAA used 442,294 overtime hours to keep the air traffic control system operating. Standing alone, that amount is a sign of danger. When one realizes that the FAA figure is an average which conceals the fact that overtime is not distributed at all evenly among facilities, the situation becomes alarming. At many facilities, a six-day work week is a norm.

Of at least as much concern as excess overtime is the fact that many facilities are operating far below even FAA's revised authorized staffing levels. A review of actual employment figures continuously turns up situations where facilities are operating with less than the number of authorized controllers.

To get a more accurate picture of the situation, we asked the FAA to provide us with a definition of a "critically staffed" facility and to delineate any facilities that were in this category at any time during fiscal year 1979. The FAA responded that there were no published criteria for designating a facility critically staffed.

I quote from the FAA's Southwest Region response - they wrote us on March 7 of last year as follows: "We do not maintain a criterion for declaring a facility critically staffed." They did not list any facilities as having been critically staffed at that time or during fiscal year 1979. Yet, just two days earlier, March 5, 1980, the Region, FAA Southwest Region, wrote a letter to the chief of the Plainview, Texas, Airport Traffic Control Tower stating in part: "We define critical staffing as continuing to provide all required services using all operationally qualified personnel including supervisors and staff with no reduction in service and no increase in the use of overtime."

Either we have a case of patent mismanagement in which the right hand does not know what the left is doing or else the FAA has not dealt honestly in executing its obligations to the public under the Freedom of Information Act.

The most frightening aspect of understaffing is the increased chance for errors in aircraft handling. Between 1974 and 1978, "system errors" or instances of separation failure increased 68.5 percent. One cannot isolate a single factor as the cause of this alarming upsurge. But certainly the combination of increasing traffic, chronic understaffing and frequent overtime must play a role. Anyone studying Human Factors in Air Traffic Control should give consideration to the effects, both in the long and short range of these variables.

Another result of understaffing is a shortened work life for air traffic controllers. In the four year period, 1976 through 1979 inclusive, some 89 percent, almost nine out of ten, of the air controllers who retired did so as the result of medical disqualification rather than reaching normal retirement age - 89 percent.[1] I am hard pressed to name another profession with such a staggering "burnout" rate.

The cost to the government -- and ultimately to the user -- of adequately staffing FAA facilities pales in comparison to the costs of training replacements for controllers who have their work life unnecessarily cut short.

The FAA estimated two years ago that the cost of training a person from time of entry on duty until reaching the status of full performance level air traffic controller at top facility, one of the busiest facilities, was approximately $175,000 for one person. Consider the number of additional controllers who must be brought into the system to compensate for those whose careers are needlessly ended by medical disqualifications and you have an example of colossal government waste, not to mention the squandering of trained, talented, highly skilled human lives.

While adequate staffing is an essential element of human factors in air safety, so is adequate equipment. It is axiomatic that a controller cannot perform with maximum safety and efficiency unless he has sufficient, reliable equipment to work with.

PATCO has been at the forefront in directing public attention to the alarming failure rates of FAA air traffic control computers. These complex machines form the backbone of en-route air traffic control and are located in each of the 20 domestic air route traffic control centers.

The situation has not improved significantly, despite the publicity being focused on it. Controllers are frustrated by the system which mandates their accepting responsibility for air traffic separation, while being required to use equipment which is susceptible to failure in vital situations.

During calendar year 1980, there were over 6,200 reported failures of those computers. That equates to one failure at each center on the average of once a day. The FAA would point out that only 697 of those exceeded one minute in duration, that is one percent per week. The length of time, however, that an outage lasts does not tell the entire story. The analogy has been made to a driver shutting his eyes while going 55 miles per hour down the interstate. That is a fairly dangerous condition even if it lasts only a few seconds. The driver may emerge unscathed, but the odds certainly do not favor it. And with mutliple high performance aircraft, the domino effect is something one just would not want to contemplate.

FAA "system error" reports confirm that the most dangerous aspect of the computer failure is the transition to the backup, or broadband, radar system. This time consuming and distracting process requires the controller to physically move his radar scope from the vertical horizontal position, then to write up a small plastic chip, known as a shrimpboat, for each target and then to re-confirm the identity of each aircraft under his control.

It is during this transition process that the most separation failures occur. To streamline the process and to eliminate the need for antiquated broadband radar, the FAA contracted for a new backup system known as the Direct Access Radar Channel or DARC. D-A-R-C.

DARC is presently being commissioned at the 20 centers, over a year behind schedule. It has already cost, according to a recent report by the Investigations Staff of The U.S. Senate Committee on Appropriations, about twice the $11 million contracted for, and the FAA foresees spending as much as another hundred million to give it all the capabilities which were originally advertised.

DARC may have the potential of being a significant improvement over broadband. Time will tell. But at present it has severe shortcomings. To use DARC, the controller must physically move the scope, the radar scope, to the horizontal position and must write a shripmboat for each aircraft just as with the transition to broadband. Also, an individual controller cannot revert to DARC when his RDP fails, his radar fails; several sectors or the entire center must switch in unison.

Despite the lack of reliable computers and adequate backup systems, the FAA maintains that it is not planning to replace the current generation of air traffic control computers until 1990.

PATCO fervently believes that an expedited planning process for the next generation of computers should begin today. The state of the computers and support systems is only the latest manifestation of the FAA's unwillingness or inability to engage in realistic long range planning activities. We are deeply concerned about the potential for the replacement en-route computer system to turn into another trouble-fraught fiasco as the DARC has been.

Before closing I would like to briefly mention one of the more positive developments recently seen in air traffic control technology. It now appears to be within grasp to provide a real time depiction of National Weather Service color weather radar showing the six levels of thunderstorm activity directly at each air traffic control sector, each control position in a center. The availability of such information would be a very valuable tool in helping the controller to provide assistance to pilots attempting to navigate around severe weather. We urge that the FAA devote efforts to expeditiously develop this capability and make weather radar available at each sector in the very near future.

In closing, I would like to reiterate the following key points:

1. Air traffic control system planners must provide for controller staffing commensurate with the increased amount of traffic in the system.

2. The excessive use of overtime leads to unnecessarily stressful working conditions.

3. The combination of chronic understaffing and excessive use of overtime leads to artificially shortened controller work lives and extremely high costs for replacing and training personnel.

4. An expedited planning process for the next generation of air traffic control computers should begin now with a view toward bringing the system on line well ahead of 1990.

5. Priority should be given to implementing a real time weather radar presentation at every control sector.

I look forward to discussing some of these things with you, talking about them more in the discussion groups here tomorrow.

Thank you.

MR. HAY: Mike is the first speaker here today who will be a group leader in one of the five discussion workshops tomorrow. Guice Tinsley will provide more insight into that in his discussion later on today. We look foward to the specifics and the recommendations of that group at its completion tomorrow afternoon.

Before introducing the next speaker, Derek Ruben, I would like to recognize the fact that we have today Reggie Furlong and Lancelot Dasou; Reggie from the British Embassy and Lancelot Dasou from the French Embassy; and we appreciate their participation today and their help and counseling they have given us throughout the past several years on this subject. With that in mind, I would like to introduce now Derek Ruben from the British Civil Aviation Authority Airworthiness Division in the United Kingdom; and his discussion will be on the Civil Aircarft Airworthiness Data Recording Programme that I'm sure we've all seen on the most recent British broadcasting system, public broadcasting system piece, which is a very good one.

Derek, would you please.

DEREK RUBEN: Thank you. Good morning. The purpose of my talk today is to describe to you the work that is going on in the U.K. on the data recording. And as you've heard, it is called the Civil Aircraft Airworthiness Data Recording Programme; and that takes far too long to say, so we tend to refer to it by the initials. Let me call it CAADRP.

Now the first thing to say about CAADRP is that it is a co-operative program between ourselves and the participating airlines. And when I say "co-operating," I mean in all respects co-operating on the contents of the program, on the conduct of the program and on the cost of the program.

Now this data recording program has been running since 1962 in the U.K., but I don't think I'll bother you with the history but come straight on with the present day activity as it now is and describe that to you.

In the course of the years that the program has been running, we have, from time to time, taken a fairly sharp look on what we're doing and how we're doing it and to see whether we're going in the right direction. And quite recently, we took such a look, and I was asked to write down the -- or restate the objectives of the program. And what I came up with was the objectives are to collect operational data for the following purposes:

1. To detect persistent exceedence as a limitation and suggest remedial action.

2. To detect unusual behavior which could be hazardous. And when I wrote that, I was talking about the behavior of the airplane and not of the crew.

3. To identify potential problem areas.

4. To provide backup data for specific investigations; firstly, in seeking solutions to problems; secondly, in supporting requirement activity. And

5. To support programs of research and problems having operational content.

So those are the objectives, and I'll try to explain to you how we think we fulfill them.

By far the greatest bulk of our data comes from British Airways, and there are other airlines which I shall mention. So I think the best thing is to describe to you the program that we run with British Airways.

On all the aircraft involved in the program, the data doesn't come from the crash recorder but comes from a recorder which runs in parallel with the crash recorder, which takes its data from the same data management unit as feeds the crash recorder, but which on various aircraft includes additional information over and above what goes on to the crash recorder. We do not look at the copy of the crash recorder.

These secondary recorders are all fitted with quick access cassettes for the short-haul airplanes like the Trident and BAC1-11's and so on. The cassette duration is about seven hours. And for the long-haul airplanes, B-747's, the duration of the cassette is about 50 hours. And the recorders are not the same equipment on those two sorts of airplanes. And for the short-haul airplanes, the crew carry the cassette out to the airplane and insert it into the reco· er, which is on the flight deck. And similarly, they bring it back when they return to London.

The long-haul airplanes, the cassettes are in fact not quite so accessible. They are larger and they are fitted by ground engineers. For airplanes that are away from base for long periods of time, days on end, arrangements are made for cassettes to be fitted and arrangements are made for the cassettes to get back to London. I don't think we need to bother here about the logistics of how we actually get all the cassettes back to London. Suffice it to say they get back, at least most of them do. We always lose a few. Now that's how we collect the data. When it gets back to London, the cassettes are all taken to the British Airways Station Handling Department, which reads the cassettes; so I'll give you now a brief description of how we handle the data and explain how we got into our present position. In all to do this, I have to go back a little bit into history.

When this program started in 1962, we were using analog recorders on about four airplanes, and these recorders ran and produced full flight data and the rolls of paper with about 12 parameters on them were scanned manually by a number of people from the CAA, and they were scanned with a view to looking for what we chose to call "Special Events."

A special event was not clearly defined. It was anything which the person who was looking at the data saw as being out of the ordinary, interesting or hazardous or requiring explanation. And inevitably, there was a certain amount of individuality in what people found. And at that time if one flight record was scanned by two different scrutineers, I think they found things would have been quite different. But we did learn after a while to put some numbers to some of these things we were looking at. For example, there's always a g spike when an airplane touches down, and it was a fairly simple matter to produce a rule that says that if the g spike exceeded some given value, then that would be regarded as a special event, and other similar things like high descent rate close to the ground or large bank angles close to the ground. You could quantify what we thought was a special event and that produced some degree of uniformity.

And then in 1966, the law required that all airplanes carry crash recorders. And British Airways at that time elected to use digital recorders to meet the legal requirement. And at the same time, they elected to fit these quick access cassette recorders in parallel with the crash recorders. Now this meant that fairly quickly the number of airplanes that we were dealing with went up from four to the whole of what was then the British European Airways fleet, and scanning these records manually was totally an impractical proposition. But fortunately, one of the advantages that you have with digital data is that you can scan it by computer. But if you are going to scan it by computer, you have to tell the computer what to look for. And it was in this context that we were able to lean on the experience that we've gained with the analog recorders. And we were able to define a series of special events, which the recorders could search for.

And the sorts of things we were looking for, just to name a few examples, flap limit speed exceeded by ten knots or more for two seconds or longer is a special event. An excessive take-off run greater than 85 percent of available take-off run is a special event. An approach speed less than Velocity-at-Touchdown minus 5 knots (VAT-5), and we defined in all about 100 events. Now these definitions are completely arbitrary, but they are agreed with the operators; and they are continuously reviewed. And, in fact, the search program that we are currently running is at Issue 12, which might lead you to believe that we change our minds fairly frequently. But I hope it means that we are learning continuously by our experience. So that is how the data is collected and that's how it's analyzed. At least, that's how we get it.

But having told you how we collect it, I must tell you how we deal with the output from the computers, so I first need to describe what the computer output consists of. Each time the computer sees a special event, it produces an analog trace on a Versatec Printer for a period from two minutes before the event to two minutes after the event. And this analog contains not all the data that's on the recorder but only certain selected parameters, which I think are fairly obvious, that we have chosen: things like speed, height, heading bank angle attitude, g, etc. If we tried to put all the data on the analog, it would get far too confusing. And the analog which is produced also has a header on it, which contains all the information relative to the flight. It has a flight number, the sector, aircraft registration, the time, the weight, etc. And I have some here which -- just to show you what they look like. That's the analog, the headed data is there and the traces are there. There's also a number of discrete signals such as gear position, autopilot and auto-flight status and that sort of thing. So on that piece of paper, we have a fairly comprehensive story about the event as it occurred. And should we require the total information that was on the recorder, this is always available and it is produced in the form of data listings, which come out in engineering units. And they can obtain all the data that is on the recorder.

And now the Special Event Search Program that I mentioned searches two levels. For example, if the approach speed is below the VAT-5 during the last two minutes to touchdown, then an event is detected; but if the speed falls below VAT-10, then the event is classified as being at alert level. And this is automatically picked up on the header. And there are certain events where the detect and alert level are the same.

Now the treatment given to the two levels of event is different. Events which are detected at a lower level are simply recorded in a data bank and provide a body of data on which we can do the statistical analyses of various sorts to indicate trends, to highlight areas where in the course of normal operations, safety margins have been eroded to a degree which has not been recognized or allowed for in the course of certification. Or there are other areas of concern that we can look at related to particular aircraft systems or related even to particular airfields.

The alert events are treated slightly differently, and they are, of course, included in the data bank as part of the statistics. But they are looked at rather more closely. And in the first instance, they are reviewed by a body in the airline, which consists of senior airline pilots of the flight manager levels and flight safety engineers. And they examine in detail the alert events and where individual events are unclear and the opinion of the pilot is desirable. Then the pilot can be asked for his, any information on that incident; and this is done through the British Airline Pilots' Association (BALPA), and it's done with their, obviously, with their cooperation.

And British Airways have issued a bulletin to, a flight crew information bulletin which describes the program for the benefit of aircrews and tells them just exactly how the data is treated.

I just want to read you a couple of brief extracts from that bulletin. It says, "The Group -- and that is the group I just described of flight managers, etc. -- looks at individual events of potentially special interest; and in these cases, it is obvious that the pilots' comments can be most important." And here is the most important statement, I think. "At all times the crew's anonymity is strictly protected and the date or registration of a particular flight is not made known to the Group. However, at this stage the BALPA representative is given the necessary information to enable him to contact the service captain. It should be emphasized that these queries are intended to be 'inquisitive' and not 'accusative'." And I think British Airways' record is very good. They haven't actually ever used flight recorder data to accuse a pilot.

The Group discusses various matters. The fact that a subject is discussed doesn't necessarily mean there is a problem. These discussions are initially determined whether or not procedure is good or could be improved. Some such discussions in 1980 were on rotation techniques, operation in strong surface winds, windshear, flight management systems and behavior patterns of some autopilots. And as a result, various flight crew notices are being issued to the relevant crews.

Now to give you some idea of the scale of the operation -- I don't want to blind you with numbers, but the number of airplanes involved is about 160 including about ten different types flying around 175,000 flights per annum. And we are scanning about 70 percent of them.

Now the frequency with which events occur, obviously, depends on the levels at which you set the detection system; and the alert levels are occurring, at the moment, at about 150 a month. And it's clearly not possible to devote very much time to 150 events per month. But fortunately, a fairly large number of these can be fairly quickly dismissed as operational quirks which doesn't significantly hazard the airplane, and this leaves a manageable number to be discussed by the body of pilots.

The statistical analyses and data studies, which I referred to earlier, are carried out by the CAA. And for the most part, we do them in-house; but when necessary, we have to go to a computer bureau if we need computer facilities because we don't have much in the way of computers ourselves. The CAA also studies individual events or groups of events, groups of similar events which are of airworthiness or operational significance. This work is carried out by a panel which is made up of active airline pilots, airline flight safety engineers, data processing engineers, structures and aerodynamics experts from the Royal Aircraft Establishment, an aviation specialist from the MET Office, a representative from the Data Handling Bureau and the CAA involved in the program. And where necessary, we can bring in the equipment and aircraft manufacturers into the discussion and also bring our own particular individual specialists in. Now that all relates to British Airways, I should just briefly mention British Caledonian's part of the program.

They joined in the program some years ago with their BAC1-11 aircraft, but now their total contribution comes from their DC-10's, and it's restricted to a total of 4,000 hours per annum. And this restriction is purely a financial one. We split the cost between us. That's about as much as we can afford. The British Caledonian doesn't have their own data processing facilities, so what they do is send their cassettes to a bureau who transfer the contents of the cassette on to mag tape; and from mag tape re-format it in the process. And from the mag tape, they produce analog pictures of the whole content of the cassette. And these analogs are scanned manually by the CAA, so we are back to manual scanning for British Caledonian. But there are always pros and cons.

And manual scanning can't find all the sorts of events that we can define and find by computer because time just doesn't permit; but you can see events which the computer would not find simply because you haven't defined them. And there was a classic incident a little while back, actually on the British Airways Tristar, where, in quite a large upset maneuver at high altitude, one which caused the crew to have lots of adrenalin pumped around, not a single CAADRP event was triggered despite the fact that they were diving frantically at one time with throttles closed and airbrakes out. And a few seconds later, they were going uphill very rapidly. But they were just inside all the limits that we had set. So there are advantages to manual scanning because that is something that we would have picked up by looking on the analog trace.

Now having collected all this data and stored it in computers and discussed it in committees and working panels and so on, what good does it do us? Well, this really is the $64,000 question and that's an underestimate. There is no way in which we can know whether the steps that we've taken had, in fact, produced any reduction in accidents or have succeeded in avoiding any accidents. Our success is measured by accidents which don't happen and that is something which we can't measure, so we have to have a bit of faith. But I think we can, in fact, be rather more positive than that. On quite a number of occasions, flight procedures have been released to eliminate particular problems. For example, speed loss on noise abatement power reduction was a problem on one airplane where the speeds were falling to a dangerously low level relative to the storm. And this problem was seen through CAADRP program. A revision to the flight procedures resulted in this problem disappearing. And similarly, the other end of the speed range, there was an aircraft which was frequently exceeding Mmo shortly after top of descent. And again a fairly small revision to the flight procedures eliminated the problems.

Sometimes a repetitive event, which taken individually may not seem significant, can be a cause for concern. There was one airplane on which the frequency with which hard landings were occurring drew attention and we did a detailed investigation of the causes. And as a result, steps to improve the situation were indicated and some insight was gained into the way in which this event was occurring. And we're still working on that, and it may eventually lead to some revision of undercarriage loading requirements.

And another example: the safety equipment such as the stick shakers and GPW. The boundaries for those sorts of equipment have been assessed using the operational data to show the frequencies with which the warnings would occur; and this enables us to set the levels correctly such that the warning occurred in time but didn't occur so frequently as to invalidate its use.

Now there is one further quite important use that we make of flight age recording, which I think I ought to mention. And that is, we use it as a certification tool. Now that may sound a little odd because we're talking about operational recording, which always happens after certification and on properly certificated airplanes, but in some cases we have made the provision of recorded operational data a condition of certification. Now we have done this when in a course of certification we necessarily had to make certain assumptions how the airplane would behave in operation. For example, on Concorde, the speed control during approach was thought to be much better than on conventional airplanes, and this resulted in what was thought to result in a smaller standard deviation of speed error on the approach. And obviosuly, this affected schedule speeds and distances. And the only way we could confirm this was to measure what actually happened in service, so we made the obvious provision that the scheduled figures might need to be revised in the light of the evidence provided by the flight recorders. And more recently, we have been concerned to justify some of the assumptions that have been made on the active control Tristar on behavior of the load relieving system in turbulent conditions. And for this purpose we are again collecting data on all turbulence encounters on that airplane, and that data will be subjected to a specific and detailed analysis which has been agreed with the manufacturer.

So to summarize, I think our aim, as is everybody's aim, is to achieve an improvement in safety levels. And this achievement is hoped for by cooperative action between the operators, the aircrews and ourselves.

Now I'm conscious that what I have been describing is not addressing itself to Human Factors problems directly, and we haven't in the past - sort of using this data in that context; but I think it's fairly clear from the experience that we've had that there are some clues in the data to Human Factors sort of problems. And it's my opinion that the addition of cockpit voice recorder data to supplement what's seen on the flight recorder would enhance the value of those clues quite considerably. And if the FAA program goes ahead for collecting flight recorder data, we would certainly be very happy to cooperate with them, exchange ideas and exchange data. And hopefully between us do something to improve safety.

Thank you.

MR. HAY: I'm told that the lunch room is ready for us. We will reconvene at 1:30. Thank you for the morning. We will see you at 1:30.

(Lunchbreak taken.)

SESSION 2
(March 18, 1981)

(Wednesday, March 18, 1981, commencing at 1:30 p.m.)

MR. HAY: Well, we'll begin the afternoon session now.

I would like to mention the following point: that we've tried from the FAA standpoint to demonstrate throughout the two previous workshops and are again striving to the best of our ability - and with your help I know we'll do it through the third workshop - to develop as much an open discussion and attitude concerning all of the issues as is possible to do. Now, "as is possible" is dependent upon your attention to input and your contributions that you make to us. All of these matters, we can assure you, will become a matter of record and will be available for all to review after these workshops have ended.

This afternoon we have five speakers: the United States Army is represented by Major Tom Frezell; Dr. Lloyd Hitchcock representing the Navy at this point; Captain Bill Connor, a Delta Captain, representing Embry Riddle Aeronautical University; and Karl Anderson and Don Thielke representing the Flight Engineers International Association.

So we'll move right ahead. And I'll introduce at this time Major Tom Frezell, Aberdeen Proving Grounds, U.S. Army. He will speak on the United States Army Human Engineering Lab and their Human Engineering efforts in varied aviation programs.

If you would, Tom.

MAJOR THOMAS FREZELL: May I have the first slide, please. We always get our logo up here first to show where we're from in case we forget.

I represent the United States Army, Human Engineering Laboratory located at Aberdeen Proving Grounds, Maryland.

We are the primary focus for the Army as far as Human Engineering is concerned, although there are several other labs that delve into peculiar issues of Human Engineering as far as medical and aerospace medicine engineering down at United States Army Aeromedical Research Laboratories at Fort Rucker.

Next slide, please. Basically, a wiring diagram is just one of the efforts within the Human Engineering Lab there. The Aviation Air Defense right at the

the bottom. We have several other branches there that deal with specific applications of Human Engineering within certain commodity areas within the Army. We're not a developer, just an applications manager as far as the Human Engineering effort is concerned, as far as new products and integration of efforts into existing products.

Next slide, please. This is a slide that we stole from the Army Research Institute. As far as basically the way the mission flows is, can this soldier with this training perform these tasks on this equipment? And equipment design, it basically circles on back through the personnel side.

Next slide, please. Our methodology, in the lab, develops from a paper analysis through a simulation phase. This was a GAT Simulator, Helicopter Operational Simulator, that we initially used for integration of a single arm controller, not side arm; and then it was integrated into an existing helicopter that flew quite a few years ago.

Next slide, please. This is one of our test bed aircraft. This being a UH-1 Helicopter that's fully instrumented. You can see some of the instrumentation in the back. It's palletized to go in and out. It records 20 Channels of information. That is, in turn, digitized and brought back into the laboratory for on-line analysis. We've looked at telemetry for in-flight analysis there. Our problem there is that on some of the flight altitudes we operate in, we find the Telemetering System there does not work. We exceed its capability.

Next slide, please. Another instrumented aircraft we use is OH-58, better known as a Jet Ranger. It's also fully instrumented, and at one time it was set up as an integrated flight control aircraft. The collective and cyclic was integrated into one control. This is the most advanced aircraft in the Army - the AAH - Advanced Attack Helicopter. And it's the most advanced effort as far as integration of CRT Display Technology is concerned, as far as the Army is concerned. This is still a prototype aircraft to replace the AH-1 Cobra. And the program for the AH is managed by Major General Brown with the test integration of that aircraft and its weapon system being conducted at Human Proving Grounds.

Next slide. Next slide, please. This is -- what we see is part of the problems that face our laboratory as far as flight integration there. We have flight control task loading, communication and communication handoff being a major problem, low visibility flight at very low altitudes, often amongst the terrain, the emergency procedures, navigation, crew coordination and visual free time.

Next slide, please. In electro-optic (EO) display technology we actually look at three areas currently. Those involve HUDs, Head Up Display, The panel-mounted-display, as discussed earlier here, being either electro-luminescent flat plate or CRT; and in the AAH currently being flown is the helmet-mounted display, which is the CRT tube mounted on the pilot's helmet that's projected on a partially silvered mirror approximately an inch and a half in front of his eye that we display all flight parameters on; also, weapon systems, status modes, hover symbology and several other modes. It's also integrated into the pilot's night visual system, the PNVS. That is currently being flown on the AAH.

Next slide, please. Basically, this was almost a copy of a slide we saw from Dr. Bertone this morning of the helicopter cockpit as far as what multi-function displays and controls will do for cleaning up the helicopter cockpit. The current instrumentation that we have in helicopters, the majority are just carried over from old fix-winged days. And they don't take into consideration in many instances the six degrees of freedom that were offered in the helicopter flight mode.

Next slide. Our integration efforts in the lab include -- these are just some of the others that we talked about, IACS, Integrated Avionics Control System, which is 15.53 compatible at Digital Avionics System presented on a CRT. We have some unique functions in that it provides us a secure mode in each one of our radio operation sets as well as the transponder. The Advanced Digital Avionics System which IACS will eventually become a part of -- and I note Dr. Strother had worked with that at Bell Helicopter -- the ADOCS Control System that was mentioned earlier this morning, Advanced Digital Optical Control System, basically one step beyond the fly-by-wire system. The EMMAD System that I'll discuss later, Electronic Master Monitor and Advisory Display System, which, basically -- there's an excellent report out in regards to this entitled "Evaluation of Factors Unique to Multi-Function Controls Displays." I think it's a joint report from Bunker Ramo in the Air Force Lab: by Calhoun, Hernin, Rising and Bateman.

As far as types of logic concerned with this, whether it be branching logic or tailored logic - tailored logic being it's already preprogrammed and set up for based on that mission phase. Those things that would normally be required are automatically presented versus a branching logic situation where you have to function down manually through different sets of logic to re-tune a radio or to bring up some specific system if you received, let's say, a caution or a warning about that system. You then have to function to bring that system up on line on view.

The Aircraft Performance Indicator, that was also discussed earlier. It's also termed at times, Left Margin Indicator, to give a pilot an idea especially on cargo-type helicopters exactly how much power or how much load capacity he can take on based on all existing conditions. That being environmental and aircraft status conditions taking into account the health of the engine - the engine's health, the engine status, the transmission and temperature, density, altitude and the rest all integrated in giving him the exact figure as far as what his performance is. That display of navigation systems that I work primarily in.

Next slide. This is a picture of one of the IACS Control Heads. You can see that -- you can function with a rotary switch there through the different radios through FM, two FMs, UHF, IDF and also Status Panels.

One of the things -- this required a branching-type logic there. And as you can see from the display -- you can only list part of your radio systems there. And you also have the capability to put ten preset frequencies into each radio set including your transponder and VOR.

One of the problems is that you can only display four of them at a time. So, if you wanted to see what was on FM-2, you'd have to then key over to the next page, the menu-page selection on this to go to that radio. If you wanted to change the frequency on that radio, you would then have to page to the logic system down to that radio and insert a frequency if you had not had it previously programmed in.

This was flown. This was installed on a UH-1 by ECOM at Fort Monmouth. And we took it for a test flight in what we considered one of the real high density areas. They have a low-level helicopter corridor that runs into Washington and the Pentagon up through National Airport, just below it.

What we would do, we would fly it in there at peak hours, peak-traffic control hours. There are twenty some odd frequency changes from Aberdeen over through Washington that are required; and also set it up in a simulation effort programmed on a display in the laboratory along with conventional radios, did a time-line analysis. And the findings were 20 percent time savings on this system versus conventional radio system as far as tuning, identifying and talking on radios, giving a true mission analysis.

Next slide. This is, basically, a schematic here of a panel savings. If IACS was integrated in there the colored portions -- this was in a Cobra -- show you the areas that contain radios. Now, that could be dropped out given that IACS was integrated to take the place of those radios, of the control heads themselves.

Next slide. This was a slide on EMMADS, Electronic Master Monitor System. This was basically discussed this morning. And right now we're looking at this as far as voice interactive display. In other words, it projects -- this being a checklist, a start checklist; and then instead of responding manually to it to show that each one of these functions had been performed, our effort is just looking to see how effective a voice interaction effort, based on helicopter noise, taking that into consideration and making the computer smart enough to recognize the pilot's voice above the ambient noise level that's created within that aircraft.

It doesn't sound like it would be too hard. But any of you that have ever worked in this area, the ambient noise within an aircraft and the frequency ranges encountered there along with the combo systems we used, which are basically noise canceling microphones that have been developed to highlight or emphasize those areas of human speech where the microphone, in turn, cancels out other noise, extraneous noise there, it becomes a very difficult task.

Next slide, please. This was an automatic map reader that I tested several months ago. This has been flight tested. It was hooked in on board a helicopter map of the earth navigation through a doppler navigation system there. This was set up to take a standard map. This one was programmed for three sizes, one to 50K, one to 100K and one to 250K, I believe.

Basically, it indicates present position. There are two plastic disc panels on there etched. One with a straight line, one with a semi-circular line. Intersection of these two lines indicates your present position in that function mode. Your present position is also annotated with 8-digit grid coordinates located at the top. And these change the function of this doppler input. We found, basically, no error in this system other than that generated by the doppler system. It has a built-in memory system that enables you to slew manually any position within this map area. In turn, read those coordinates in one of two memories, which, I think, on this prototype model had 16 memory functions in each one. And then, in turn, it will automatically keep up with your flight tracking mode and return to that once you select present position and go back there.

Also, as you reach the edge of a map area, within memory, if you have to pull the map out, refold it or insert another map it will continue to track. All you'll have to do is make sure that the area that you -- the part of the map is on the new sectional that you put in there. And it will automatically update itself based on distance and time of travel that you were there.

One of the interesting features that we found in this device was: number one, its cost over projected map displays; and number two, the light-weight utility. There's nothing that has to be permanently installed in the aircraft. This could come out and go back into the briefing room for updating the tactical situation prior to that. If the aircraft down system isn't lost to the rest of the inventory it can be placed in another aircraft.

Next slide, please. This poor slide attempting to show probably the future of navigation and mapping. It's being worked on at Fort Monmouth and is the digital map display. That is, digitizing current existing sheet maps from Defense Mapping Agency or from U.S. Coast & Geodetic Survey and then presenting them in a digital format and highlighting certain features.

Next slide, please. These didn't turn out that well. This is a digitized portion of a map showing a topo picture of it. There's an arrow right here; and basically, it's pointing to a hill. I don't have my slides out of order, we can see what that looks like in a plainer view based on your absolute altitude that's encoded into the digital system.

Next slide, please. Next slide, please. That's that hillside from the hill that you viewed on the other map, basically showing your relation to that hill there. That can be functioned out of the digital display based on your input from aircraft either on an absolute or barometric altimeter.

Next slide, please. This is contrast in gray with terrain relief pictured on some hills.

Next slide, please. This being the same shot on a colored imagery with Military symbology overlayed with the current tactical situation, which I know doesn't really affect most of the people in here; but on the same hand, it would be no harder to overlay your airports or VORs or other significant navigation features on there either.

Next slide. That's it. Thank you very much for your attention, and I'll welcome any questions you have after the briefing.

MR. HAY: In introducing Dr. Lloyd Hitchcock, I have one small anecdote. I'm sure the Navy won't mind me saying this. But when we called the Navy to have an input from them they said, the most knowledgeable person in this area you've just hired away from us. You get him and we'll support whatever he says.

So, with that, I think that holds for a very good reputation. Dr. Lloyd Hitchcock, please.

DR. LLOYD HITCHCOCK: Thank you, Cliff. I do feel a little bit awkward in making this presentation. As Cliff says, I am very much the new kid on the block and here I am right off talking about the old neighborhood.

But I'll try to be as brief as I can. I recognize I'm working the siesta shift. So, let's get with it.

May I have the first viewgraph, please. Navy Aviation Human Factors Research and Development Program is concerned with solving the primary problems in Human Engineering within the Navy as assessed by the Human Engineering Community and Chief of Naval Operations. In terms of how severe these problems are, several years ago the Navy Safety Center at Norfolk was requested to survey Human Engineering problems in but a single area, controls, displays within Navy Aircraft and their contributions to accidents within the Navy Aviation Community for a period of five years.

Essentially, they looked at pilot error accidents and only included in the survey those that were obviously related to design and instrumentation, deficiency-induced errors. The results, significant numbers of aircraft lost, related to this particular problem.

In terms of a more meaningful sense, what does this mean operationally? Look at what the Navy has suffered as a result of cockpit design deficiencies. When we're looking at six F-4 Squadrons, three A-4 Squadrons, etc., etc., and an airwing of men, we're talking about a significant reduction in operational capability directly related to Human Engineering problems.

What has the Navy been doing about it? In the basic research area, the 6.1 area, we're attempting to develop new techniques and methodology to make more effective the interaction between the Human Engineering Community and those elements of the Naval procurement system that are procuring, designing, developing the equipment that the Naval Aviator will have to work with.

In the exploratory development area, taking the basic information techniques, using them to be evaluated for their true effectiveness in the operational community involved in these kinds of activities.

The development o. new display concepts, this is the AIDS, Advanced Integrated Display System, the old AMOS System of the Navy. And it has been involved with the presentation of flight data, new techniques for the input of information into the control context. How do we introduce numeric data? How do we select functions? Modes? Using CRTs as a new model input technique, evaluating those techniques and approaches.

The payoff for this kind of work shows up in aircraft such as the F-18. The F-18 had to go to advanced display techniques - not because the Navy was extremely far-sighted and imaginative but because they had no choice.

We look at the number of square inches of panel space in the F-4, 1750. We look at the number of square inches of panel space, console space, in the A-7, 1450. Then we look at the F-18, 1850. The F-18 operationally was designated to do the job of the F-4 and the A-7.

With new techniques in computation, new techniques in navigation, and information transfer, in spite of the fact that the panel space has gone down significantly, the information requirements have more than doubled. There is no way that you are going to shovel all of the conventional, dedicated instrumentation associated with the F-4 Mission and the A-7 Mission into a cockpit of the F-18 size. You're going to have to go to new techniques.

The techniques that have been developed in the Navy, although they did not supplant or serve as the exact techniques that went into the F-18, provided the background, the exploratory development, the justification validation of the approaches which the Navy relied upon in justifying to Congress its new approach to the development of the F-18 cockpit, which you see here in markup.

We are currently doing the same sort of work to provide the preliminary justification for new approaches for the anti-submarine warfare and patrol aircraft community.

Here you see a markup which would be roughly for an aircraft the equivalent of an S-3. And this shows the tactical approach on the right and new flight approaches and displays on the left.

We are doing a good deal of work in the development of new display concepts. On the left you have an old Lear concept. I believe it came out in 1958. You'll notice the flight path display in the center. On the right you see a flight path display photographed from a television screen. That was done in 1978. It only took us 20 years to perfect the technology necessary to actually implement the concept that came out in 1958. We have these new techniques. For many, many years those of us in crew station design wandered around saying, "There must be a better way." And looking at the 1917 steam gages and aircraft and repeating, "There must be a better way." It almost became a litany. We kept saying it over and over and lost meaning for it.

Then one day our good friends in display design came in with their large-scale integrated circuits and their micro-miniaturized signal processors and symbol generators and said, "here's the better way. What do we want to do with it?" And we felt a significant breeze between our belts and our knees because we were caught with our pants down. We hadn't really thought about how we would use this new capability. We're trying to rectify that and work into some new concepts now.

This is a concept for displaying instrument presentation of thrust in a twin engine, high performance aircraft. In the center you see the starboard engine almost up to full thrust and the port engine just starting to power up. On the left it is more power, higher RPM. You see the triangle is growing.

Here we have both engines almost up to speed. When both engines do reach 100 percent thrust or more the two triangles merge and are painted a solid green. Thus, a pilot on a catapult awaiting launch would only have to perceive a green triangle in the periphery of his vision to confirm that he has adequate power for launch.

Would you show the other one, too? This is a new concept again for monitoring engine performance. In this case the various parameters are so scaled so that out-of-tolerance readings coincide with the dash lines, either high tolerance or low tolerance. When a parameter is out of tolerance it shifts to red. We also recognize that there are occasions when perturbations in a parameter, even though they do not go beyond tolerance, represent a critical position. That can be shown as it is in the center of this display by a ribbed painting with the word FLUX.

We also compare the presentation of such a display in color with its counterpart in black and white on the left.

This represents innovations on this kind of display. We recognize that there are parameters which can go out of tolerance and still not be a critical situation. They are critical only if they are out of tolerance beyond a certain period of time.

In this particular mechanization there are 15 vertical lines painting those bars. You'll notice the bar on the left is out of tolerance. It may remain out of tolerance for a period of time. Each one-fifteenth of the time that is available in tolerance, one of the green lines goes to yellow. When the last line is to be painted yellow, then the whole display turns to red. This gives us a method of portraying something we have not been able to portray before. And that is the time criticality of parameters that are out of tolerance.

In the Advanced Development Area we are working with voice interactive systems technology for test and evaluation and something I'll mention a little more about, Computer-Assisted Methods for Human Factors Engineering Design and Evaluation.

We are working the area of designing decision augmentation systems, working toward-not automation because the Navy does not really consider automation a reasonable goal. We're looking toward augmentation or synthesis or interaction, where we are trying to design the computer to work with the operator - not to supplant the operator.

The Navy has developed a technique of Computer Simulation of Operator Situations, the Human Operator Simulator or HOS. This has been used very effectively in comparatively evaluating prior to even significant drawing effort, new crew stations which are proposed for various uses in Navy Aircraft.

One of the techniques for assisting in cockpit design and the evaluation of contractor efforts and cockpit design is a technique called CUBITS. CUBITS is derived from the combination of BITS of information, Criticality and Utilization.

Basically, it is to handle the problem, which I don't know whether it exists or not in civil aviation, but it certainly does in Military. Crew stations tend to be designed on a first-come first-serve basis. The guy who gets there with a panel drawing first gets all the space he wants. And the people who come later get progressively less console and panel space simply because they didn't show up soon enough.

In short, the stability augmentation panel, three-toggle switch, is pitch role; and "on and off" is usually designed by the time the program manager gets through with his greetings for the kickoff meeting for the project.

The radar panel, which has 97 functions, mostly interactive, very difficult to design, doesn't come in for 18 months later. The stability augmentation panel gets 5½ inches because there's unlimited space when he shows up. The radar panel, he has 3½ inches because that's all that's left by the time he gets there.

Basically, this approach is to a priori allocate real estate, in a more realistic way to accomplish the objectives that we have.

First, the communication between the man and machine is broken down into standard information theory units, BITS. Obviously, a toggle switch, on/off would have one bit of information. We rather arbitrarily reduce the continuous displays and controls into bit units, but it seemed to work fairly well even though it was arbitrary in origin.

We weigh the number of bits associated with a subsystem on the basis of how frequently they are used and whether or not their use is mission critical or safety-of-flight critical or really rather irrelevant to the circumstances of the system at the time.

When we then take the CUBITS, the weighed information associated with each subsystem, and add it up and then divide the total or divide that by the total, you see that we now have a markedly different allocation of real estate. In other words, System B now has 49 percent of the real estate because it has 49 percent of the assumed man-machine communication. That's its responsibility.

Similarly, the other subsystems are proportionately allocated real estate. We found this to be a very effective technique. For one reason, the engineering people we deal with seem to understand it, accept it, and are willing to work within its limitations. And as a consequence, it is extremely useful in establishing the basic ground rules even before system design begins.

Another technique that was mentioned this morning is the Crew Station Assessment of Reach, the CAR Technique. This is based upon a -- you can flop it, but it doesn't really matter -- based upon a very simplified technique of assumptions regarding body links within the human operator. It is very simple to use. All that is required is an X, Y, Z coordinate in aircraft terms, which are very easily derived from the drawings or the contractor's computer. This is supplemented with a description of the design eye point and X, Y, Z coordinates and a description of how each control of interest is going to be operated, whether it is with clenched hand, fingertip or extended finger.

Each control is described by name, method of actuation, type of actuation and circumstance under which it will be used, whether it will be zone one, arms locked, zone two, stretch, zone three, unrestrained.

The output of the program is a percentage readout of the number of operators that should be able to activate that control under the specified circumstances.

Now, this population is drawn from a sample of hypothetical pilots which is derived from the 1964 rendition of the anthropometry of Naval Aviators.

Essentially, a program has been written which uses the means, standard deviations and intercorrelations between the body links derived from that study. It uses a modified Monte Carlo sampling technique to create a population of hypothetical pilots which have, if their sample population is reduced, the same means, standard deviations and intercorrelations as the actual pilot population.

The program takes each one of the hypothetical pilots, sticks it in the cockpit and determines whether or not that particular pilot with obvious variations, his 17th percentile forearm and his 29th percentile upper arm and his 52nd percentile sitting eye height, can reach that particular control.

We have found this to be a much more realistic assessment technique than the old, "Can the 3rd percentile man reach it?" and then "Can the 95th percentile people?"

This has been a very useful technique for rapid evaluation. With the computer program, I have given turnaround on an anthropometric analysis to a contractor within 20 minutes after an initial phone call - which means you do have an opportunity to evaluate very quickly and to interact very meaningfully.

In addition to just measuring percentile or percentage of compatibility, the program gives you a measure of how far the control would have to be moved in order to meet a specified percentage criterion. In other words, how far would I have to move it in order to make it accessible to 95 percent of the pilot population. This also is extremely valuable because you could call a contractor and say, "Hey, we've got a reach problem on the fire handles." You are instantly perceived as asking for a major redesign of the entire cockpit with incredible consequences. And you're apt to start getting the entire defensive reaction, which is usually forthcoming under those circumstances. If you can say, "Hey, wait a minute. I'm only talking about three-eights of an inch closer to the center line," now it's perceived as a doable do. And you settle down to talking to each other as reasonable people in terms of how to accomplish the objective. This has been extremely useful.

We are looking at some new starts in areas that we perceive as necessary to continue to support the design efforts on workload. The design of intelligent systems, again, to augment the operator's capability. We're updating the models of human operators. We're looking at improved anthropometric accommodation in air crew stations.

One of the elements that has just been completed under that is to go back and revise the CAR model I was just talking about so that the reach capabilities and the limb motions reflect not the nude body but the pilot equipped with both regular flight gear and equipment and arctic gear. So we can now get a more realistic assessment under actual operational conditions.

We are continuously working to validate the assessment of design criteria that we are using to make sure that they are credible, realistic and cost-effective.

Thank you very much.

MR. HAY: That description was very interesting to me personally, Lloyd, because having followed several of the major manufacturers over the last eight years and parallel programs that were certainly driven by the Department of

Defense interests and contracts at that time, it's certainly well layed out.

Now we come to Captain Bill Connor of Delta Air Lines, who is representing today his position as an adjunct Professor at Embry Riddle Aeronautical University.

At this time I would like to welcome Bill Connors and his airline issues. Please, Bill.

CAPTAIN C. WILLIAM CONNOR: Thank you, Cliff. One of my problems was I wanted to make sure I gave my disclaimers before we started, which, of course, are that I'm not speaking for my airline and I'm not speaking for the Airline Pilots Association. But I am speaking for Embry Riddle or representing them.

When Guice Tinsley approached me about this twenty-minute presentation I told him I had a problem, which was too much information for that time frame and could he possibly help me out with my problem? This was his response. (Slide shown). So much for governmental understanding.

I think that the airline operational issues that we'd like to address or I'd like to address is that, first of all, we've got to identify the external environment that we're going to operate in in the 1980-1990 area. This, of course, goes with the type of computer that will be handling the air traffic during these years. Presently, it's an IBM 9020. And right now it's estimated that the traffic will increase by 40 percent over these next ten years. This means that the General Aviation Aircraft will proceed from 200,000 aircraft to approximately 307,000; and that the commercial jet transports will go from approximately 2200 to 3107. Of course, this means that there is a definite need for a collision-avoiding system; and presently, there is nothing new on the drawing boards as far as how they're going to control this environment.

DARC is the backup presently. And there seem to be some problems with that area. Presently in Miami, the system load in that area is 3200 handlings a day. And during the past year this has approached almost 3500 in the summertime on certain days. And actually in the winter time, 4000 to 6000 on a couple of occasions down there. So the slack right now is being taken up by the Controllers. And with their 40 percent increase you can see where our problem is going to mount quite considerably because there are no new airports and there are no new facilities or airspace to take care of them.

The next area that we'd like to identify is the standard airport facilities environment. I feel that all runways should have ILSs with Glideslopes with DMEs installed on them. I think it's kind of silly to take a $40,000,000 airplane and be shooting ADF approaches with it.

Also, that we have VASIs on the runways; that the runways all be grooved and that the standard runway environment include an ALSF II, a lighting system, which would be an approach lighting system, which is ALS; sequence flashing lights, SFL, and REILs.

This system would allow CAT I-II-III approaches and allow the users to equip the aircraft to the maximum precision approaches or for his maximum utilization. I think the economics here would be saved because the person would be able to use the aircraft and know that where he's going his holdings or diversions to alternate airports would be cut down considerably because the airport environment is so well equipped that it's only up to what he has in the aircraft and his own limitations that can get him there.

The next area to identify is what type of cockpit instrumentation is needed. I think we ought to standardize the minimum requirements, not to the old issues but to the newer ones.

I think that the altimeter with the pointer, with the digital readout, is a must because of the misreadings that we've had in the past; that these aircraft should have Dual Digital ADFs, Dual Head VHFs with transfer switches; and that we'd go to either Head Up Displays or VAMs, which is the Visual Approach Monitor. And, of course, here's our slide right here. Here's an F-18 Head Up Display, which is Military model of this.

Here's the Klopstein version which I think is an outstanding type of Head Up Display for commercial use. It's very simplistic, very straightforward, and the information transfers very easily.

This is my own little version of this thing. I thought something that should be added to this is that you'll notice on the left side is the figure 140 and on the right side 1020 with a -.7. To me, to use the straightforward information, it was there I would like a reinforcement to tell me what it actually is telling me, which is that I'm doing 140 knots for a lineup; and that I'm at 1020 feet, and I'm descending at 700 feet a minute.

Other things that we need in there are advanced CRTs for our ASI and HSI and MFDs, which are Multiple Functional Displays.

Thanks to the Air Force and the AFA, here's a presentation of an MFD which is telling you on this particular slide here that -- it's the afterburner, but it could be on your commercial jet. It could be your turbine section is overheated. And you're looking at your display to tell you where to go with it.

Now, of course, this is telling you about impending overspeed. And you see you've got your caution.

And now here I think, which is very effective, that you have to do an engine shutdown, and here are your memory items right off the bat to go to.

And now that you've gone through these items it's telling you now that you've got the particular engine secured and shut down. I think this is an interesting approach, and I like the idea of pictorials to lead you in as information. And you notice here it's not decisional information. It's an information feed in to you to filter so you can go ahead and use your own decisions on it.

Another interesting display which is your CDTI, your Cockpit Displayed Traffic Information, this is the monochromatic type which is one color. Now, you can see this looks pretty cluttered. But this could be -- as you look at here the A's there are - because it's an Air Force version - which means the enemy which is the card; and the little rectangle there is unknown; and, of course, the half circle is friendly.

Now, once this is put to color, notice the big difference in how quickly you recognize it. Your friendly is in green, unkown is in yellow, and the enemy is in red, which is really a good color scheme the way you really follow emergencies, anyhow, or instrumentation in your aircraft.

The difference in the time on this, as you can see here, from the black and white to the color is almost six seconds in recognition time, which I think is very, very prominent.

And here's just another graph to show you the difference between the common round dials which we use in commercial aviation now as to reaction time with a black and white CRT and then finally with a colored CRT. It's quite a significant change. And if we start to go this way it's interesting that -- of course, it's all going to be economics. But if it can save you time and the recognition and response is there and is needed for what our environment is going to be in the next ten years I think it's very well worthwhile looking into.

Other items that -- let's see, is that the last one on that? Yeah. Okay.

Other things that we'd have in there would be the Flight Management System. And here we go over to the other side. Well, I'll have to wait a few minutes on that one. Would be Flight Management Systems.

Next area I think we ought to identify is the Navigational Systems to be used during this time frame. Presently, we have the VORs and the Tacans and the Vortacs and the ILSs make up the bulk of our Navigation Systems.

Also available now, which are fairly expensive, too, in the commercial version, are your RNAVs, INS, OMEGAs. Things to come that are still in the work are your TRSB/MLS, your NAV STAR/GPS and the possible acquisition of using 4 D NAV in to your large terminals.

This was used in Kennedy about a year ago which is metered air spacing. And they found that it increased the traffic flow by 42 percent. And when you start talking about fuel savings, this would really be a tremendous boost for commercial users as well as general aviation.

This slide we have over here is a map display which is another area on the instrumentation that I think is a needed time, which is -- right here it's showing you the total color concept that can be thrown in here. It's quite high, and it looks quite garbled to you right now; but it's to show you how much it can be done with the lakes, streams, roads, cities, airports, restricted areas, and what have you. As you notice now, this is a raster-type presentation right now. But notice now as you do for an airport how it moves. Of course, if you don't lose it.

There's your aircraft. Now, this is total uncluttered. Now you notice your city. And now you notice you're starting to pick up information - there's your streams - which is going to be helpful to translate to your approach plates.

Now you notice the flight path line. Now, this is just a, kind of, another spinoff towards a potential highway in the sky type thing; but it is giving you a lead in to where you're going to your airport.

Now you notice you're starting to get in closer, now. It's starting to give you more information about that particular area that you're interested in landing your aircraft.

Now, this is a progress report, now. You shift back. And it's -- now here's where you are in this time frame. And now notice this has now secured itself to an almost northerly-type indication from the horizontal up to the vertical. So that it now re-positions you as you're now shooting to your area, which I think is a very interesting concept in that some of the other previous ways were not able to do this. There's more continual progress. Notice your field, all your information about your field is there, especially the radio frequencies. This seems to be a real problem because you get into a lot of areas of high congestion and density; and there are a lot of problems with, "Did you get the right frequency?" "Did you switch over?" And this information clutter seems to be a problem depending on how great the traffic is.

The next thing I think we'd like to identify here is the pilot's role in flight deck automation and the methodology to train him into the loop. There's been a lot of concern over that. If we give a person a flight guidance system, he will very well be able to handle just about any traffic environment and reduce his workload.

Actually, our first steps into this area were a little bit primitive as you can see there. However, we got the point; and we moved on into a little better flight guidance system. This is a Plume-3 departure out of Kennedy. And I want you to recognize that this is a standard instrument departure. And if you're taking off on Runway 31, as you can see there, it's immediately after lift-off you're to make a sharp turn to go inside the 039 radial of Canarsie and to pass below the 250 degree radial of Kennedy at 2500 feet or above; and that you're to intercept the 176 degree radial of Canarsie and track outbound until you intercept the 236 degree radial of Hampton to the Plume intersection.

Now, this is the Flight Guidance System, the L-1011; and this is programmed just for that departure. You can see on the left-hand side is Canarsie 12-3. You've got your indicator speed 250. You've got your heading select 250, which will be your turn. Then you have your course, which was supposed to be 176 - a little typo there - and 252 for Kennedy. There's your 2500 feet arm, and there's your 15/9. As you can see, these instruments all correlate to your console on the lower area there.

There is very, very interesting because the standard instrument departure out of Kennedy on the Plume-3, the only thing standard about it is that you're not going to follow it.

So, when you've programmed this into your computer after you make your immediate turn, their comment that comes back is, "Cancel the altitude at 2500 feet, maintain five, turn to head into 130, intercept the 155 degree radial of Kennedy, track to Plume," which then you have to go to Sea Isle. So, for all the help the guidance system gave you, you just dumped it.

So, now you've got to go and reprogram this thing in a turn which your head back in the cockpit halfway between your knees trying to get this system reprogrammed.

Now, that's a very interesting departure there because everybody is really hustling; and it's a very high density area; but you can see a conflict there. Why have a standard instrument departure when you don't follow it, when you know very well that you're not going to follow the standard instrument departure?

Now, I want to show you another one that I do quite often. And just take a look at what you can do with this one when they start changing it as they do the Plume-3 departure. How do you like those apples? And then they change the runway.

So these plates, when they start changing these things, go from about an eight-inch size plate down to about one millimeter when you're trying to start finding the information on these things. So you can see here they've gone to a lot of trouble to give you a lot of information to try to help you integrate your flight guidance system; and you're totally ignoring the system. So now if you have to dump it, what would be a better way to try and program the man into the loop? So I think that the flight deck automation that we ought to try and work on putting the pilot in the center of the loop.

This drawing that I've made up on this thing, that the pilot should be just like a wheel in the center of the hub. He should be the CPS, the Central Processing System. He should be able to do the informational filtering of the visual perception, his auditory recognition; and the communications transfers should be both ways so that he can very adequately handle what's going on in the cockpit.

Now, as far as the Flight Guidance System, using this same concept, I think there are three ways you can go with it. You can either be in the monitor mode, control mode or in the support mode. And you notice the support mode is actually two ways.

The way I do the departure out of Kennedy is that I go in the control mode. And the control mode means manual to me. I let the system track me because I know that they're not going to stay with their standard instrument departure. However, I put it in the guidance system; and it's there if for some strange reason they would decide to go by their standard instrument departure.

Once they've gone and turned me around a few times and had me headed towards the 155 degree radial, at that time I switch from the control mode, which is manual, over the the support mode, which means to re-update my flight guidance system, put the changes in that I want to, the altitudes and what have you, the intercepts, the headings and what have you. At that time I'm in a support mode. I've re-manualed. I'm the support mode to the Flight Guidance System. Finally, once I am tracking twoards and I'm starting to get a capture on my 155 degree radial, at this time I go ahead now and hook it up and go to the monitor mode. Now, I've hooked up the guidance system with the autopilots, and now it's tracking; and it makes its automatic capture and captures the radial, captures the altitude and away I go.

However, by doing this I've kept myself totally in the center of the loop all the time. And I'm an operational feedback to my system. It's actually a feedback system to me.

I think one -- another problem we're having with instrumentation is that your being a CPS informational filter given streams of information is, by far, decisional; and informational is a very good problem rather than your having one type of information being fed to you from various instrumentation. Some of this information is decisional, and some of this information is informational. And I think this transfer problem is a real problem because you're having to do interpolation which you don't want to be getting into under time compression. If your're under critical situations you want the information as uncluttered and as simplistic as possible to come to you so you have the time to make your selections, your alternate selections, to the information that's being fed to you. Otherwise, you have to interpolate as to what are you seeing. Is this --

and what happens with this is you stop glancing at your information and you start dwelling on your information. And then that starts disrupting your informational flow to you which you have.

So here's the last slide on this, which is -- here is the problem. We have decisional information being -- instruments feeding you, and informational sources also being fed to you. And now you've run into a clutter problem in your judgmental response because the main problem is here. Rather than the speed and the accuracy of the computer or the new instrument helping you to make a more accurate decision faster, you're now having it cluttered because you're having to decide which is decisional, which is informational and how much of decisional do I want to actually go and filter and how much of the informational language or the information to me is actually supporting me or just need to know or nice to know.

So, I think you've got a communications problem here in your information flow. And I think then when you start doing this that your Flight Guidance System and other supporting systems to it are now working against you.

The next area that we've moved into, which I think is a very interesting concept, is LOFT, which is Line Orientated Flight Training. In the past, most training was procedural. And that's how you pass your check ride - how well you handled your procedures during your emergencies.

LOFT has finally moved past this training from procedural towards perceptual motor and some cognitive or medial-type training. So, which I think is a very good step in the right direction. I don't think it's the total answer, but it is a start in the right direction. Everybody has high hopes. I think -- was it -- Ruffle Smith, his test that he did out at NASA Ames originally was, really, kind of the swing end of the LOFT training because it's very interesting how people started handling their human resource management. They started having problems. And it seemed that the weaker pilot became more and more solo as the problems compounded rather than utilizing his crew and utilizing the things that he had to work for him. He started regressing back into his shell and tried to fly it totally by himself. And this program was able to show a lot of people that they no longer were handling the aircraft. It was handling him, and the situation was handling both of them. So, this was a very interesting test or study. And finally, LOFT moved a couple of more steps past this.

I think it's interesting that when you look at the accidents that we've had or the accidents that have been investigated, there were something like 100,000 accidents that were investigated. And out of all these accidents, the same percentage of accidents happened from six miles from the airport in. That percentage never changed. It's still about 58 percent. With all the alerting devices that were added to the aircraft, all the new instrumentation, it still stayed there. So, obviously, we were looking at the wrong thing. Obviously, we were training to the wrong area because there's something here that the pilot is having a problem with, R&R, Recognition and Response. Time and time again he's looking at very critical information. And it's not transferring. Why not? This -- they're highly developed pilots. They're not utilizing their crews. They get into a -- they seem to drop back into procedural rather than using the other things that are available to them, which is their perceptual-motor and their cognitive.

So it seems that the training was so high on procedural that the person regresses back into having interference, which is the thing he's most comfortable with - he knows his procedures. And, of course, it can't bail you out. I think there's a problem where our alerting devices are reaching a point where they're more distracting than they are alerting. We have lights, horns and bells that go off, you know, continuously. Your ground proximity warning device is a very interesting device. It's very helpful; but everytime you shoot a non-precision approach, you're going to get that horn because it senses no Glideslope. So it's only a matter of time to-how well-respond to that instrumentation or that sound because you know the Glideslope is not there; so it's a false warning. The Pensacola accident brought this out.

There's another one that we have on a lot of aircraft where there are four takeoff warning horns for four conditions. It's the same horn, but it's four conditions. And it's either your spoilers or your flaps, your flap position or your stabilizer setting.

And consequently, there's nothing on your pilot's caution warning panel that draws you back and says, "That's your stab position," or "Your flaps are not matching up with your flap handle." You've got to go guess what it is while you're roaring down the runway, so you end up aborting. Whereas, if your pilot's caution warning panel immediately says -- the horn came on and said, "That's your stay position,: you knew what to go with; or "That's your spoiler handle out of detent," you would immediately do it and you could drive on. So if you're going to have an alerting device, have it alert your hearing but direct your visual to know what it is to go ahead and solve the problem. Get your loop going, your information coming in. That's only one string of it. And now it's seek and hunt.

So I believe that LOFT training is a very good start for us. It may lead us to some very informational areas and informative to help us identify some of the reasons why pilots create the errors.

As far as our simulation economics, what level of fidelity in simulation do we want? We've got the six degree of freedom simulators, our visual systems, CGIs. We have the capability of 150 degree view. We have textured, untextured surfaces with realistic color shading for chromostereoposis effect. We have highway in the sky. And a new interesting area that's come in is the second level instruction available with the CAI, the Computer-Assisted Instruction. Most of you are familiar with the PLATO. But there's a new one out called TICKETT, which is really outstanding, that has -- they do an F-18 instruction on it. It moves. It responds to your information. It's a teacher. It's a graphics. And for teaching approach in the Flight Guidance System, it's very, very exceptional in the way it can transfer training to you. One of the most interesting things was anything that was in alphanumerics that they wanted to transfer for you, they put it in blue. It seemed like it transferred about 68 percent, which is an interesting idea.

Also, that the -- another area that was interesting that they were using was that if they wanted highlight, it was in yellow; and they use green in some of their other areas. The information stayed with you. But when you do a guidance system it is too expensive to use a simulator, a great big L-1011 Simulator, to teach a man a Flight Guidance System. But he does need to have hands on and actually see the thing move because he has nothing to relate it to from previous aircraft.

So rather than using an expensive simulator where you can be doing all the other exotic maneuvers that you want to, this second level terminal, table-top terminal, can do the same thing, can question him, give him a spin up on the system and move him very rapidly through his training.

With this capacity or capability you can actually select either the economy or fidelity that best fits their operation. So, it's very flexible.

As you all know, we're going through the Phase I, Phase II and Phase III. And, of course, you're more familiar with the Phase I. And, of course, most of the companies are moving to the Phase II Simulation, which is to have an upgrade capability for new captains. Most of them are in the 2A, which means that they're moving towards the two. Phase III, which is total simulation; and the person's first trip would be a revenue flight.

I think one area that very definitely has got a lot of attention lately and it should really be stressed is to identify the fatigue factors associated with flight deck operation.

In order to have an effective audiovisual, the person's going to be processing his auditory recognition and information transfer, his long-term, short-term memory and his visual performance the same way - information transfer. This, then, through the information filter goes through your cognitive or your decisional to work with your human resource management, which is your entire crew, and to determine whether this is a procedural or a combination of procedural-perceptual motor response to accomplish your task.

Well, this is all well and good if it's at an optimum performance time. However, let's find out what we could do that could affect this type of informational flow after it's been filtered.

Here are some of the fatigue factors that I think are interference areas to accomplishing adequate task accomplishment. We get time compression when you get into tight approaches. You have various levels of stress and fatigue. Your physiological inactivity, which is long durations of time in flight where you are cramped in the seat and you're not able to get up or you don't get up and there are no exercises available, which should be available, to help stimulate the circulation. I think this is an area that needs to be looked into.

Dehydration. When you're at altitude, we have 5 percent humidifiers. And for long periods of time this really does a number on you. And most people will end up to going to drinking coffee, which accelerates your dehydration.

I did a little test going out to the West Coast, a five-hour flight. I drank eight ounces of water every hour. The copilot, he drank nothing. By the time we got to the Coast I was fine. I felt fairly refreshed. His skin had scaled up just like an alligator. So, there is a problem with dehydration. And as to what it will -- how it affects you mentally and physically, I don't know.

Another area we have not even addressed is nutrition. If you're in these long time periods up there and you're starting to become physically tired, mentally tired, what do you know to eat or drink that can help bring you back up? Do you have it available in the airplane or can you bring it with you? We know absolutely zero about the nutrition.

Visual noise. There was a test done on some of the recent CRTs that are being looked at for commercial jets. And it seemed that when you had an alphanumeric type of presentation it seemed to be all right because you were only glancing. But when you went into the continuous strain-type thing, which you would have on an HSI, you know locked in on the lines. And now, rather than glancing, you were dwelling. And over a period of time when they hooked the individuals up with the pupilometer, it started showing that the lens started tracking the visual noise in the CRT. And I forgot what time frame it was that they actually started having lens fatigue. And once they had the lens fatigue, there was no longer accommodation on the instrumentation inside or outside - an area I think that will be very, very important to look into in the near future.

You've heard a lot about the Circadian Rhythm, Internal Desynchronization, these people that are transversing to numerous time zones. It seems that now some of the latest information or some of the information on this is, once you have crossed this six time zone type thing, even though you get eight hours sleep, you've lost 3½; and your recuperative process is 50 percent the first day, 50 percent the next day until you finally recoup this back.

But this is going to vary with age. It's going to vary with your condition, conditioning. I think nutrition is going to have -- that you see now that nutrition has a point in this area that can accelerate it or decelerate it. If you're doing supersonic flight where you can go back -- go over and come back relatively near the time zone change - that you do not have this problem anywhere near as severe as subsonic jets do. Of course, everybody knows that if you have shipboard travel you're only traversing about 30 minutes of time change per day. And the body resinks normally to it, and there's no mental or physical effects to it.

One of the biggest areas that's interesting was that not only is there a physical degradation but also a mental. And how well can you do your task when you can't even recognize when you're losing your mental performance levels?

And I think the things that we look at -- one of the most interesting things that they've talked about is, let's start measuring optimal performance levels. Why measure optimum? Why not look at the man's overload capacity level? What can he handle outside his normal optimum level? If a guy's doing fine, he's running on all cylinders, then that's fine.

Now, that level is going to vary. What you need to do is get this person in a position to where he is mentally tired, he's physically tired. And now, get him up to an overload capacity and see how long it takes him to digress away from his procedural ability, and start losing this mental process that he's trying to control the crew, knowing what's critical, knowing what is not, what is -- where his stream of information should come from and how he's going to go ahead and handle his resource management there. That, I think, is a critical problem.

No person can be optimal at all times. At certain times he is fine. But you have to take our crew rotations that we have, take the persons out, and I would suggest if in a month's type operation, if a person is flying odd cycles, let him fly the first three weeks of those cycles. And then bring him back into the simulator and put him in exactly the time he would have gone out on his fourth rotation, the exact same time, give him the exact same condition. And put him on the same type of food, the same type of movement that he would have available in the same aircraft.

Another area that has not been addressed in a simulator is re-creating realistic post noise, which is noise around the post; and infrasonics, which is your low-level vibrations and low-level frequencies that really are undetectable to you but are continually eroding you fatigue-wise, mentally as well as physically.

And, of course, when these things start interferring with your information stream and your decisional processes here, this not only affects your human resource management on your task accomplishment but it affects everybody that's in the cockpit with you, their ability to perform, also.

I think if we can even get an approach where we could actually take the people and run them through a test and see if we could get them psychologically tired and physically tired that we could -- how do you know this? How can you measure this? How would you be able to get this person to understand this?

Or that you would know that he's at that point to start measuring his degradation? I think if you were to go up to him and say, "Are you ready for our next fatigue test?" and if you got the following answer, I think you're probably about there. (Slide shown) "Today I may rise but I refuse to shine." that says it physically and mentally.

The bottom line on future training: Let's stop training the pilot's ego and start training his judgment.

Thank you very much.

MR. HAY: That's very well-balanced presentation, Bill.

Sometimes you get a long coffee break, sometimes you get a short coffee break. This is going to be a short coffee break. Coffee and the donuts are available. I'd like to see you all back here at 3:20, please.

(Break taken at 2:50 p.m.)

(Break ended at 3:25 p.m.)

Now, to start this afternoon off we'll pick up with the Flight Engineers International Association. Donald F. Thielke will be representing them. And the subject will be Future Automation and the Flight Engineer. Please, Don, if you would.

DONALD F. THIELKE: A few comments before we start. You'll notice on your list of speakers that there are two names, Karl Anderson and myself. I lost the toss; so I'm here.

The speakers preceding me brought up some very interesting facts, terminology. With Dr. Hitchcock the CUBITS thing. If you'll remember your Biblical history, CUBITS and Noah were associated with a degree of technology that probably prefaced one of the larger if not the largest disaster on the face of the earth.

Again, Mr. Connor, one of his comments was referring to the new automation. And when you talk about the first revenue flight of the crew, approaching the aircraft for the first time after all the preliminary simulation, preprogramming, to me, it's a little bit frightening. I don't know if we can do it.

The topic of the paper is Future Automation and the Flight Engineer. So let's get to the nitty gritty.

The utilization of automation in new transport aircraft such as the Boeing 757/767 and the Airbus A-310 is a two-edged sword.

And at this point, I may interject that it's a sword with no handle. So no matter how you grasp the blade, you're liable to draw blood.

There is the potential for improved operations and safety, but since we do not know precisely how to apply automation in the flight environment, the results may be disastrous. NASA has summarized the problems in a recent Senate hearings. Dr. Alan Chambers of the Ames Research Center said "...in the area of automation there are some problems, since 'inappropriate' automation may lead to complacency and erosion of crew skills..." He suggested that automation not be halted but "...that better guidelines be established for allocating functions between automatic devices and the crew." Unfortunately, there are few guidelines to handle even the current low level of automation, and research has yet to yield the necessary information for appropriate future decisions.

Automation has been with us for a long time and many of the early problems have yet to be overcome. Sell and Pulsford, in 1967, described automation associated with power system control room operations which deals with what might be considered in the aviation community as "low technology" equipment; power systems have been around for a long time and have evolved to a high degree of reliability. However, they stated:

> "it is not possible to guarantee the 100 percent working of the hardware components used. Even complete duplication of all the subsystems will not eliminate the risk of failure."

Another gentlemen by the name of Grodsky in 1962 states:

> "that a human being in a system with duplication of equipment is more reliable than a system with five degrees of redundancy but without a man."

The basic problem with automation as pointed out by Sell and Pulsford is that if people are not integrated into the system, they may not notice when a system is abnormal. If it is necessary to have human intervention, they may not be able to appreciate the true problem and act quickly enough. This is the man-machine allocation of monitoring versus active participation for which human factors can provide guidelines, but precise recommendations -- but not precise recommendations for specific pieces of equipment.

It is, therefore, instructive to review the man-machine allocation problem. May I have the first viewgraph, please? Now, such a cockpit provides one end of the automation spectrum - total human operation. Now, if you look carefully you will se the "8" ball. And it's right in the center panel.

With total automation, we have a different picture. May I have the second viewgraph, please?

Obviously, neither alternative is desired, but the real question is "Exactly where between the two should we go?"

May I have the next viewgraph, please? Here are some of the things that we, as humans, do best:

- o We draw upon varied experience in making decisions; and we adapt decisions to situational requirements.
- o We act in emergencies. But if you'll note, it does not require previous "Programming" for all situations.
- o Select alternative modes of operation, if certain modes fail.
- o Reason inductively, generalizing from the observations.
- o Apply principles to solutions of varied problems.
- o Make subjective estimates and evaluations.
- o Develop entirely new solutions.
- o And concentrate on most important activites, when overload conditions require.

The next viewgraph, please. Now, here are some of the things automated systems do better:

- o Apply deductive reasoning, such as recognizing stimuli as belonging to a general class (but the characteristics of the class need to be specified).
- o Monitor for prespecified events, especially when infrequent (but machines cannot improvise in case of unanticipated types of events).

- o Retrieve coded information quickly and accurately when specifically requested (although the specific instructions need to be provided on the type of information that is to be recalled.)
- o Process quantitative information following specified programs.
- o Make rapid and consistent responses to input signals.
- o Perform repetitive activities reliably.
- o And exert considerable physical force in a highly controlled manner.

You can remove that viewgraph.

Smith and Dieterly in a NASA review of automation, pointed out that in order to understand the man-machine allocation and automation, we must have an approach. Neither of the two they suggest "hits the mark." First, a behavioral science approach is difficult for while there are many different methods, there is no solid theory. Second, engineering analysis is geared to current understanding, but human behavior is too complex for the simple models used, and specific approaches to systems are not easily generalized.

Although it may seem that we can easily overcome these difficulties, it is probable that there has been an under-reporting of automation-induced accidents and incidents in many fields. Paraphrasing Dieterly, many times partial equipment failures result in atypical conditions and then trigger a chain of events that are constrained by the system and company policy in such a way that an accident could result that is blamed upon the human.

> "Since most of the human error examples are discussed in terms of complex partially automated systems this should be a critical issue for automation research. Automation is anticipated to reduce human error but frequently it only changes the location of the occurrence of the human error."

Given these possibilities, we Flight Engineers have serious doubts about the automation and how it can be applied to radically change the roles and duties of flight crews so that only two crew members will be required on future aircraft.

With regard to the use of the latest technology in the design of the new aircraft, past experience has shown that the crew workload on each new generation of aircraft is not reduced. While some specific tasks may be eliminated, others are added. Moreover, past experience has also shown that the automated systems are never trouble-free and can, at times, serve to increase the workload. But more than anything else, the new technology is needed simply for the crew to keep up with a workload that grows constantly as the skies become more and more crowded.

When all is said and done, the automated systems are no "smarter" than the programs that are built into them. Even the supposedly highly-sophisticated technology planned for the next generation of aircraft will permit the computer to monitor the aircraft's complex systems only to the extent designers of the computer programs have adequately anticipated the almost endless number of possibilities.

The unlimited faith the manufacturers are displaying in the ability of automation to displace the Flight Engineer assumes that the computer can be programmed for all of the abnormalities and failures that are possible in the aircraft's systems - including false alarms - and for all of the possible sequences and/or combinations of abnormalities and failures that might follow the first signal.

Reliance on the computerized system would be absolute. If something is amiss in one of the aircraft's systems, the computer - not the pilots - would decide what action is needed. Indeed, pursuant to its programmed instructions, a faulty system - even one that is falsely told by the computer that it is faulty - would switch itself off, and the pilots would learn of this only after the fact by the message displayed on a screen. It is only then that they would know of the need to take corrective action.

This procedure is fraught with danger, because of the possibility of multiple simultaneous problems in one or more of the aircraft's systems. The computerized system will be able to react to the problems only sequentially, according to its pre-programmed determination as to the importance of each, and would not present the piltos with the "mix" of problems at one time. Not until the crew responds to notification of the first indicated system failure will the computer signal the next. In the event of simultaneous failures in the systems, the crew would not be given the full picture they need to enable them to cope as they think best with the totality of the aircraft's difficulties. The thinking would be done for them on the basis of the information that has been programmed into the computer.

As was indicated earlier, these computerized systems are not without problems. They can suffer breakdowns, and they can also give off faulty signals - to which they will respond because they are not "intelligent" enough to do otherwise. This happens even now with the highly automated systems in the generations of turbojets that are currently flying. But in these instances the Flight Engineer is available to deal with the malfunctions and/or faulty signals. By cross-checking with other readings on his instrument panel he can often detect faulty or misleading signals, whereas, left to its own devices, the computer will simply follow instructions and shut-down the system, and this may then generate an entire sequence of faulty signals.

Here are examples of what we mean by a computer and/or automated equipment simply following instructions without fully understanding what is occurring:

(1) In an approach with the autopilot in control, a bend in the glide path at 500 feet above the ground caused a very marked pitch down, resulting in excessive sink rate. The pilot, though fully aware of the situation, did not react until his position was so critical that a very low pull-up had to be made;

(2) The altitude pre-select (a device to level the aircraft a predetermined altitude) malfunctioned. This went unnoticed by the pilots and an excessive undershoot was made, which is a descent below desired altitude;

(3) At a level-off by use of the altitude pre-select and with the throttles in idle -- and here we raise the question: was auto-throttle in use or was it expected to be used? -- the speed dropped close to the stall point before this condition was detected and rectified by power application;

(4) While in navigation mode (the autopilot steering the aircraft to maintain a track over the ground), the aircraft turned the wrong way over a checkpoint. Although the wrong turn was immedaitely noticed, the aircraft turned more than 45 degrees before the pilot took action.

No matter what the aircraft manufacturers would have the American public believe, there is no such thing as 100 percent reliability in any automated system. Experience with nuclear generating plants, however low their accident rate, has made this clear. Their highly-automated systems, because of safety considerations, have been designed to assure as much error-free operation as is humanly possible. Nevertheless, they have suffered failures and have on more than one occasion been victimized by faulty signals from their automated monitoring systems. There have been accidents that the automated systems were not equipped to handle or, in spite of all of the pre-programming, did not handle as they should have.

Such reliability may be a serious problem as more and more "black boxes" are relied upon in the future systems. The military has had problems with such systems even though extensive testing and reliability calculations were used in the volumes of Military Specifications and Standards. For all the emphasis in this area, the problem has become so acute that Congress has commissioned various Government Accounting Office reports in this area. The latest such report was published in January of this year and showed how extensive problems with automatic test equipment and maintenance impaired the readiness of the F-15 Fighter. And I believe we've heard some other references to that in previous deliveries here today. Such problems may or may not be magnified for commercial airlines.

The minimum equipment list concept in which designed-in redundancy is purposely overlooked to allow aircraft to be dispatched without all equipment operating properly, has influenced accidents and incidents before and will in the future. Flights dispatched with all systems operating normally, including the redundant protection, are the exception rather than the rule in present everyday operation. Will the highly automated and computerized flight management and systems monitor/control displays be "NO GO" items? We doubt it. We believe the manual reversion and reallocation of duties would definitely increase workload.

In addition to these general problems, there are specific problems with the display and control technology associated with automation. The reliance on CRTs, proposed by manufacturers as the predominant means of information presentation in future cockpits, has the following difficulties.

May I have the next viewgraph, please?

The visual problems in turbulence, I think, are well known.

Scan rate interactions, another problem.

Sun and viewing due to the brightness of the display between daylight and nighttime is another problem.

Radiation hazards. I'm not sure that we have a total handle on this.

Color. There's a definite presentation problem here.

After images; picture wobble; limited experience including minimum military experience, screen coatints and dirt influencing reflection characteristics.

You can switch that viewgraph off.

The automatic systems with their pre-programmed computer are simply not an adequate substitute for a Flight Engineer. Those automated systems should be used to back him up and help the crew make decisions. They should be used to supplement the Flight Engineer rather than to supplant him.

The manufacturers are simply refusing to recognize the essential need for a human monitor, just as they are refusing to acknowledge the invaluable contribution the Flight Engineer makes to safety by adding a third pair of eyes to the cockpit. This contribution is most important during the critical takeoff and landing phases of flights, particularly at busy airports. The crewmembers are aware - even if the others are not - of how key a factor these eyes are to the safety of the aircraft, especially since the takeoff and landing phases are the busiest of any flight for the pilot and copilot, both in connection with the craft's operation and the maintenance of essential communications with air traffic control. And I believe Mr. Connor's reference to some of those SIDs verifies that. Because there is a Flight Engineer present, the entire crew has more opportunity to scan the skies for other aircraft that may be nearby and that may present a threat to the safety of the flight. Technology is simply no substitute.

In the application of automation to commercial aviation the Systems Design criteria requires a reasonable amount of judgment in applying information on human factors research.

Although a research investigation may provide statistically significant results, the effects of the research might be of very limited practical significance.

The extension of research results where fully confirmed data are not available and when it is not feasible to carry out research in the particular situation such as the real-life environment of commercial aviation, produces a judgment of applicability little better than a guess.

The seriousness of poor judgment in this environment is apparent.

Further, frequently it is not possible to achieve an optimum in all possible criteria for a given design of a man-machine system, so flexibility must be accepted. The possible trade-off of one feature (as suggested by the results of research) for some more desirable pay-off is obvious.

And we in FEIA believe that technology as a servant, as well as safety, is being sacrificed in favor of economics.

Thank you.

MR. HAY: Thank you, Don. Now we come to a subject that all of us had been on the fringes of for the last several years. And that's Metrication. Today we have Captain E.V. Friend, Huges Air West. And his presentation will be Human Factors Impact on Metrication on Air Operations.

CAPTAIN E.V. FRIEND: Thank you. I appreciate the opportunity of being here today. The Metrication issues I feel sometimes have been overlooked because most people seem to feel that it's well down the road and there are other problems that are more pressing. And while I have to agree with the fact that there are many other more urgent problems, certainly we should be planning for the future.

The views I want to express here today are a combination of Air Line Pilots Association Policy. Some of it is positions of the American National Metric Council, which is an organization in which I participate for the Air Line Pilots Association. And I Chair the Air Operations Subsector Committee. Within that group we have operational groups such as AOPA, GAMA, NBAA and others. We are always trying to invite members, particularly from the operating end. We like to get some controller input to complete the loop.

I hope those of you in the audience had a chance to pick up a handout in the lobby. It explained some of the ideas I'm going to be talking about today.

First of all, I'd like to say that the Air Line Pilots Association is not opposed to Metrication of the International Airspace System. We do want to point out the fact that there are some serious operational problems - particularly in the Human Factors and operations end - that very seriously need to be studied. We also feel that the Human Factors element in general have been long overlooked. And we're very pleased to see the fact that the appropriate government agencies are finally interested in trying to resolve this issue.

Accidents don't just happen. It's easy on Monday morning to figure out how the pilot crashed. But the important thing is, why did he crash? What led an intelligent rational human being into the trap that caused him to make a decision which on Monday morning looks like a very poor decision? This is the area that we need to look at, the "why."

Let's see what is in store for us in the cockpit as far as Metrication changes.

First of all, the ICAO, the International Civil Aviation Organization - I'm sure most if not all of you are familiar with. The Annex 5, Amendment 13 has been approved. This calls for conversion of several units of measure, most of which we don't feel will be a problem.

But the conversion of the International Airspace System is a big problem. We don't care if we're flying around in an airplane that was designed to metric dimensions and for that part that the engine instruments read in metric units, but the airspace conversion itself does present problems. Some of the proposed changes call for the knot to be replaced by the kilometer; the foot to be replaced for altitude measurements by the meter, vertical speed, - there are actually two changes, - from the foot per minute to the meter per second. I'm not quite sure why the time interval was changed, but I'm sure there was some reason for it. In pressure readings for altimeters the inch would be replaced by the hectopascal, which numerically is equivalent to the millibar. The proposal calls for changing to the hectopascal the 31st of December, 1985. Some U.S. Aircraft presently have both the millibar and the inch displayed in the altimeters. So, it would not be a problem for these aircraft. Other aircraft, however, that do not have the dual presentation would be faced with the use of conversion charts. And we're not in favor of conversion charts because that's putting another chance for error into the cockpit that we don't feel needs to be there.

In this light I happened to be attenidng a meeting at the American National Metric Council a couple of years ago. And one of the Aviation Corporations, Aircraft Manufacturer, had a slide that showed a conversion chart for altimeters. And I looked at the chart on the slide; and low and behold, one of the altitudes was wrong on the chart. And I had to ask myself the question: if someone can't even make up a chart in an office, can a pilot be expected to read a chart accurately at night and in turbulence and under the stress of normal workload and perhaps an engine out or other problems?

As far as the conversion to the hectopascal is concerned -- could I have slide No. 1, please. It's a 35 millimeter. That's -- yeah. There, it's getting better. That's good.

You can see on the left the 1013 millibars which, as I mentioned, is numerically equivalent to the millibar. Conversion to the hectopascal actually causes a loss in accuracy. That is to say we can no longer set our altimeters quite as accurately with the metric scale as we can utilizing the customary units. This amounts to a ration of 3:1. One one-hundredth of an inch amounts to 10 feet of altitude, whereas one millibar, which is the lowest unit in the millibar system or hectopascal, amounts to 30 feet. So this means to the pilot that he can now -- he cannot set his altimeter as accurately as he could before. This is important to us when we're operating close to the ground. And I think anyone can understand that.

Would you show slide No. 2. If you'll look - try to notice these are made with altimeter settings gradually changing from 2992 to 2993. The changes are very small, but if you look at the digits you can tell.

Let's have No. 3. All right. Now, this is the millibar. You notice that there was about a ten-foot change going from 2992 to 2993. This is 1013. Now look at -- Let's have the next slide. 1014 is almost 60 feet. Now 1160. So, there's almost a 30-foot difference there.

What we're proposing is to take a close look at the decapascal instead of the hectopascal. It's ten units smaller and would actually be more accurate than the inch. Our position is if we're going to make any drastic sweeping changes let's go for something that's more accurate and not less accurate. And let's not take a step backwards.

Another change -- and this hands down the biggest change -- is the replacement of the foot for altitude by the meter. Here again we run into a slight derogation of separation. The proposal calls for 300 meters to be a flight level. Right now 1000 feet, as we know, is a flight level below 290. 300 meters converts to 984 feet. So this means that we have 16 feet of lost altitude with each flight level. Not very much in and of itself.

However, when you get up to 29,000 feet -- let's have slide No. 5, please. What we have at 29,000 feet is a combination of all these 16-foot increments that we've lost all the way up. Could we have slide No. 5, please. This amounts to 500 feet at 29,000 feet. So now we have the same amount of traffic compressed into 28,500 feet that today we have allowed 29,000 feet for. Doesn't sound like a great deal, but 29,000 feet is a critical altitude in terms of separation, especially today.

If you look down in the lower right-hand corner you'll see some of the allowable tolerances we live with today. And you can see that in the worst case, an aircraft traveling eastbound with allowable system errors, that being ramp altimeter error, allowable difference between the captains and copilots, altimeter at crew's altitude, plus or minus 100 feet for pilot error, which is built into the system, and as Captain Stenberg of IFALPA pointed out, also, the density of the aircraft, which from the bottom of the bell to the top of the tail, it can be from 30 to 50 or 60 feet, all these errors start -- allowable errors start adding up. And you get to the point where you can have about 1050 feet worth of allowable errors. Statisticians will be quick to point out the fact that the odds of this happening are minuscule. Something like on the order of one in ten to the seventh power. We wouldn't argue with that. The point being, if you run yellow lights all your life you may do just fine and then again you may not.

Theoretically, in the worst case, an aircraft traveling at -- westbound at 28,000 feet with altimeter errors and allowable pilot errors to the maximum and one eastbound at 29,000 feet could conceivably pass with the aircraft that's supposed to be at 28,000 feet higher than the one that's at 29,000 feet. So, our position is, we don't feel that the separation standards that we have today should be decreased anymore than they are. If anything, they should be increased, especially in view of some of the statistics we've heard about projected in traffic counts in the year 1990 and 2000.

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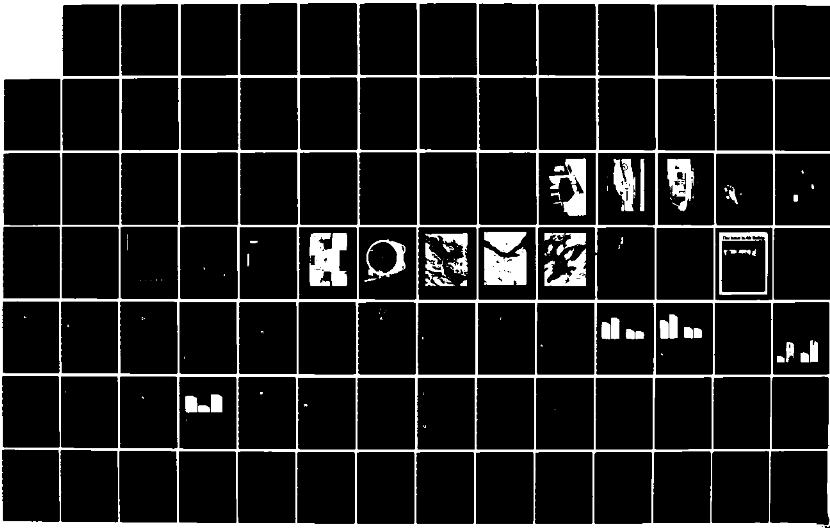
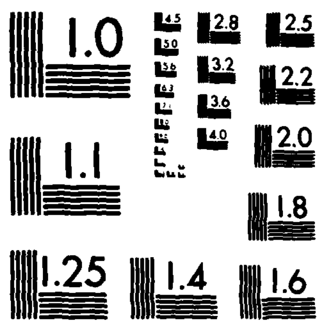




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Altimeter Design. If we could have slide No. 5, please. Correction, No. 6. Can we have the next slide, please. This is actually a drawing of an altimeter that came from a blueprint of an Aeroflot aircraft. I'll show you another one in just a minute, but let's look at this one for the moment. It's the closest thing to the type of display that we're used to. The needle is at 12 o'clock when you're on an even flight level. We're used to this. Couple of things about this, though, that are unusual. If we level off utilizing metric instruments -- and this is when -- measurements. This is when we get into the Human Factors elements. You can see that if we level off at what would normally be 1000 feet in metric units, the hand of the altimeter will be on the three. 2000 feet, the hand would be on the six. 3000 feet, the hand would be on the nine. However, these numbers do not repeat themselves each revolution because the next sweep of the second hand your flight level, the needle will point at two then at five then at eight. The next revolution it will go one, four, seven. And then you start over again. These are the Human Factors type things that we'll have to look at if and when this comes about. And ICAO is constantly putting the pressure on the U.S. to make this change.

Another factor is -- and the Human Factors element of this is that needle, because it's only going to move from the 12 o'clock position down to three for the equivalent of 1000 feet, is going to move a lot slower than pilots are used to looking at. In fact -- as a matter of fact, it will be moving three times slower. A little bit of difference there in our sensory perceptions of how fast we're gaining or losing altitude.

Now, let's have the next slide. This is a real dilly here. This is also a Russian Altimeter. To me it looks like an accident waiting to happen.

First of all, the zero is at the bottom at the six o'clock position instead of the 12 o'clock position. Secondly, each flight level -- for each flight level the hand again would be in a very unusual position. Another point about this altimeter is the fact that the -- you'll notice small numbers alongside of large numbers. With each revolution you transition from the small numbers to the large numbers. And then the next revolution back. Another point about this particular instrument is the fact that the hand in its present location can partially cut off the eight. It doesn't in this particular picture; but a little bit more to the right and it could partially cut off the eight, make it look like a three. And you'll notice that the hand points to the big three. And when you look at the three, the hand tells you that you're either at 4300 or 4800. Then you refer to the digital box to determine which you're at. However, the hand covering up the eight making it look like a three, you could still be back in the same situation.

Okay. That's enough of that slide. Thank you.

Next I'll talk about a proposal that has been put forth by an airline pilot from SAS, Scandanavian retired pilot, has some good ideas. Basic philosophy sounds good. And yet there are problems with this system, too. It's called the ICA System, I-C-A, stands for International Civil Altitude. It's based on air density above the demarcation zone, which they specify somewhere between 20 and 26,000 feet. Up to the demarcation zone they propose to use meters. Above that your altimeter would read a number which would basically reflect air pressure. So, in effect, hopefully, if this were designed properly and were workable, it would absorb altimeter errors at higher altitudes. One good thing about this system is the way they numbered the flight levels from the Human Factor standpoints to pilots that are used to flying with the customary system. This is a big plus. The flight levels that they proposed are on the left. And you can see that flight level 28 is almost 28,000 feet, 27,779. This numerical equivalency is retained throughout the spectrum fairly closely until you get to the higher altitudes. That's one real good thing about it from a Human Factors standpoint because a pilot that's used to flying with the customary system won't have quite the adjustment to make with his proposal.

Now, some of the bad parts about the system are the fact that there is reduced separation above 29 -- correction, flight level 290. Today, as you know, the system is structured for a 2000-foot level above -- flight levels above 290. However, with the system they are proposing, flight levels would continue on up from 29 in numerical sequence. You'd have flight level 30, 31, 32 right on up to 50 or 60.

There are some problems with this aside from separation. Could we have slide No. 8 now. If we look down at the bottom again we can see the types of errors we're talking about. At 35,000 feet the actual separation between ICAO level 34 and 35 is 1241 feet. And we can see on the right that there is only 1000 -- that 1050 feet is eaten up by these allowable system errors. And I have to apologize. I used that error earlier for the 28,000 feet. It's a similar type situation, but I won't bother to trouble with the numbers. It's the same type of situation.

Another problem with this system is the fact that the altimeter is above the demarcation zone. In order to accommodate this new philosophy there's a cam built into the altimeter which comes into play at the demarcation zone. If this were to be adopted, it's very obvious that pilots would have to have an indication in the cockpit as to the position of that cam to ensure that it was not only inserted but was in the proper position because that's the basis of the flight levels. And if the pilot -- if the cam were not inserted or were not in the proper position, your altitude could be off dramatically by three, 500, 800 feet, possibly higher when you get up into the, say, 45 - 50,000 foot range, in which Lear jets operate. Obviously, another thing that would be required would be a means for the pilot to insert and/or adjust this cam manually from the cockpit, should it not function automatically.

Another problem with this concept has come into play or come to mind recently by virtue of the fuel crunch that we've all felt. In the past we've been used to flying our arrival paths by the charts. Just as depicted pretty much. Now, in recent years we've -- with the fuel crunch we are all trying to save our companies fuel, fly the airplane to its optimum efficiency. And each company has come out with its own desired fuel profile to save fuel. So now we have to make this fuel-efficient profile fit the star, the standard arrival route. Sometimes these don't match too well. This calls for extra mental gymnastics in the cockpit on the part of the pilot. It seems as though no sooner do you get the situation resolved then center or approach control will slow you down, which changes all the parameters again and negates everything you've figured up. And you have to go through the process again. And about that time they vector you off course which changes your distance to the airport, and you have to do it again. These are Human Factors type things that go on in the minds of the pilot that would not even be obvious riding the jump seat watching the operation. A person watching the operation might think the pilot is sitting there looking at the instruments or looking out the window for traffic when, in fact, he's thinking about these mental calculations in order to put the airplane down on the pavement without making a steep descent and in a manner which will satisfy the requirements of crossing restrictions on profile descents and save fuel. We've got about three or four things that we have to work on at one time in addition to the normal cockpit workload.

Another problem with this system is the fact that because the levels vary above the demarcation zone the pilot no longer will be able to use a 3:1 descent ratio or a 4:1 or a 2:1. We're not really quite sure how they may work out becaue now the vertical and horizontal dimensions don't match up because the vertical dimensions will vary as we go higher. So this means that we'll have to look at another means of planning our descents, particularly at the higher altitudes above the demarcation zone in order to save fuel and satisfy ATC Restrictions. This brings out a requirement that we feel is very important for vertical navigation in the cockpit. The pilot workload is at a peak. It's not going to get a great deal better even in spite of the new inventions. As it's been pointed out, they do save a lot of work in some areas; but it seems like some of this is negated a little bit by the fact that they keep adding more and more black boxes and alert signals in the cockpit. Ten years ago or fifteen years ago we didn't have radio altimeters. We didn't have GPWS. We only had two digits on the transponder instead of four. We only had four digits on the radio instead of five. It seems like the cockpit is ever expanding, which increases workload.

Vertical Navigation Systems should be incorporated into the flight director and autopilot so that the pilot could insert information in the computer as to the requirements for his fuel descent profile as well as ATC crossing restrictions and be provided with flight director guidance which would enable him to fly the aircraft down on an appropriate flight path to meet the restrictions.

As far as this system is concerned, as I mentioned at the outset, some of the ideas of the system are good. The numerical equivalency to our present day numbers is good. If, in fact, the system were to absorb these allowable errors, we think that would be a plus. That's something that someone is going to have to study and take a real close look at. The important thing is that this demarcation zone should be set as low as possible. The other aspect of it is that the exponent that they use to determine this variable altitude should be looked at very closely to ensure that it does, indeed, absorb all the errors that we live with today.

The other change that is proposed by ICAO is the conversion of the nautical mile to the kilometer. For years the nautical mile has been the standard. It's one minute of arc at the equator, as we all know. It was used by sailors in the old days and early aviators. It's been around quite a while.

We wonder sometimes if there really is a need for the entire world to convert to metric or one particular unit. Astronauts use radions for their distance when they're going to the moon. Are we going to require them to use kilometers? What they're doing really doesn't affect what's going on down on the earth. They're in an entirely different environment. Although ours is not so glamourous and certainly doesn't require the skills that they have, it really doesn't affect what goes on on the earth, except between us and the controllers. So we really wonder if it's really necessary. We are in favor of international standardization, but we think that in-depth study should be accomplished to determine what is the best standard and makes the most sense, and let's go with that and not change necessarily to metric or any other system simply for the sake of changing.

One of the biggest areas of problems with Metrication will be the transition. A fast transition has some advantages in that it will practically eliminate any necessity for conversion charts which we feel is very good.

However, there's a problem with training to try to convert in a very rapid manner to ensure that all the crews are used to the new parameters and can make the changeover in a very rapid manner.

Some of the problems with the slower transition, of course, are the obvious: the fact that we would have to use conversion charts, the possibility that we would have dual instrumentation in the cockpit. This could in itself lead to human errors. The pilot flying in a mixed environment could be instructed to level off at 10,000 feet. Instead he levels off at 10,000 meters. Or what's worse, vice versa. At any rate, he's going to be at the wrong altitude and is subject to conflict with other traffic.

As far as the fast conversion is concerned, someone is going to have to look at the manner in which that is conducted.

How do you change an entire airline fleet, airforce fleet, general aviation fleet in a very short period of time? Say, a matter of a month or even six months? Do you chagne the airspeed indicators in all the aircraft at one time and then go back and change the altimeters and then the vertical speeds? Do you do them all at once? Do you change the left side of the cockpit then the right? You lose redundancy that way. You can't really change one instrument at a time when they become due for overhaul. Some of the proponents for Metrication have been pushing this philosophy to try to sell it because they know that neither airlines and the military can afford to pay the several billion dollars required to make these changes overnight when they have perfectly good instrumetns in the aircraft already. But the fact is, you can't change the instruments simply when they're due for overhauls at different times, which means that you might have an airspeed indicator in the captain's side of the instrument panel that is due for overhaul and gets replaced with a metric airspeed indicator. Now the captain has metric, the copilot has nautical or knots. The same thing holds true for altimeters and vertical speed instruments.

In summary, I would like to pose some thoughts for particularly the FAA and the transpotation agencies of the Government to consider: number one, that any changes that are made are made so that we enhance safety, we enhance operational capability and certainly don't go backwards.

A prime consideration should be a display of the flight instruments that will be in the cockpit, and certainly new technology should help us in that area.

The flight levels that are proposed by the International Federation of Air Line Pilots Association, which, I might mention, the Air Line Pilots Association, USALPA, does not endorse at this point. That should be looked at very carefully. And, if possible, the good ideas should be extracted from that concept and, of course, the others discarded.

We don't feel that dual instrumentation is a very good way to go at this point because, again, of the Human Factors possibility of reading the wrong instruments. It's also been suggested that airspeed indicators, as an example, might have an inner and outer scale of knots and nautical miles. This would make the instrument fit in the aircraft all right. You wouldn't have to have another slot on the instrument panel, but again you create the possibility of another error for the pilot in reading the wrong number at the wrong time when he's busy.

Our purpose, as I mentioned in the beginning, is not to shoot down Metrication but to try to wave a yellow flag and point out the fact that there are some serious problems that need to be addressed and some studies that need to be accomplished before continuing with the program.

I'd like to pass along a little story that I think will be of interest to you. There was a train going up a very steep mountain. And in that train were President Reagan and Carter and Kennedy. As the train got near the top of the mountain, it stalled out. There was just too much weight, and the engine just couldn't cut it. So it just stopped. The Engineer came back to the front compartment and told the people what was happening. President Reagan said, "Well, that's no problem." He said, "We can just disconnect those last ten cars." He said, "Those people have been riding free anyway. They've been given a free ride this far up to the top of the hill. Just disconnect them. Then the paying passengers can go on over the hill." Kennedy piped in and said, "No. We can't do that." He said, "Those people have been riding free for a long time. They're used to riding free. It wouldn't be right to turn them loose. They deserve to continue to ride free because they're used to it." President Carter piped in and said, "No, you're both wrong. What we should do is pull the shades down and pretend we're going over the hill."

And I'd like to leave you with that thought today. When it comes to Human Factors area, let's not pull the shades down and do any pretending. Let's look at the why's as to why these accidents are happening and try to get them solved. Thank you.

MR. HAY: Don, I'd like to just suggest one thing to you. Tomorrow I would hope, in your workshop as your issues are formulated and suggested actions directed toward them, that we really ask the question: What is the safety issue that demands the change in the first place? And/or is there a market that demands this? Or where is the market for aviation and aircraft? And does that market demand such a change? Those are issues that I think are often-times set to one side.

I thought that was a very thought-provoking presentation on your part and one that all of us have a very, very serious interest in.

Now, to look at tomorrow. First of all, we'll have Guice Tinsley, who is the Chairman of the FAA Human Factors Task Force, now for the FAA. And he'll present his outline of how he expects things to operate tomorrow. And following that we'll have a viewing of an Air Force film. Following that we'll have a reception at 5:00. And right now I'll turn it all over to Guice Tinsley.

H. GUICE TINSLEY: Thank you very much, Cliff. We are going to stay on schedule. So, I'm going to keep my remarks very brief. We are going to the workshop format tomorrow because we do want to give everybody an opportunity to participate fully and express their point of views as we attempt to formulate the significant safety issues. So, we have gone to a five-session format. And what I'd like you to do is select one of the five. Use the blue sheet, and we're filling out a sheet for two reasons. First, we'd like to tailor the rooms. We've got different size rooms. So we need to tailor the rooms to the group. And the second, it serves as a locator for us so that if you have messages, the messages will be delivered directly to the room. Many of you have turned them in. But if you haven't turned them in, would you fill them out now, please, and Les will get them as she walks along the aisle. Mine's right here, Les.

It's very important we communicate clearly. Now, I realize we're not going to agree on all the issues. But I think as we leave here we certainly should have an understanding of why we disagree. And my favorite story about lack of communication has to do with the farmer that had the horse for sale, a very inexpensive animal at $50. The buyer came up to him and said, "Tell me about your horse." "Well, he's for sale for $50," he says. "It's a standard animal, seven-year old gelding, very nice disposition, but he ain't too good looking. He ain't too good looking." The buyer said, "Let me see the horse," went out and looked at it and said, "Fifty bucks. I can't go wrong. I know I can turn this over for a hundred tomorrow." So he said to farmer, "Deliver the horse to my barn." The farmer dropped the horse off that night. The next morning the new buyer got up, went out, and tried out his new horse standing in the stall. The horse had a hard time getting out, bumped into the side of the stall, walked into the side of the barn, immediately bounced off that and hit a tree head on. Well, it didn't take this new buyer long to figure out this horse was blind. So he raced back to the farmer; and he said, "Now I can't understand this. For fifty bucks you sold me this blind horse. Why didn't you mention this, say something about it?" He said, "I told you twice," he says, "He ain't too good lookin."

We may not be completely blind; but in your views sometimes maybe we "ain't too good lookin."

Tomorrow's your chance to open our eyes and give us clear insight as to what you see the safety issues in these various five areas.

Now, we've got the five groups: General Aviation, Helicopter, Airline, ATC and Metrication. We've got the forms filled out. The groups will be posted, and I think Les will probably have that done by the time the reception is done. They will be posted in the lobby with the room numbers.

Schedule 9:30, and there will be coffee in the rooms. So take your breaks as you see fit. There's no problem, we would like to hold the lunch to 12:30. And we do that if you're going to use the cafeteria here because we like to give the people that work at TSC an opportunity to get in before 12:30. If we hit them with 100 people, it overloads the facility. Then we will go back after lunch, continue discussion for another hour. At 2:30, the break at that time we will have coffee and donuts right down at the entrance to the auditorium. We'll reconvene back here then at three. The group leaders from each of the discussion groups will go through a summary. And I've allowed twenty minutes for each of the five groups, twenty minutes each, that is, so that they can give a summary of the discussions that went on in each group so then all of us can benefit from what went on in those discussions. I say, messages will be delivered if they come in to you, they will be brought directly to your room. You don't have to worry about that. And if possible -- and I realize this is difficult -- if we could come up within your discussion groups with a prioritized listing of the significant issues, it's of great value to us as we then go into our planning process and try to turn out a program plan for an Advanced Human Factors Program.

Now, the proceedings of this workshop will be open for an additional 30 days. If after you leave here you have further thoughts, comments, recommendations, in written form, and send them to Les Foster with the TSC address that you have on the front of your agenda. Okay.

Now, you've met most of the people through their contact here at the podium that are going to lead these workshops, but let me just run through it quickly. General Aviation. You haven't met Archie Trammell yet. Archie, are you still here? Would you stand up so people could see what you look like? Archie will be leading the General Aviation Group.

You've met Bill Connors, Airline Operations, true Human Factors expert, test pilot with industry and is an active Airline Captain. Clearly, he understands the full spectrum of this issue.

Mike Simons you met from PATCO.

Dora, are you here? Dora Strother is going to be leading the workshop on the Helicopter Issues. She's the Chief of Human Factors Engineering Group at Bell Helicopter. Is Dora here?

And, of course, Vick is going to lead the Metrication discussion. And Vick is the Chairman of the Air Operations Subsector of the American National Metric Council Aerospace Sector Committee. Maybe he can explain to us what that all means.

One of the concerns we've got with the metric issue is that the ICAO Annex 5, Ammendment 13, becomes applicable November 26, 1981. Now, that's the units of measurements used in airground operations. It's time that the policy be formulated of what we are going to support. And I say, "we" as a country, collectively. This is your time now to input to us as we develop our policy statement for exceptions that will go to the International Civil Aviation Organization.

And the question I keep asking -- Vick touched on it just slightly. He stated, you know, "Why?" I'd like to start with a basic "Why are we going to do all these things.?"

Hopefully, the workshop sessions will do several things. It will allow you a chance to express your point of view. I hope we come up with some specific questions and issues in a prioritized order; and again, 30 days you can give us written inputs. And we will publish the final proceedings in an additional 30 days. So, in 60 days you will receive a copy of the final proceeding.

Now, I entered this film as optional viewing. It is titled "A New Breed of Cat" which is the Human Factors Revolution. It's an Air Force film, and it goes through the requirement for Human Engineering, the evolution of the discipline, the desire for the interface between the man-machine in the working environment. It touches on aviation, instructional methodology and advanced use of simulation.

Now, if you know what the COMBAR man is and HEADCAT, you're above this film; and you're wasting your time to watch it. If you don't, you may find it interesting.

So, if we could have the film, please.

(Film presentation at 4:30 p.m.)

GUICE TINSLEY: I'll close today's session with a paraphrase quote from the former Texas Congressman Sam Rayburn. After a particularly long day of hearings he came up and told the group, "We can continue to sit here and be small and stupid or we can go upstairs and have a couple of drinks and be big and smart. So let's go upstairs and get smart."

(At this point the proceedings adjourned for the day at 5:00 p.m.)

SESSION 3
(March 19, 1981)

MR. TINSLEY: Today is going to be general summary session and closing remarks. A number of people have airplanes to catch, so we would like to stay to the schedule as closely as possible. We will start, first, with the General Aviation Group.

ARCHIE TRAMMELL: Thank you.

We had a lively discussion at the general aviation session, a very good one, and I want to publicly thank those who participated in the discussions that we had and for all the information you passed along to me and to each other.

A little housekeeping note: Someone asked about direct quotes because we were recorded, and you can rest at ease that session will be summarized. The information or what you said will be summarized rather than direct quotations of every single word that came out down there. So if your tongue slipped, that won't go on to posterity. I hope I can do just half as good a job at summarizing what we discussed as the participants did in the original conversations.

Looking at -- we basically split the discussion into two parts. We first addressed the problem or the safety implications of current aircraft. That is, aircraft that are in the fleet that have been certified, that we're using today. What can we do from the Human Factor standpoint to reduce the accident rates with those aircraft and also the pilots who have been certified and trained? How can we get to them in some meaningful way that might result in a reduction of accidents? The concensus of the group seemed to be that we really need more information on these people who are involved in accidents. And you heard that from this rostrum yesterday. Several people said that we need to gather the data on people involved - a greater depth of data. And I personally feel that's very true. We don't know a lot about these pilots who are involved from the standpoint of their psychology, their background. We're currently not collecting data on what kind of equipment was available to them. For example, in the case of a thunderstorm accident, the data isn't necessarily gathered as to whether or not they had a radar system on board. We don't know whether they had flight directors on board. And so this group felt that we should concentrate on getting better quality information on people who are involved, and that would help us in the future and some of our activities to eliminate accidents in the future.

Along with that, this group talked at some length about the safety reporting system and felt that activity should be emphasized and re-inforced because there's a lot of information that's gathered. And in this case, it's informaaion on incidents, things that did not result in an accident, but could have. And through some action of the pilot or the crew or the ATC system or whatever, the accident was prevented. And I felt that if we had more of that information, it would be good for us. And they were referring to things like some of the magazines do. For example, I learned about flying in Flying Magazine, which I read for many years. I felt that was very good information for the current pilots in helping -- it would be very useful to them in preventing future accidents.

A third thing that was discussed in connection with aircraft that are currently in existence was the problem of the second owner, or I could say the second and third and fourth owner of that equipment. It was observed that many times a second owner of the equipment doesn't get the in-depth training that the original purchaser got. And we're talking about the aircraft itself and also the equipment on board that aircraft. Many times, speaking to the equipment that's on board the aircraft, the second owner really isn't that interested in it. That is, the first owner, when he bought an RNAV System, for example, bought it because he was very interested in it, and he'll put forth the effort to learn how to use that System properly both as a safety tool and as a tool for helping him get better utilization of the aircraft. But when that airplane is bought by another owner, the second owner really may not be that interested in a particular piece of equipment, and this can lead to some problems.

We're aware of that in the case of some of the jets today, the small jets especially, where they're going into ownership, second and third party. They're not getting initial training that they should get. And as a consequence, some accidents have resulted, and this group felt that should be addressed.

A fourth thing that was mentioned is that we may not be making the best use of the information that we already have relative to Human Factors. We may not be assigning the most qualified people to some of these -- in some of these areas to work out the solution to them. And so it was felt that we ought to look at that more closely.

And, finally, there was a mention -- and, again, we're referring to aircraft that are currently in the system and aircraft -- correction, pilots that have already been trained. There was a feeling that we need to know more about the effect of recency of experience or recent experience on the accident rate. So it was felt that a study is needed in that area.

We then turned to aircraft of the future. That is, aircraft that have not yet been designed and certified from a Human Factor standpoint. What can we do that would most favorably impact the accident record for these aircraft, say, that are yet to come? The agreement was that we need to have a focus for all the research that is being done now. Research and development, I should say. There was some feeling that this equipment, this exotic equipment that is coming along is not really being integrated into a truly integrated and cohesive package for the pilot to work with in general aviation, and certainly not as occurring with the military and with the airlines. And so there was a feeling that there should be some focal group or organization to make sure that all of these exotic things are packaged so that they have the greatest impact on aviation safety.

A second area was in -- for lack of a better term -- the packaging of weather information. It was felt that there is a lot of information on weather simply not getting into the cockpit today and that needed to be considered in the design of future aircraft. Interestingly, this group hadn't a whole lot to say about crash worthiness of future aircraft except to say that, like apple pie and motherhood, everybody's for it as long as it doesn't decrease the useful load of the airplane or add to the cost of the airplane.

Some discussion about the noise levels of cockpits versus pilot performance. And it was felt that more study is needed in that area. Looks like there's some connection. Looks like, sometimes, noise interferes with a pilot's ability to see. That is, when his ears are impacted with information, that part of his brain that assimilates information from his eyes may go into the coast mode, but more research is needed in that area.

We then turned to the principal cause of accidents, both today and as we see them continuing. We first discussed the weather accident, primarily, the

VFR and IFR conditions and what can be done to reduce accidents from that cause. And the group very strongly felt that the work that's currently under way aimed at reducing the number of hours that are required before a pilot can get an instrument ticket, that work should be continued and be encouraged because it was felt that that's probably the best thing that we can do to reduce this type of accident is to encourage the pilot to get an instrument ticket so that he can operate in adverse weather when he encounters it. It was agreed, by the group, that although we need to keep working on the problem of understanding what the weather is and getting that information into the cockpit, that that would probably never totally solve this problem of continued VFR because, too often, there is just a little bit of a weather, maybe only 10 or 15 miles of weather. That's the pilot's undoing. And unless we know what the weather was over every square inch of the country, we might not be able to solve that. So it was felt, again, that the best thing to do was to qualify that pilot to fly instruments so that when the weather was doubtful, he could file and complete the trip safely.

The consensus was of the group, both in terms of existing aircraft and future aircraft - was that probably the best area to look at is in training. Now, there were some who were -- had other feelings about that; that hardware can do quite a lot for us. But we had a lot of discussion on the need for better training which is an age old suggestion, of course, training that would be aimed at modifying the behavior of the pilot with emphasis on cockpit discipline, as the best preventative, particularly for the stall spin and mush accident and for those accidents that might be classified simply as miscellaneous - that is, all accidents other than the purely weather related accident or the stall spin accident.

That is just a very brief summary of some of the things that were discussed up there. I'm not quite sure what form -- what we discussed might be available to all of you, but those who were in the group, most of them, were taking notes heavily and I thank you for the discussion that we had and hope everyone got half as much out of it as I did. Thank you very much.

MR TINSLEY: Thank you very much, Archie Trammell. Let's go to the airline group and Bill Connor.

CAPTAIN C. WILLIAM CONNOR: Speaking of fatigue, we were able to break it down to about six thousand items. We had a very interesting conversation and it was very enlightening. And what I'm actually going to do, by recommendation of one of the people that was there, which I thought was a good idea, is I'm going to list all these items. I'm going to send it out to them and I want them to list them in their order of priority, which you all get a copy of, also. But nobody can really lock in on what were the most important items in the Human Factor research area. But what we did do -- I'll give you a list of some of the ones we looked at or discussed.

Human Factors in certification: The information alluded to between the manufacturer and the user and the FAA, the user and the manufacturer, industry-wide. What parameters are used and how are acceptable levels met? And, of course, we're saying that the crew should be taken into account, that you're looking at the Human Factors as to the acceptability of this aircraft to fly with 2, 3, 5 or 6 people, whatever. It has: What was used? How was that profile drawn up? What were the subject pilots? What was the environment they flew in and how representative of the real world was that environment in the parameters that were used?

Circadian cycle was talked about quite extensively. Can we measure it in simulation? Can nutrition help decelerate or accelerate it? There has been a study on this. If we're going to have to fly these cycles on airplanes, the economics of it which are here with us, if that's going to be a steady item, a non-breakable item, then we're going to have to have some way to put the man into the loop so that he can fly in those out of synch conditions. A nutrition area study showed that you could either accelerate or decelerate the synch, or you could actually accelerate or decelerate depending on which way you wanted to go. I think this is an area which ought to be looked into to help the pilot better do the job on the flight deck.

Identification of Human Factors problems: How do we identify it? How do we measure it? To what level do we define acceptability? And then establish a foundation to solve those four things.

Communication: Communication of the computer, computer communication with the flight deck automation, communications with the external environment and the Human Resource management communication problems.

Software maintenance: This is going to be a problem. This instrumentation we have now -- are we going to be able to establish a commonality among all the airlines? Otherwise, the cost is going to be enormous in the next set.

How do we effectively monitor flight deck automation?

Accident incidents: How they fit into the Human Factors role? CRT colors that were about to be embarked on in the fourth generation aircraft. Mainly, military pilots have been flying these displays. An interesting point was brought up that in our Class 1 Waivers - there is a waiver on color vision. What we would do with those people, they would have to fly those CRT's with multiple colors that have a color vision problem. Also, the frequency synch of the CRTs when there are more than two or three in the cockpit.

The man instrument interface as it applies to today's cockpit management: How do we handle the pilot's problems today?

Complacency: Has the person been trained adequately to monitor or support his flight deck automation system or the environment he is now operating in?

Another area is the major concern of risk, predictive risk, liability and the economics of these things, these three. Again, we get back to fatigue. What are we measuring, physical fatigue or safety? And in safety, how do we establish the acceptable performance level via age or experience? And in this system, how do we establish the Joe Average measure because, as you have seen in so many areas, these tests that we run have been with outstanding pilots, probably up in the upper 10 percent area being test pilots or the cream of the crop from various agencies or airlines or whatever. So we're ascending boundaries from the top priority or group of pilots. We've got to find out who is the Joe Average and what is his capability and how can he actually function with this system in this environment? And once we find out who this Joe Average is and what his level of ability is, then we have to develop measures to measure his performance level in that environment.

Again, we came back to the automation in the flight crew interface problems, system performance requirements, and in the dispatch, the aircraft operational control, the combination between the pilot in command and the joint responsibility with the dispatcher, his problems that are associated with training, work load requirements, utilizing the computerized form that they use. Mental fatigue from long periods on a CRT which they're monitoring, their duty hours which are ten hour set ups now, must be studied. And they go into a rotating shift which is also another form of your circadian rhythm problem. We had a tremendous amount of discussion in there, and actually all we did was keep making the area broader and broader and found more problems. As soon as we identified one, we found three more. But what I'll do is, after I reduce this information, we'll put it out to the people who are on the committee and let them identify the areas of the highest priority and then once these things are identified, I'll ask them, in their one comment area there, that they tell me: Why they picked their number one? How they arrived at that particular selection? Mainly, because after we've talked so much today, after we've left here for about a day or two and let some of this information filter back through our own system, our own priorities may have changed. And once we have that back, then I'll re-submit that within the next three weeks.

Thank you very much.

MR TINSLEY: And speaking for the Air Traffic Conrrol Group, Michael J. Simons.

MICHAEL J. SIMONS: Thank you. The Air Traffic Control Group met this morning, and met again after lunch. We had a frank, cordial and productive discussion, as the State Department community would put it. There were quite a number of different points of view represented, and I think a lot of them got aired, aired very well, very articulately.

I would like to thank everybody who came. Everybody who came participated fully, and it was a very good session, I thought. I was particularly appreciative that in all five hours that we met, nobody once asked me when the controllers were going to go on strike. We talked about a broad range of issues, the planning for the next generation of air traffic control computers, current Human Factor issues, ways of measuring those issues, ways of measuring those factors, I should say. We talked about weather dissemination. We talked about human errors and system errors, and several other things.

The group came up with a list of nine prioritized recommendations to the FAA, most of which deal with systematic concepts, things that should be looked at. A few of them deal with things that should be addressed -- issues that should be addressed at the next one of these planning sessions in May.

In the context of a command control system, air traffic control system is investigating the communication aspects with a view towards reducing errors. Recent reports have emphasized the criticality of this problem. Reassess the role of the controller and the pilot from the human factors and system engineering perspectives. Thoroughly study the weather gathering, interpretation and weather dissemination processes. To what extent do we want to place the controller in the weather business? How much data and what data do we want to give him? How much training do we want to give him in assimilating that data? How much do we want to make the controller the weatherman? Who should have the overall responsibility for rerouting traffic in severe weather situations? What alternatives are there to reliance on the controller for the delivery of weather data to air crews? What is the possibility of using the Center Weather Service Unit, the CWSU, as a direct line between all surface personnel and air crews?

The FAA should investigate controller/pilot communications processes with emphasis on determining behavioral and psychological aspects involved in normal performance as well as stressful situations and in error situations. In this area, the FAA should determine valid knowledge and significant gaps in that knowledge. The FAA should commission a baseline study on how the en-route controller assimilates and uses the information available to him at his current work station. This should be done before setting the parameters of the next generation of RDP computers.

The FAA should place continued emphasis on simulation studies by various elements of FAA and outside research organizations to study complex communications, procedural and organizational issues. The FAA should encourage the cooperation of controllers and pilots in real world studies to supplement these simulations.

The group also made two recommendations that apply, specifically, to the next FAA planning meeting which we have been informed is tentatively scheduled in Atlantic City, tentatively in May. We recommend that NASA prepare an ASRS data base study to categorize and prioritize their traffic control problem areas. For example, pilot/controller information transfer, controller information management, etc. This for the purpose of designing a research program. And the study should be presented at the May 1981 Air Traffic Control Human Factors Workshop to be held at the Tech Center.

NASA should be asked to make a presentation on automation at the same meeting. Specifically, they should be asked to present an overview of what is currently known about the proper allocation of cockpit tasks between man and machine, what remains to be determined and the applicability of current insights to the air traffic control system functioning.

Thank you.

MR. TINSLEY: And for the helicopter group, Dora Strother.

DORA STROTHER: We had a list of about a few thousand items that we would like to bring up with you today. However, I will try to limit them.

I couldn't help but want to share with you, however, some of the problems that I have listened to over the various days about the definition "Human Factors" -- I got some correspondence the other day directed towards my group in the human factory. I think all of us have been confused with the human resources group, and I imagine that you all get as much mail that is confusing to you as it is to me. I'm constantly encountering people who think they're Human Factors experts. They're human after all. Their mothers were before them; their mothers before them. But I must share with you one of my favorite definitions and it applies to Human Factors and, particularly Human factors in safety aspects that we have been considering these last two days. A little before my time there was a cartoon character, an Irish bartender named Dooley. Any of you who have ever seen Dooley's cartoon know the great truths that Dooley gave to the world and one of them -- my particular favorite -- is, Dooley said, "It ain't what you don't know that will hurt you. It's what you do know that ain't so."

With respect to the items that we discussed in the helicopter workshop, we wish to review with you some of the problems and some of the research areas that we discussed. Throughout all of these areas that I'll try to list here, we feel that there is a distinct need, first of all, to determine the severity of the problem. Is this a real problem among the industry, or is it just our ideas and how severe are these? Two: To identify and structure or delimit the problem and to examine it in depth. Three: To define a program to educate the appropriate sector. This might be the pilots; it might be management. Whoever is appropriate in this area, often is the person who makes the decision, and sometimes is not based on Human Factors evidence. And then, four:

To improve the item. So these four items we'll keep in mind as we go through this list. Then, as has been discussed yesterday, we feel that there is a distinct need for an in-depth study to identify Human Factors causes for accidents. And the things that we would like to list are those items that we feel are different between rotary wing and fixed wing. There are many items that we share in common, but these will be those that we feel are different.

The things that we listed for problems and certification were also those that were listed for standardization. These include the development of data to permit Human Factors considerations in the certification and standardization of new displays and new controls, to assess the transfer of training from current displays and controls to future displays and controls, to assess the transfer of training from rotary wing to fixed wing and vice versa, and the use of simulation and this simulation of systems in the certification process.

In the area of air space or air traffic control, we felt there were some distinct problem areas and that one of them is the request of the individual helicopter owner for his own IFR approach route. This may seem strange, but this is already starting to be a problem. If you spend a couple of million dollars for your own helicopter, you would like your own IFR approach route to your corporate front door. And how in the world are we ever going to handle that in the air space control?

Then, the means of identifying a helicopter when the helicopter is within the radar clutter. If the controllers can't see the helicopter on the scope, there is the problem of controlling him. The problem of air traffic control or air space control with helicopters in remote areas, such as the off-shore rigs where there are now thousands of helicopters carrying, I imagine, from 6 to 16 people in each helicopter, sometimes more.

A study of the mix in the air traffic control system of slow and fast aircraft and the special holding pattern problems that are needed by the slow aircraft, the helicopter.

And then the problem of controlling multiple helicopters around special popular events, such as the Super Bowl or races or political events, around disasters. The control of medical evacuation helicopters.

Then we addressed an area of cockpit geometry problems that are unique to the helicopters. And let me insert here that these are in no priority.

One of our problems is vision. We have special visual needs for the helicopters. We need a better definition of visual restrictions. I'm sure all of you in the design process have the same problem that we do. The problem of having the obstruction measured in inches rather than in visual angle. The problem of the visual requirements -- and here, of course, as we said in the beginning, it's necessary to go to the users and determine some of this. This includes a survey of the over-the-nose visibility, the side visibility. What happens if we're making a ten degree IFR approach angle with between a three and, I guess, a six or seven degree nose up angle, what happens to our over-the-nose visibility requirements?

Then, one of the major problems was the seat design and back problems that the helicopter pilot encounters. And we realized that the helicopter, the young helicopter pilot does not understand the problem that he's going to face after a few thousand hours in a helicopter.

Another problem is the anthropometry requirements for the flight crew. And we suggest that, since many of the manufacturers are selling worldwide, that the requirement for a coordination between the FAA, the CAA, NATO - that those be established as well as the male-female various requirements for anthropometry.

We felt that there was a need for a user survey in terms of, first of all, design. How did the users feel about vision, about switchology, about fatigue, self-imposed stresses, weather and environmental problems? And we felt there was also a problem in training and transfer of training between fixed and rotary wing. And a problem that existed in some quarters about the priority given to rotary wing aircraft. Was this, indeed, a more complex or less complex aircraft? If you had a few thousand hours as a fixed wing, was switching to rotary wing going to be a piece of cake?

And there is a problem with external lighting. Is there a special need for unique lighting for slow moving traffic? I looked outside my window yesterday morning, looked in the clutter of the buildings across the river, I could see a light move, but I couldn't see the helicopter.

Then we felt -- we didn't get into this in detail, but we all felt it was a common need -- to study the design requirement of heliports. The problem of lighting obstacles around heliports, the special problem of low altitude navigation aids.

And then we wanted to reiterate the things that Dr. Bertone brought up yesterday, and that we feel that there is a need for a task force composed of people concerned with the helicopter Human Factors problems to meet with the FAA and define these areas in depth. Thank you.

MR. TINSLEY: For the Metrication group, Bill Thievon, from the FAA Aeronautical Center in Oklahoma City.

WILLIAM THIEVON: The metric issues group met and we had quite a lively discussion on Metrication, which I imagine is pretty unfamiliar with most people here and even in our industry. We also got into cockpit work loads, cockpit configuration instrumentation. We probably discussed and touched upon about the same items that all of the other work groups did because in the area of Metrication we're talking about you solving that problem and we're going to turn around, right around and create another by metricating it.

One of the first issues that came up, which was a hot discussion for a while, was whether the U.S. will actually go metric or stay with the customary English units. And this discussion ranged from positively never will happen, to maybe, to you're damned right it's going to occur.

For discussion purposes, in order to keep on the subject, we had to make the assumption that Metrication will come. The big issue is when, what kind of timing and how we're going to adapt to it? We decided that, at this stage, there isn't really anything we can do about the timing. It will probably be a generation or two away, but it may be sooner than we think.

The problem we really got into was the Human Factors area. How is this going to impact the cockpit flight operations as related to the stripped Human Factors? If we have to accept the assumption that we're going to go metric, then we have to look at how we're going to get there and then how's this going to impact, not only air traffic control, but the airway systems, the airplane designs and the operations. I think it was -- and I say, I think -- it was agreed that we would have to have a planned approach. We're getting caught too frequently with fire drills, things that come up and then we try to work out how we're going to solve them and answer them. In this particular area it appears that we have at least a ten year lead time in most of areas, maybe twenty year lead time, that we ought to start working up a plan even if it's just a contingency plan on how we're going to get there.

The general feeling was we have problems with the current environment English units. We assume that the Communist world, China, Russia, in particular, Red Block countries, which are operating in metric have problems. Some may be similar; some may be different. But the safety in the Human Factor problem that we wanted to address was the transition period. How do we go from an English system into a metric system of operation in the cockpit? I think we kind of agreed that this would be the most critical time, both safetywise and human factorwise. This also reversed us back to, "metric will never happen here."

If the United States stays with customary English units and the rest of the world has gone metric, which they have in their practical sense, how are we going to operate on the interface? It means every pilot that files internationally will have to know how to fly in metric environment, metric traffic control and operations. Every pilot that comes into the American air space, in turn, will have to be able to go from metric to an English system.

We foresee this as a most critical safety item. For economic, safety and practical reasons, if we do change to metrics, it cannot occur overnight. There's just too much money involved, too much equipment changing that needs to be made, too many different aspects of operations and flight that have to be considered before we can even get into it from the pure Human Factor side. One of the members of the group said it has got to be done fast; the quicker you do it, the easier you get over this hump and the easier it is for the Human Factor problem to be resolved. We have a conflict as we do in everything else.

There is a feeling, at this stage, that we need a little more direction, a little more policy and guidance. If we're going to go to metrics, how are we going to go to metrics? There's probably a need for more government leadership and guidelines and direction in this area. Under the Metric Conversion Act, the government side is kind of handtied. We're directed to go at the pace industry sets, do it the way industry dictates, and wait for them to come to us.

On being a member of the American National Metric Council, I get it the other way. Damn it, why don't you regulate it more? Why doesn't the Government give us more direction? Why don't you force the issue? We want leadership from the Government.

We see some of the problems that need to be resolved and looked at it, not only from a practical sense, but from Human Factors. Industry, in this case, needs to identify regulation changes needed to accomodate metric. You have to work up the designs, the industry has to develop the techniques and then they'll find stumbling blocks in our rules and regulations in order to come to us and tell us. We're kind of barred by the Act from doing it in reverse.

We also agree that the changes should start now. During this development period, we're coming up with new designs, getting away from the clock dial instruments, going to CRT, going to analog or digital readouts. We should be planning now for metric conversion.

One of the gentlemen mentioned equipment must be compatible. He said, "Let's use the word compatible rather than interchangeability." It should be built in whether it's breadboard, switches or what. It should be a built-in facet that the new equipment is prepared and able to accept the metric conversion. One of the gentlemen used the word, "bi-dimensional."

We have to prepare for some day - which is colloquially used right now. It's called "M" Day, the day we're going to go to metric. We cannot do like they did in Sweden, and when they went from the left-hand to the right-hand side of the road, and simply stop traffic for six hours or so and the next morning that was it. You can't do that with the entire fleet of aircraft, not only in the United States, but throughout the world.

Some of our discussions also revolved around existing Human Factor problems in the cockpit, the same factors that some of you others discussed. The feeling was we better resolve those problems before we get into the metric conversion because if we carry the same problems into metric conversion, they're going to be worse because just a straight conversion over creates enough complexity without adding a problem that you bring with it.

There appears to be today -- to possibly repeat some of your own discussions -- with some of our air traffic control procedures, a letdown in the way we handle traffic. There seems to be a subtle, heavy work at times on both the controllers, and possibly the pilots, in trying to mentally gymnastically adjust to these changing directions. They need a cockpit-assisted computer, whatever you want to call it, to do some of this stuff for them before the work load gets too high. We go into a bi-dimensional system, it's going to be worse. And if we convert, we'll just have to be designing from scratch, anyhow, so let's resolve the problems at that time.

How do we get metric into the cockpit? Do we convert one instrument at a time? Do we convert the whole cockpit overnight? Do we go half-side, half-side? These are just discussed at Human Factors studies. What's the best way to go over? As I said before, the off of the top of the head comment from Human Factors was do it suddenly, do it quickly, do it completely. I don't know how we can do it under our system. This is the conflict that exists between our economic and our practical restraints versus the Human Factors problem. You just can't convert three hundred thousand (300,000) aircraft. I don't know how soon -- even in six months -- a lot of money and a lot of work involved.

Our discussions went all over the place. We covered a lot of things. A lot of it had to do with metric problems. Primarily, the one that we zeroed in on and talked about in Metrication and conversion was altimetry. Altimetry needs a lot of work even as it exists. It's working for us today. Why the hell do we want to change it? I imagine the Russians, the Red Block countries, who are flying metrics have the same attitude. I don't know whether we're going to be any better off in pure metric or any better off staying with what we are.

The problem is transition or trying to live with a dual system. I think the agreement was that the dual system is almost impossible to live with in international air travel.

So one of the assumptions, in addition to the conclusions we arrived at is to recognize that the human and economic factor impacts change. It should be made gradually. It's the only way we seem to be able to handle it.

The proposal here was to replace the instruments at the end of their normal lifetime, to the maximum extent possible. Some of them you can't wait that long. And when you do put in a replacement -- since we're talking about a 10- or 20-year time period, we're talking about working a bi-measurement system for a while - the instrument should be bi-scaler. There should be some sort of switching mechanism in them so that you can read in metric if you want to read in metric, so you can read in English if you want to read in English. This, again, designwise forces us -- kind of forces us to the concept of getting rid of dials and hands and going into digital or analog direct read-out instruments, CRTs and some of the other things that the manufacturers have on the drawing boards today.

The encouragement -- as I will repeat -- is consider having metric capability built into them.

One of the problems we did have within the Government and in industry is there is no time element established on metric conversion today. The recommendation, from this group, was we better try to establish some sort of time line, critical decision points, PERT-chart milestone, or whatever you want to call it, to figure out how we're going to get there. And, I would say, at this point, we probably would not put dates on these time lines, just put critical points and some time between them. Publishing the time line, publishing the plan, issuing it to the aviation area would allow the "players" to make inputs and advance alternative solutions to the plan. Since some of the carriers are currently using both English and metric flight information -- the Russians are flying into the United States. We are, Pan American, is flying into Russia. We will soon be doing the same with China. We should use these air carriers and air routes as test beds, test areas for bi-scaler, metric, dual operations, whatever else we want to do in the Human Factors area. We should also look at each element of the flight data and examine and determine if the dimensions or the units we're currently using, and historically use, can be changed. Can we come up with -- forgetting what the air speed is -- just as we did with the horsepower and the power on the engines. You fly at 100 percent, 90 percent, whatever it may be, it's a non-dimensional unit. Why can't we have VSO or stall or R rotation or something on an instrument, electronically controlled, so that a number, like 1 or 100, on every airplane you get into is the point you lift off? You cruise at a fixed number which is the aircraft's number system. This is not eliminating the mock meter, but converting an air speed indicator over to a unitized system that really means nothing, except it gives you key marks instead of green marks on an indicator. That's a problem area we could look at.

We also got into the same problem I imagine AT and the rest of us have - is if we go to an automated system, is the pilot integrated into the system or is the pilot the back-up to the system? If he is, basically, the back-up to the system and is just playing with a computer and a dial and the equipment is flying the airplane, then your pilot gets to the point where he can't fly anymore, he can hardly land or take-off. So you have to look at that, again, from the Human Factors side. He should be in the loop somewhere. He should be actively participating. Possibly, the flight management system or flight data computer, whatever you want, should be able to provide him with the information he needs, and he still flies the flight director concept.

These were the things we got into. We also got into the idea that -- I brought it up because I recently read an article -- of all of this stuff, it may be passé, and if we continue with the way the state of the art is going, we may be talking about satellite navigation, satellite communications, satellite operations in the not too distant future, maybe about the time 1990 or 2000, when metrics comes into play. And then we may have a completely different set of problems. But these are the kinds of things we discussed about metrics. And I'll end that as the end of our meeting, but I was asked and mentioned metric conversion. I don't know how many of you followed the Metric Conversion Act, but we do have a treaty. It's handled on the international game with ICAO, which I imagine most of you are familiar with. And under ICAO, when ICAO writes a standard, we're obligated by treaty to comply with the standard unless there is some outlandish reason why we cannot. This is not a recommended practice. This is a standard. Contracting states will conform in accordance with the convention. In this case, it was a treaty. In the event of impossibility of compliance, notification to the Council is compulsory under Article 38. 38 is our escape clause under a treaty that says, "You don't really have to comply with the treaty if you've got a good enough excuse." And you list the differences with ICAO - that tells you how you're going to operate differently from what the international standard calls for. Most countries do differ from the ICAO standard in some areas and in some respects. Under the international agreement, though, when we fly in foreign air space, we fly in accordance with foreign rules. When they fly in our air space, they fly in our air rules.

1948 the ICAO developed what they call Annex 5, which was a measurement system, units of measurement, for air and ground communications. That's where it started. That was the beginning of metrication of our air traffic control and our communications system. It started out in 1948. They have been continually trying to change over to the metric 100 percent, currently referred to as the SI Systems International for Measurement in Metrics. In March of '79, they finally passed what we're referring to as Amendment 13, which is the new standard for units of measurement to be used in air and ground operations -- no longer communications, but operations. Originally, it was a standard and a practice. It is now a pure standard. Originally, before Amendment 13, there were 18 areas of air/ground communications, which involved metric and English, allowable alternatives, that dealt with flight operations such as altitude, distance, elevation, longitude, latitude, a few things like that, which were common to the air traffic control system and the pilots. With Annex 13 and SI units there are now 125 units identified in metrics. Out of the 125, there are approximately 11 of them where they have allowed an alternative to be used for an indefinite period. They call it a non-SI alternative unit. One hundred twenty-five (125) covers the whole spectrum of aircraft design, aircraft structures, aircraft operations, aircraft communications. If -- it's a big if -- the member states of ICAO adopt Annex 5, they can cram down our throats the full metric SI system for even importing our products in their countries. This has a very subtle possibility. As I said, this was passed and adopted in March of '79. It became effective in July of '79. They allowed a little over two years, that's to November of '81, for the member states to comply, change their regulations, and get prepared to operate under the international standard Annex 5. Every annex in ICAO is under revision to incorporate these standards and metrics. How many countries are going to file differences on November 26th is anybody's guess. The United States must also file a letter of differences. If we're completely cold and honest about it, we would have to file a difference of 110 on 125 units because we just don't use them. The scientific community does use a lot of them, but we don't in aviation. We're going to try, at this stage of our proposal, which has to go up through the State Department and everywhere else -- we have been in contact with some of the letter organizations on our proposal. We're only going to talk to those units which deal with flight operations and try to keep the differences down to a minimum and not make an issue over the 100 plus other ones. This comes down to about eight or nine differences from the standard. An example here is where you run into it - they allow, under the standard, to measure distances in kilometers as the SI standard. The nautical mile, they're saying, is a temporary standard to be eliminated in the 1990's. We can stay with the nautical mile. That's for a long distance. For a short distance, it's all meters.

There is no alternative provided for. Runway lengths is in meters. No alternative provided for. Fuel tank capacity, which we could care less about, but I'll just throw it in, is in pure liters. Cockpit flight operations, you know what the capacity is. What the hell do you care when you're talking to ground communications about quality? See, we can ignore something like that.

Visibility in kilometers. That has created a very interesting problem I'll mention to you. I believe TWA wanted to take off from London and was given a RVR runway length in meters. When he converted to English, it was about two feet short of what they permitted the United States aircraft to operate in by his flight manual. He could not take off. The British were taking off; the French were taking off, but he could not take off. In measuring RVR, they used meters, and I don't remember it exactly, but they round out to 10 meter, 15 meter deal. We, in the United States, do it in feet. We round, also, to some element of foot. Just in their rounding, they grounded this TWA from take-off.

These are the kinds of problems we're going to run into more and more. If the foreign countries decide to follow the standard and to force metric on us, we may have to be putting out metric flight manuals, may have to provide metric altimeters for pilots to fly in. When Pan Am goes into Russian air space today, they're flying at one of our flight levels, 21,000 or 28,000, whatever it is, whatever it may be, and they go into Russian air space, they're given an even metric number and have to change altitude immediately and fly an even metric number which is an odd foot number all the way into Moscow. They have approach plates, Seppesen, for Moscow and in both metric and English units, and they get all their instructions and all their directions in metrics. So unless he's really proficient, he's sitting there converting continually. This is just one of the things that are coming up in this metric conversion that we're talking about. It's one of the reasons why it was put on the agenda and why we, in the operations area, Mr. Luffsey's office, are very concerned in what might happen in metric conversion.

MR. TINSLEY: I used to have a neighbor that was in the planning business, DOD. He was on the 15 year plan, and this gentleman used to work late at night and work on weekends. And I grabbed him one day and I said, "You know, you're working a 15 year plan, what can you possibly do on the weekend that's going to affect us 15 years down the road?" It's a very simple thing. One of their assumptions would change, something would impact the assumption that they did their plan on, and they would change their basic assumption and go back and do the whole plan. And this is a very critical point in a planning process of what our assumptions are. Now, I happen to participate in this group and there's one advantage in being the M.C. You get a last shot.

GUICE TINSLEY: It's very important on what assumptions you make when you look at the metrication issue. And I think, from our office standpoint, we will take a very serious look at the safety impact. And I think we can help the industry by making a policy statement on what we are going to support and what we might provide in this area. I think there are three areas of study that need to be looked at. Certainly, flight operations and the safety impact. I think maintenance needs to be looked at. I also think we also need to look at the design factor for new equipment.

I also want to emphasize that the way the law is written, it is a voluntary program and those of you from the industry here, I would like to hear what your requirements are. What needs do you see? What should we be doing to assist you? I also would like to know what the other countries are going to do. I hear what we think they're going to do, what they say they're going to do. I would like to know what they're going to do. And I think if we gave some indication of what we were going to do, it might help other countries make up their mind on what they would do.

I think we really have to scope this problem. The only way we can get into a real cost basis of what it would cost and cost the country is to know exactly what we're doing, how we're going to go about it and what the schedule is. I think with the realization of the dollars involved it may temper our approach to it. Given these things, then I think we can come up with a realistic plan to implement whatever we decide to implement. And I'm not dealing in total knowledge in everything, but I can guarantee you that we will not support anything that compromises safety.

As a taxpayer, I get very concerned about the impact on the Department of Defense when we start talking these things. They operate a great, large fleet of aircraft. They also operate in civil airspace. And to take billions of dollars to throw into complying with something that's ill designed, I really rebel against it when we could use additional equipment, better trained people, and so forth.

Just a couple of quick comments. Dr. Bertone you have a request. If you would like to talk to a group of people within the FAA that deal in the helicopter business - Harlan Hosler. He has the operational task force for helicopers. His number is the same as ours. Contact him. I'm sure he'll make whatever arrangements. If you want to talk to a Human Factors group, I chair that group. My number is the same as Harlan's and I'll be glad to make any arrangements you would like. The invitation is the same to any of you.

We're going to finish just a little bit early, but let me re-emphasize a point. Comments, please, written within 30 days. They'll be included in the proceedings. Of course, I'm happy to take phone calls or comments at any time. We'll be done a little bit early. The buses will be ready to go as soon as we're done and everybody can get their bags on the bus.

For our concluding remarks, I would like to introduce Ken Hunt, he's the Director of Flight Operations for the Federal Aviation Administration in Washington. Ken, please.

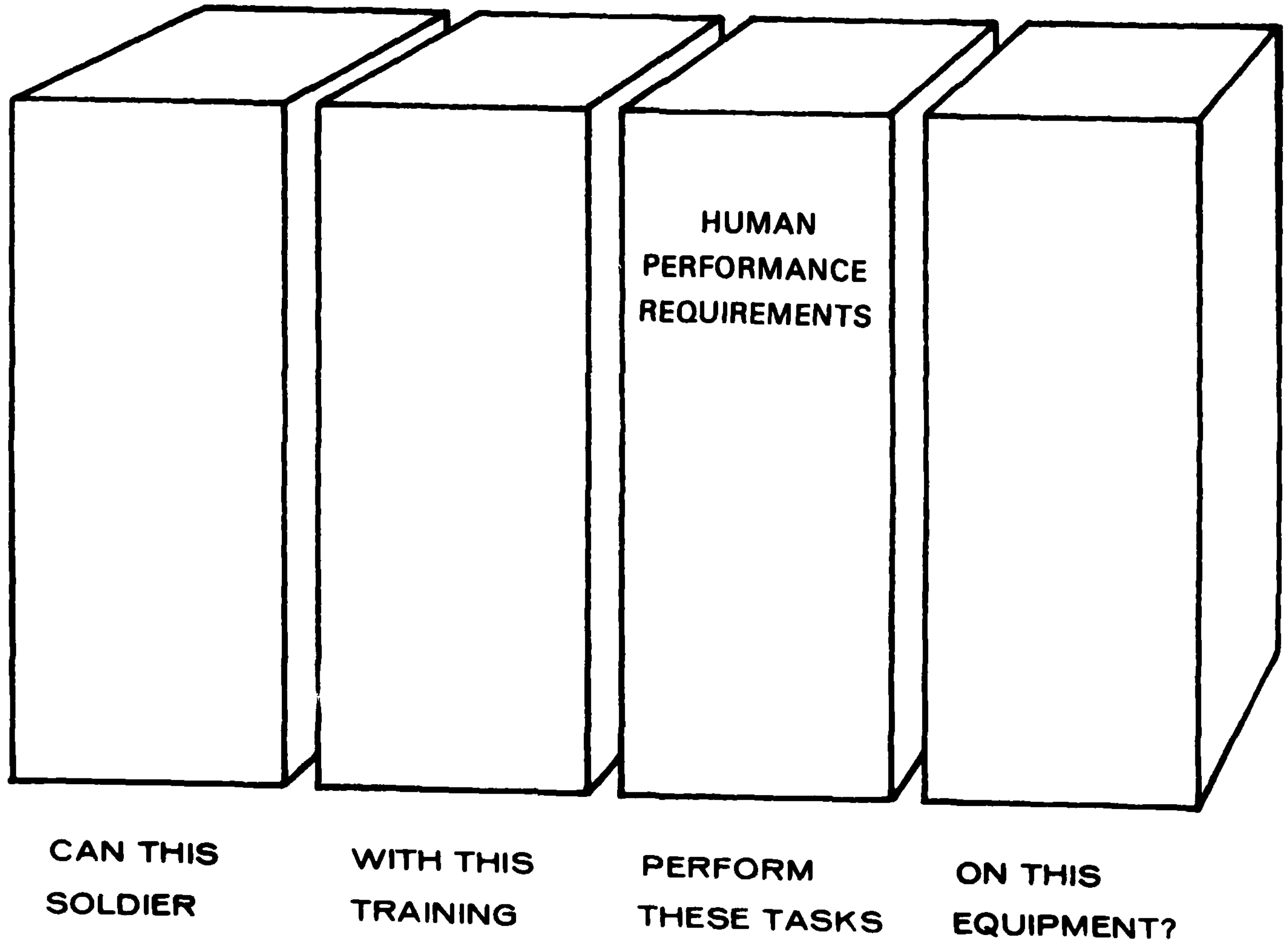
KENNETH HUNT: I would just like to say that it's been a real pleasure, and I want to thank each and every one of you, for our aviation standards organization in Washington, for coming. I had the opportunity to sit in on about three different work shops today, and I was pleasantly surprised with the participation. I mean, everybody in each one of the groups that I went into, was actively participating in the group. I think we got a lot of good input here. I would like to personally thank each and every one of you for coming and thank you for Walt Luffsey, who had to go back. He got a call and we're trying to work our budget out, I guess, there in Washington now. He told me to be prepared to work this weekend, so I thought, Maybe it's snowing so I would get stuck up here and get out of it"; but it looks like I'm going to have to go back. But I would like to thank each and all of you for coming.

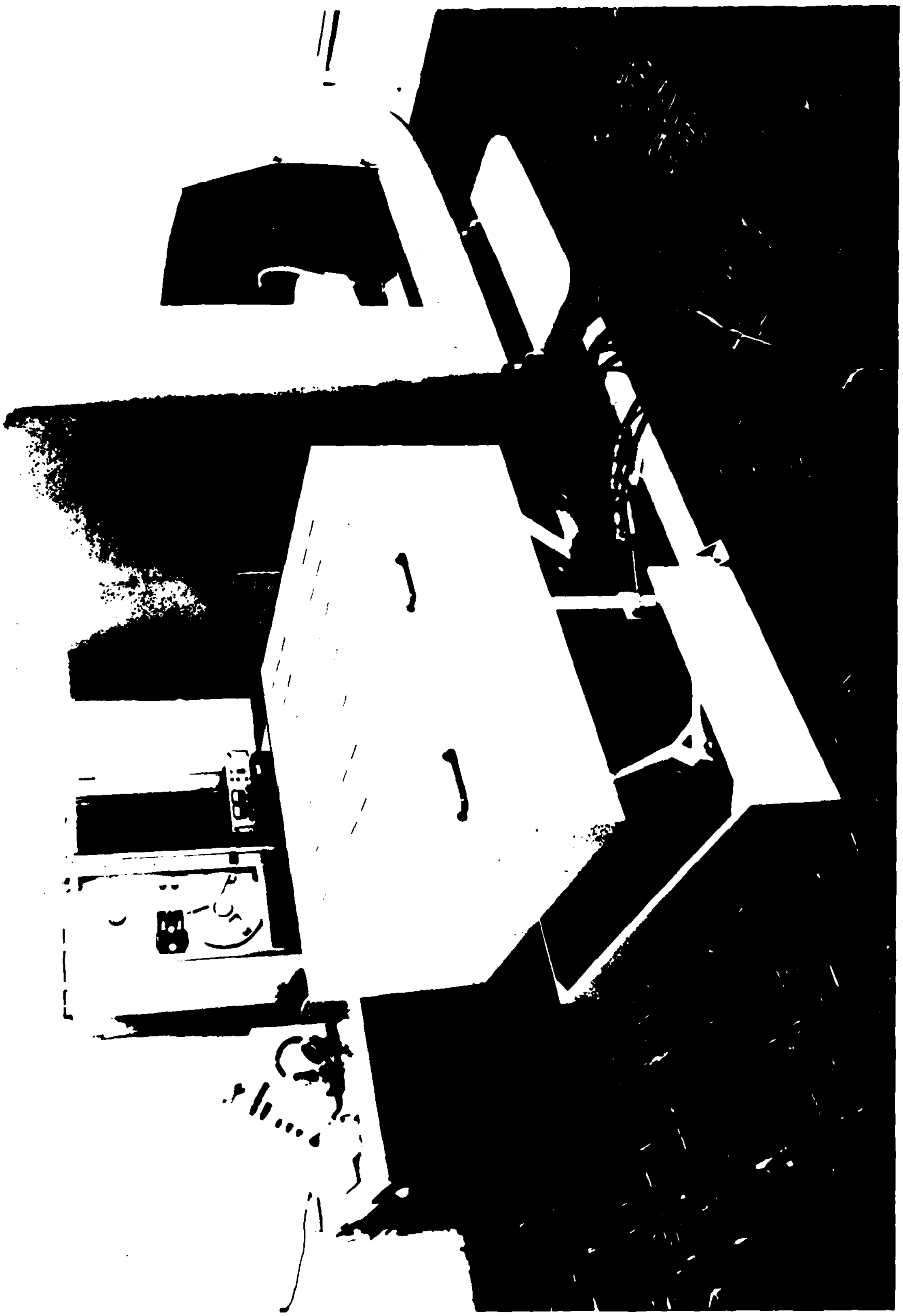
And they asked me to announce the future workshops that we'll have. We're planning, right now, to have our next workshop at the FAA Technical Center in Atlantic City on May the 13th and 14th. And it has been said before, at this one we'll discuss the ATC interface. And then we're proposing to have another workshop at Oklahoma City at our Civil Aeromedical Institute on medical behavioral problems which will probably be scheduled sometime in July. So we'll have some further information out as soon as we determine the dates they will be held.

And I would like, at this time, to thank the people at TSC. As usual, they put on a good show for us and everything was great, Dr. Costantino, thank you very much. Jim Andersen, we appreciate everything and I would like to say that Cliff Hay, again, has done an outstanding job in putting this together, Cliff and Guice Tinsley. And with that, I won't hold you any longer. I'll let you get out and thank you very much for attending.

SLIDES USED BY MAJOR THOMAS L. FREZELL
IN HIS PRESENTATION

TRAINING AND PERSONNEL TECHNOLOGY



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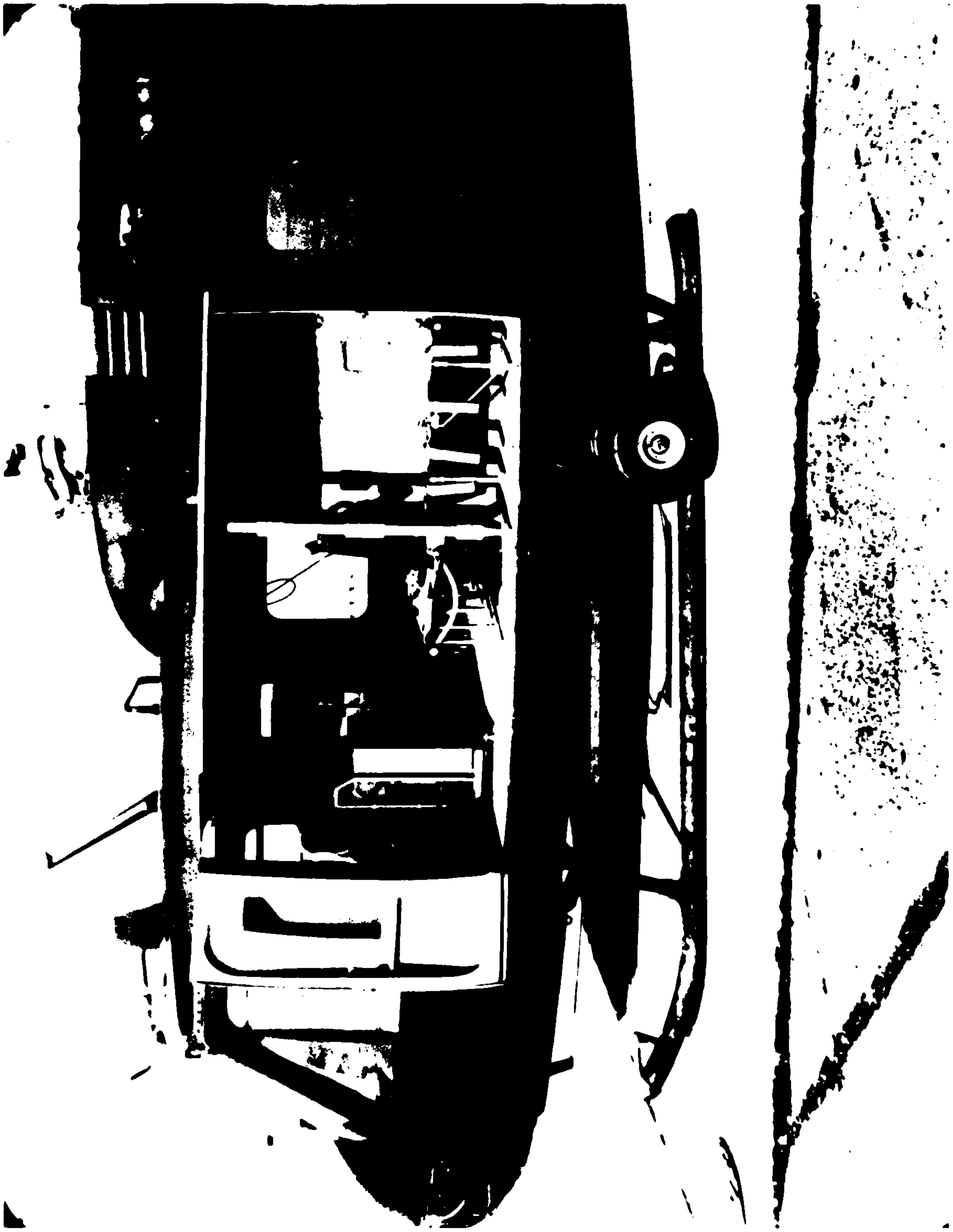

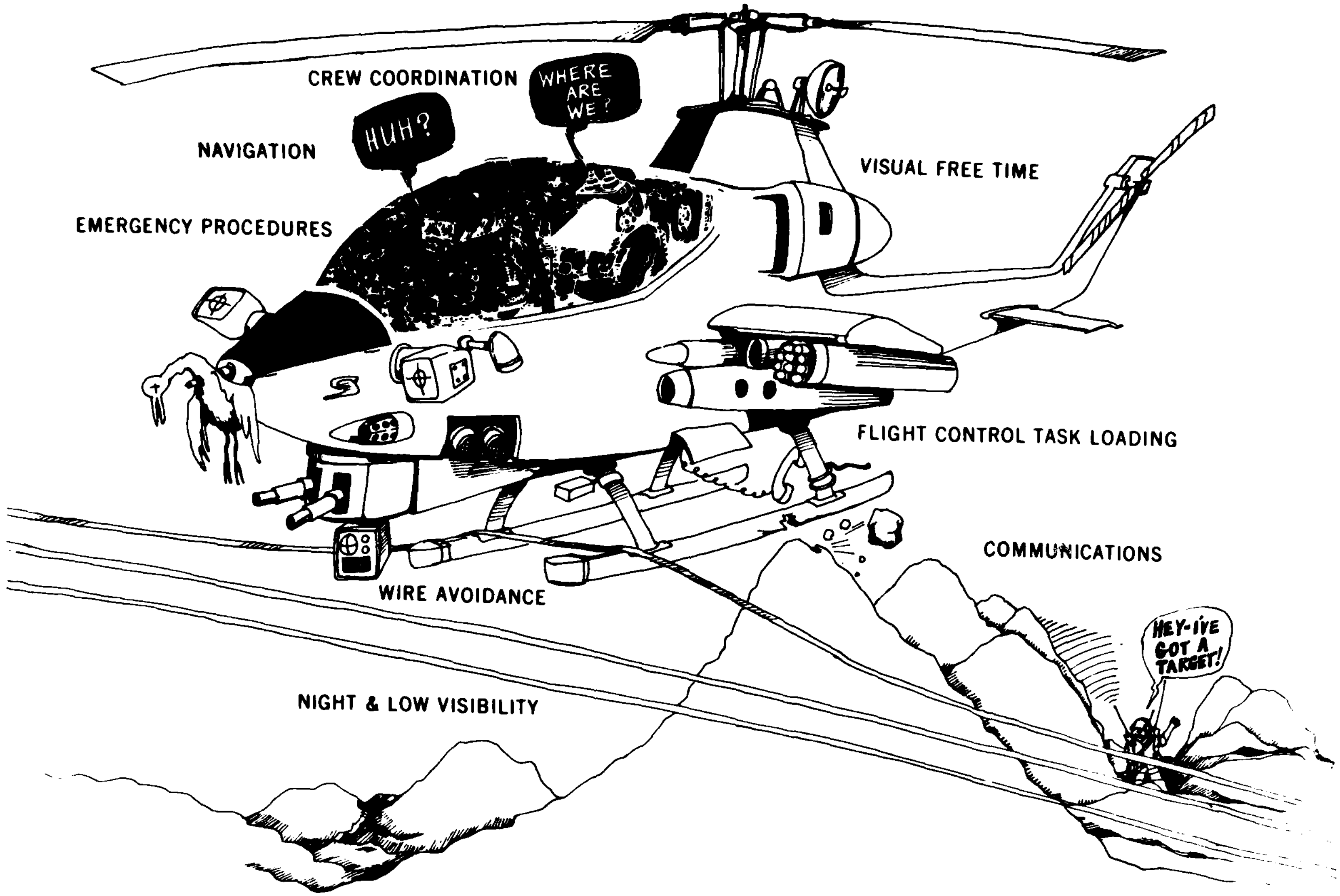
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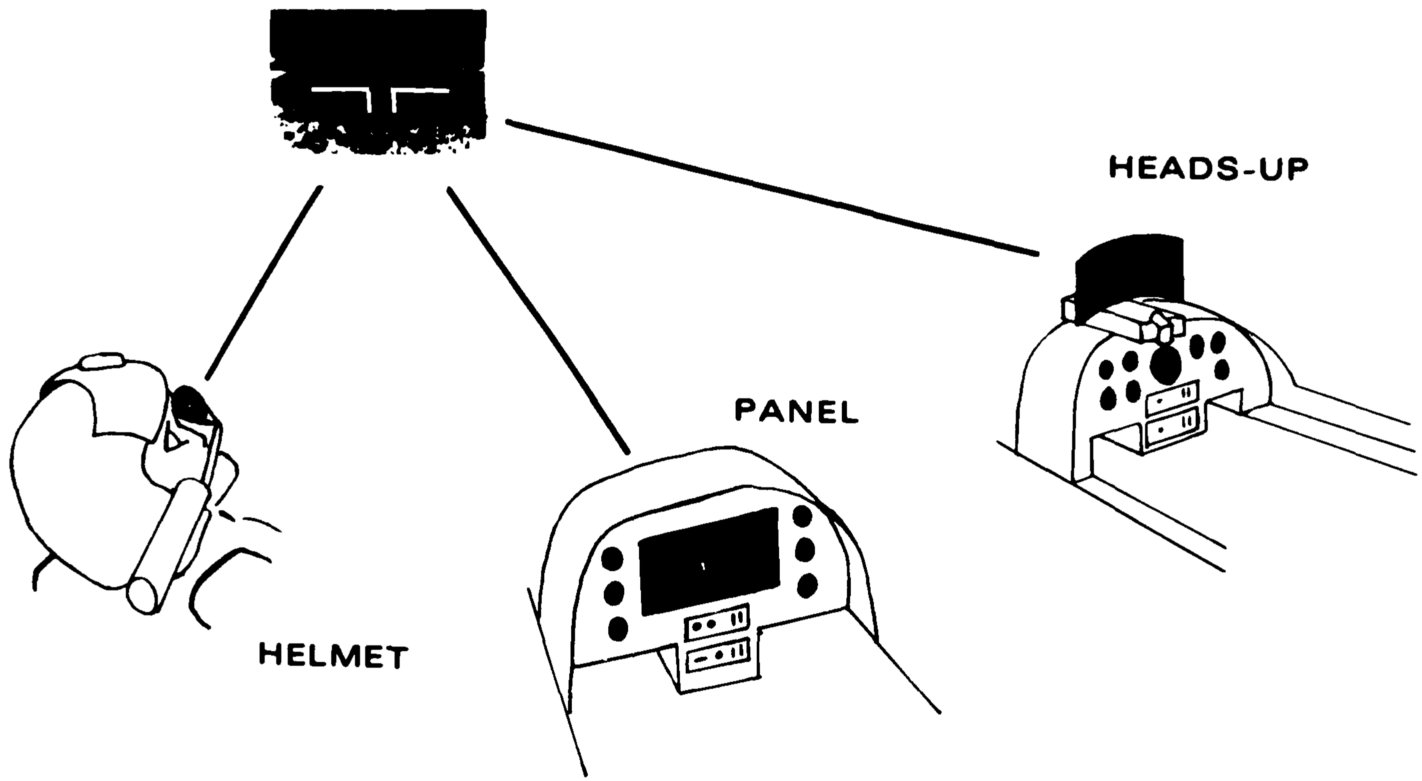
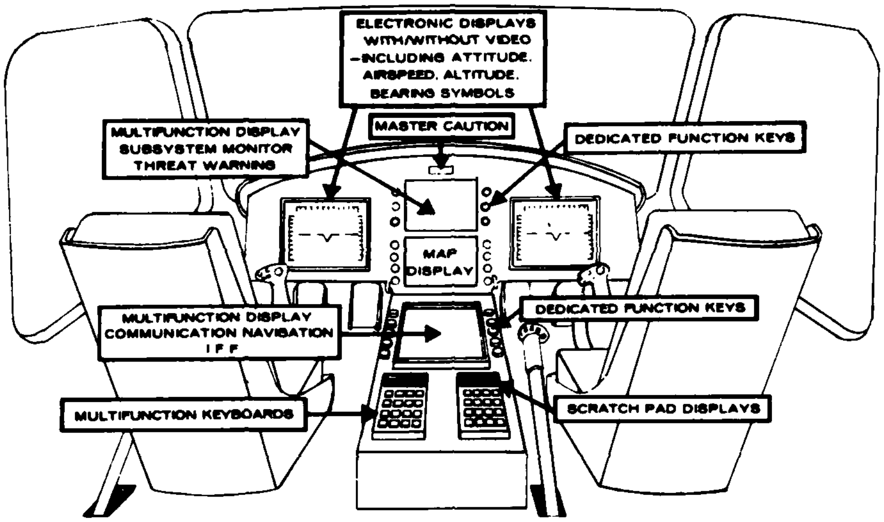
WIRE AVOIDANCE
NIGHT & LOW VISIBILITY

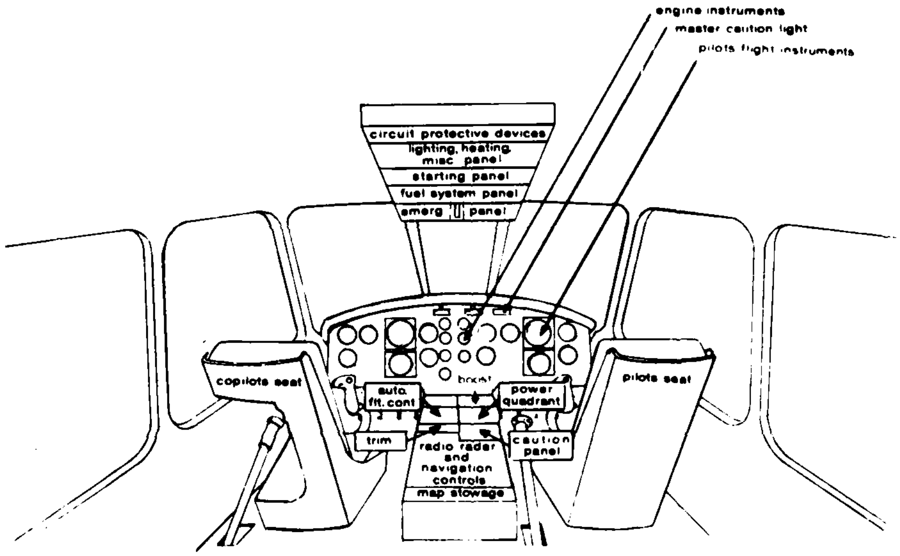
ELETRO-OPTICAL DISPLAYS FOR ROTORY WING AIRCRAFT



HELICOPTER COCKPIT CONCEPT
FOR
MULTI FUNCTION CONTROL AND DISPLAYS



CONVENTIONAL HELICOPTER
SIDE BY SIDE COCKPIT CONFIGURATION



INTEGRATION EFFORTS

INTEGRATED AVIONICS CONTROL SYSTEM (IACS)

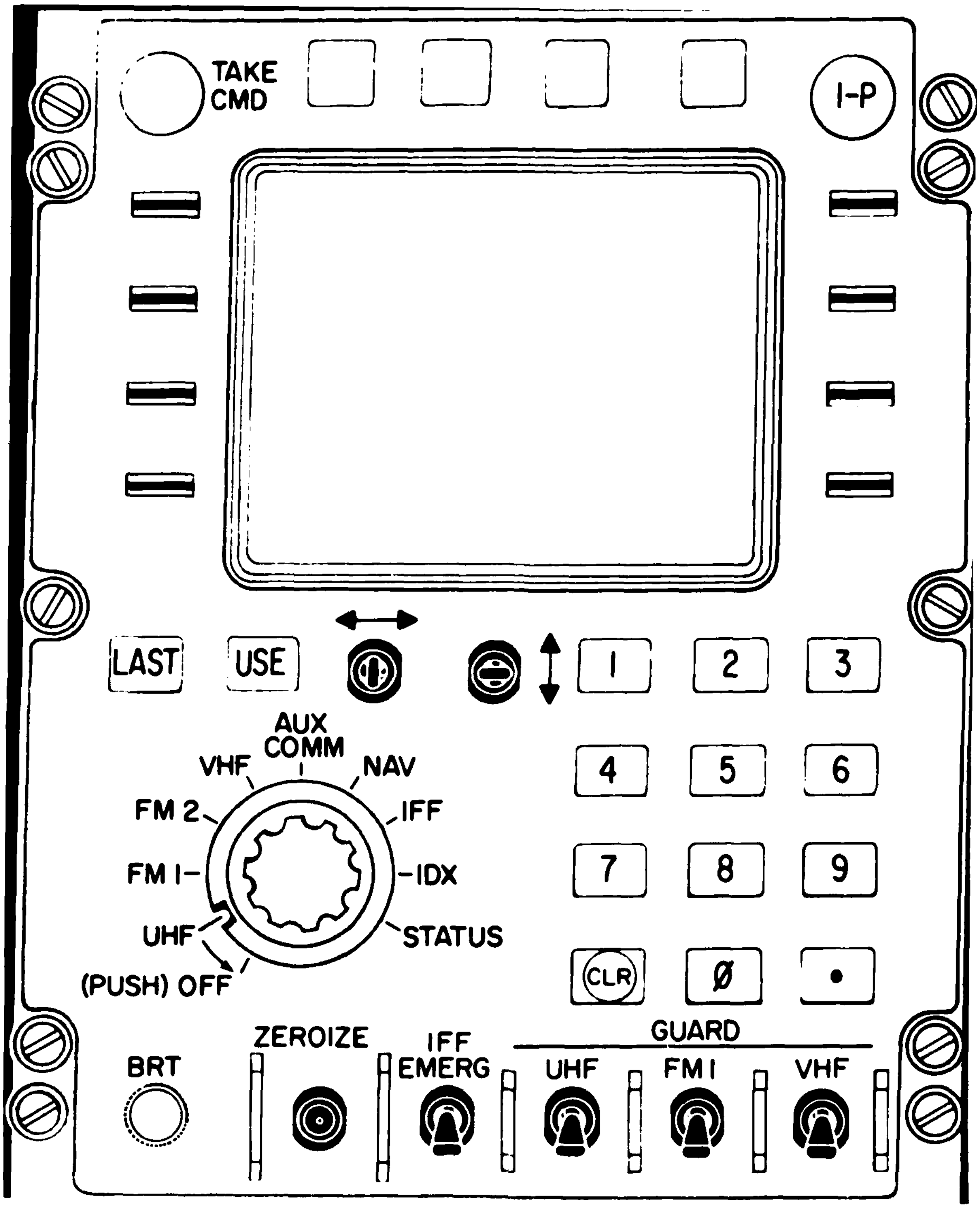
ARMY DIGITAL AVIONICS SYSTEM (ADAS)

ADVANCED DIGITAL/OPTICAL CONTROL SYSTEM (ADOCS)

ELECTRONIC MASTER MONITOR AND ADVISORY DISPLAY SYSTEM (EMMADS)

AIRCRAFT PERFORMANCE INDICATOR (API)

MAP DISPLAYS/NAVIGATION SYSTEMS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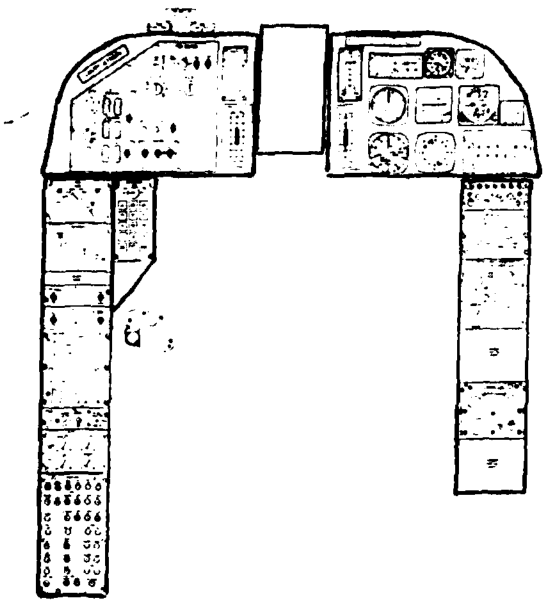


Figure 1 Forward crew station with standard avionics.

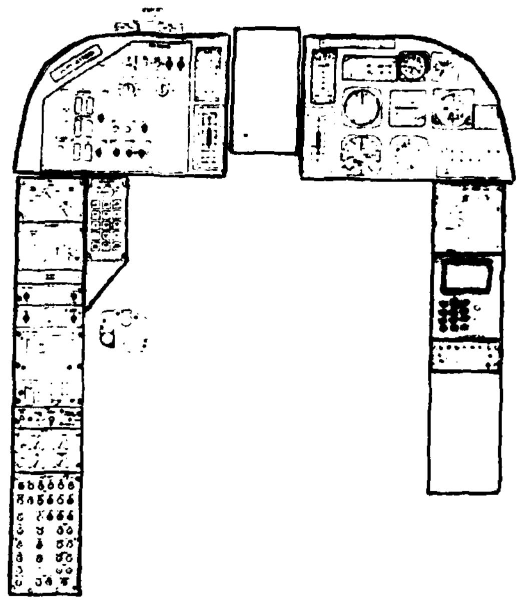


Figure 2 Forward crew station with IACS.

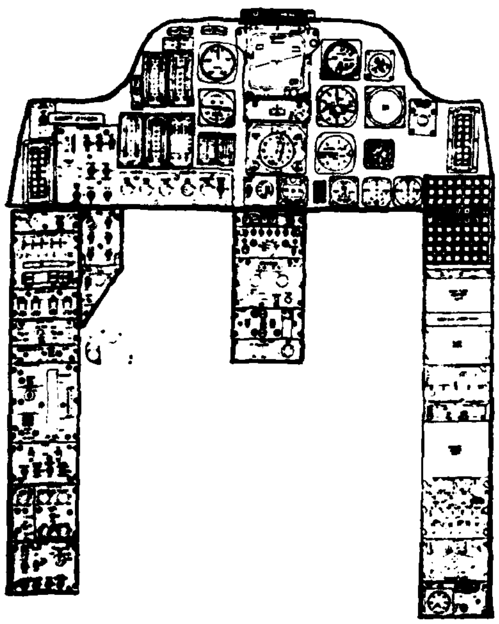


Figure 3 Aft crew station with standard avionics.

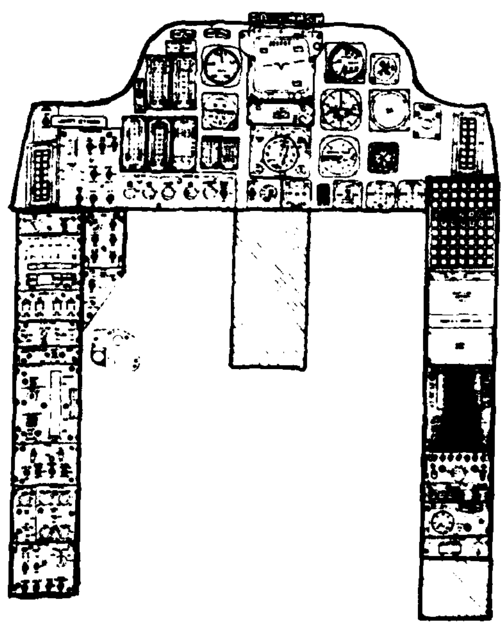
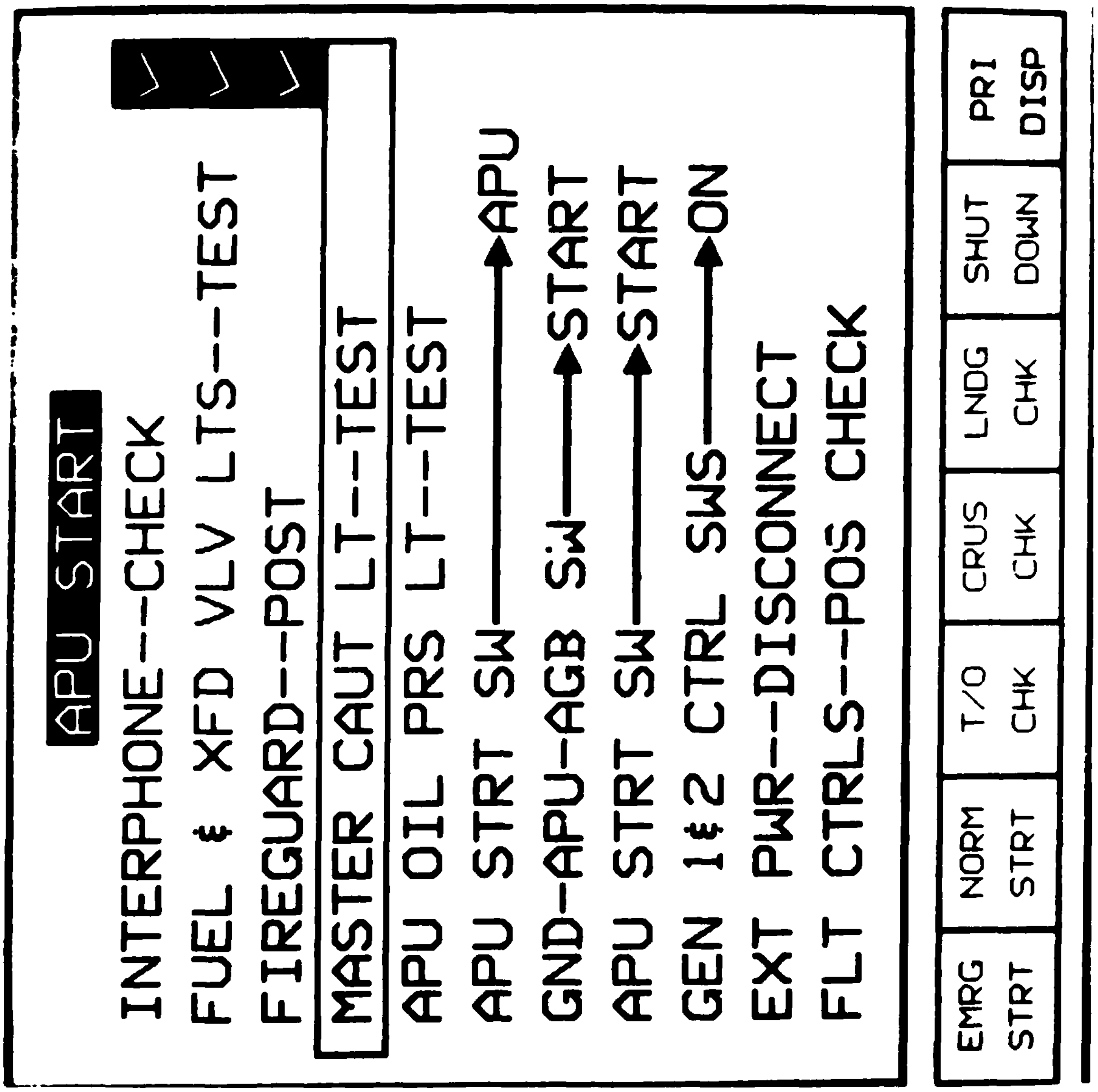


Figure 4 Aft crew station with IACS.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FIREGUARD--POST
MASTER CAUT LT--TEST
APU OIL PRS LT--TEST
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APU STRT SW→START
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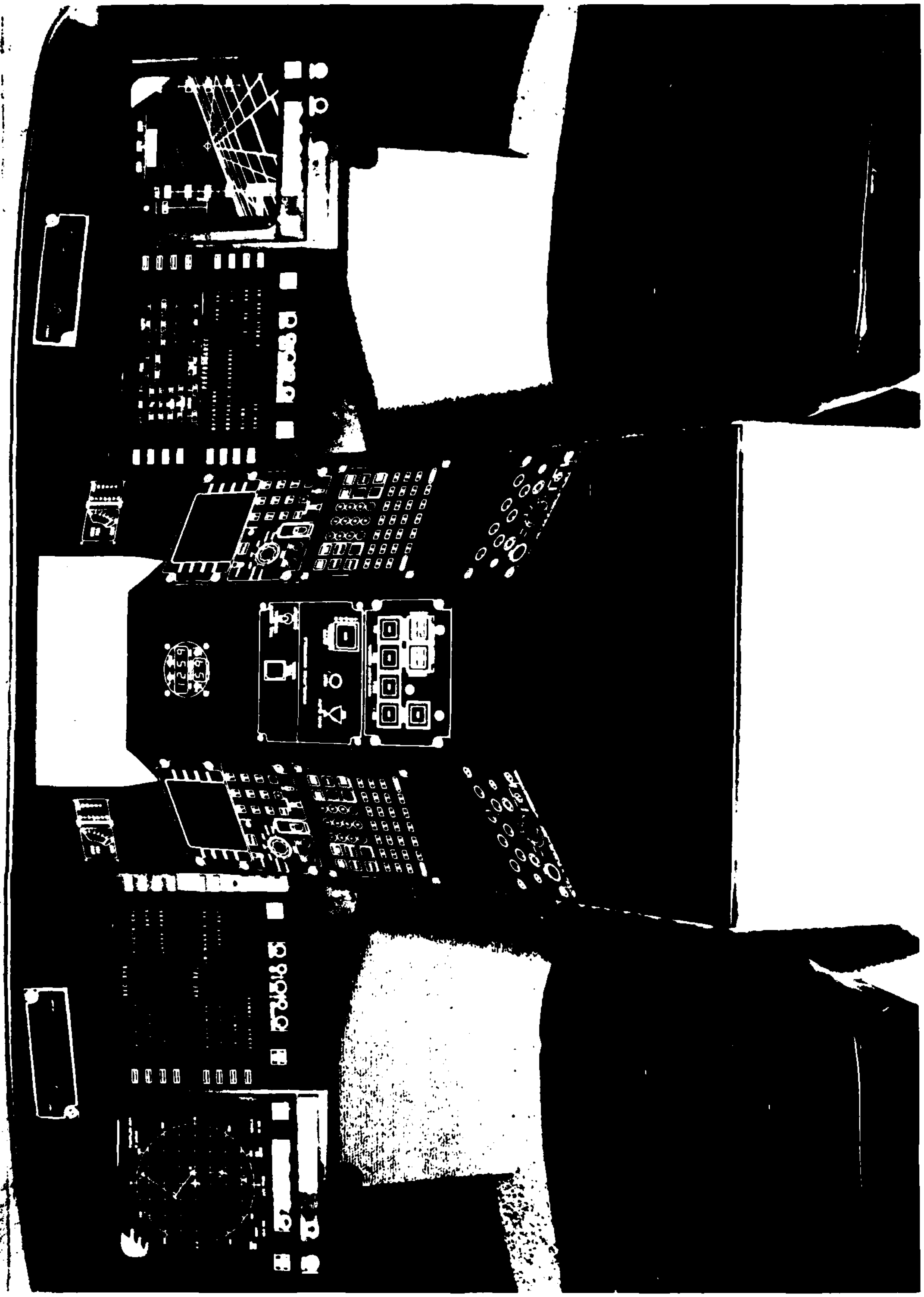

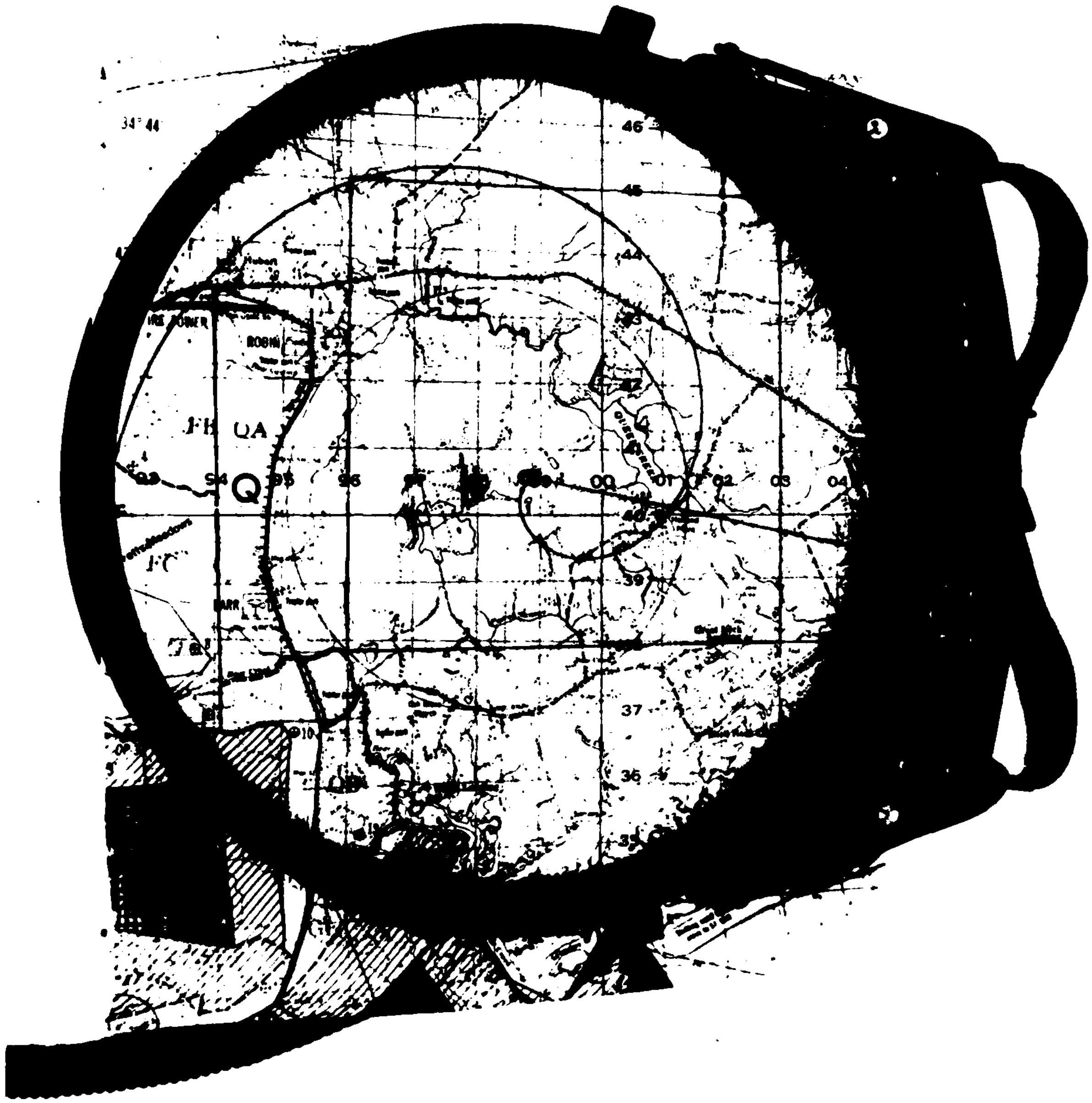
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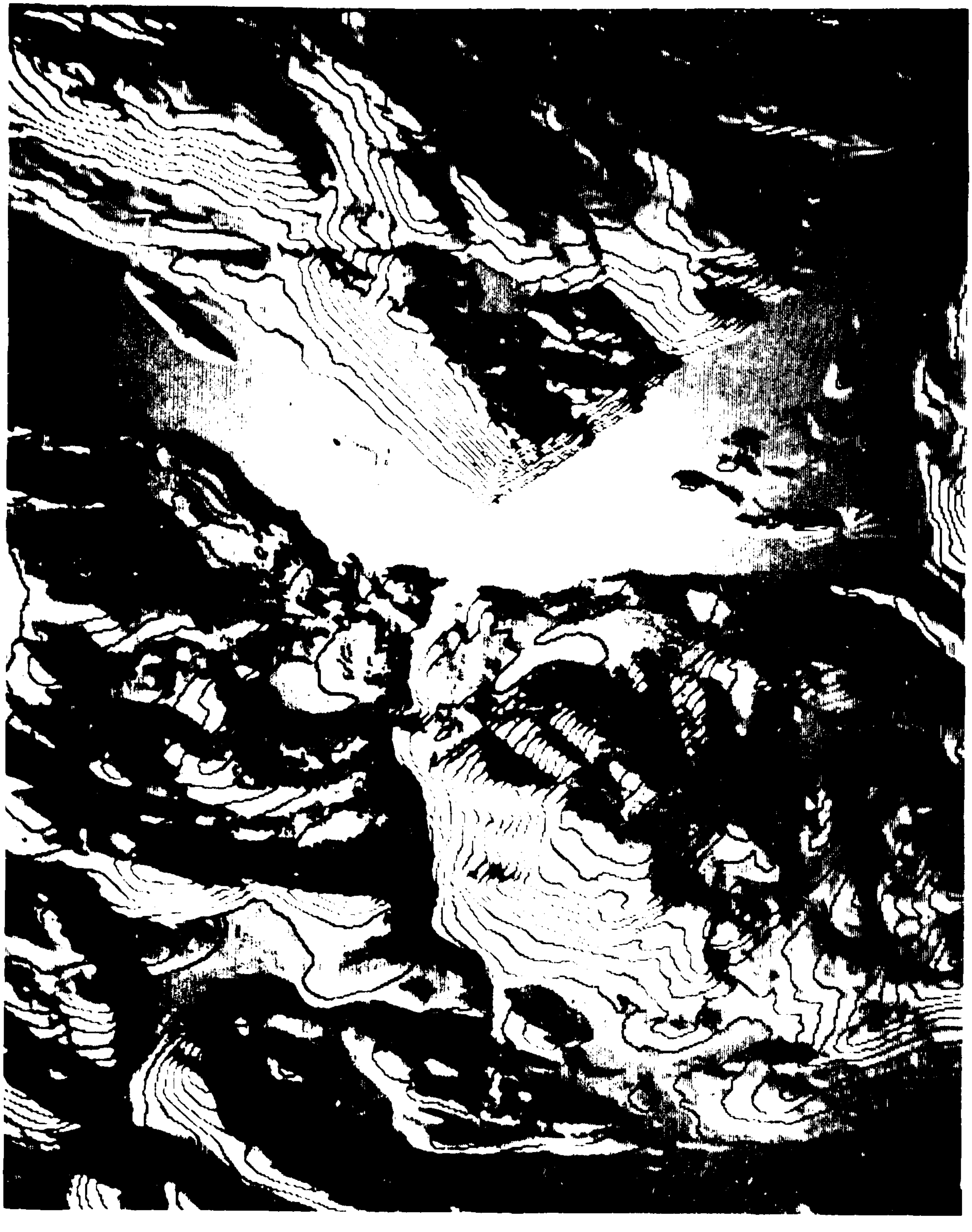
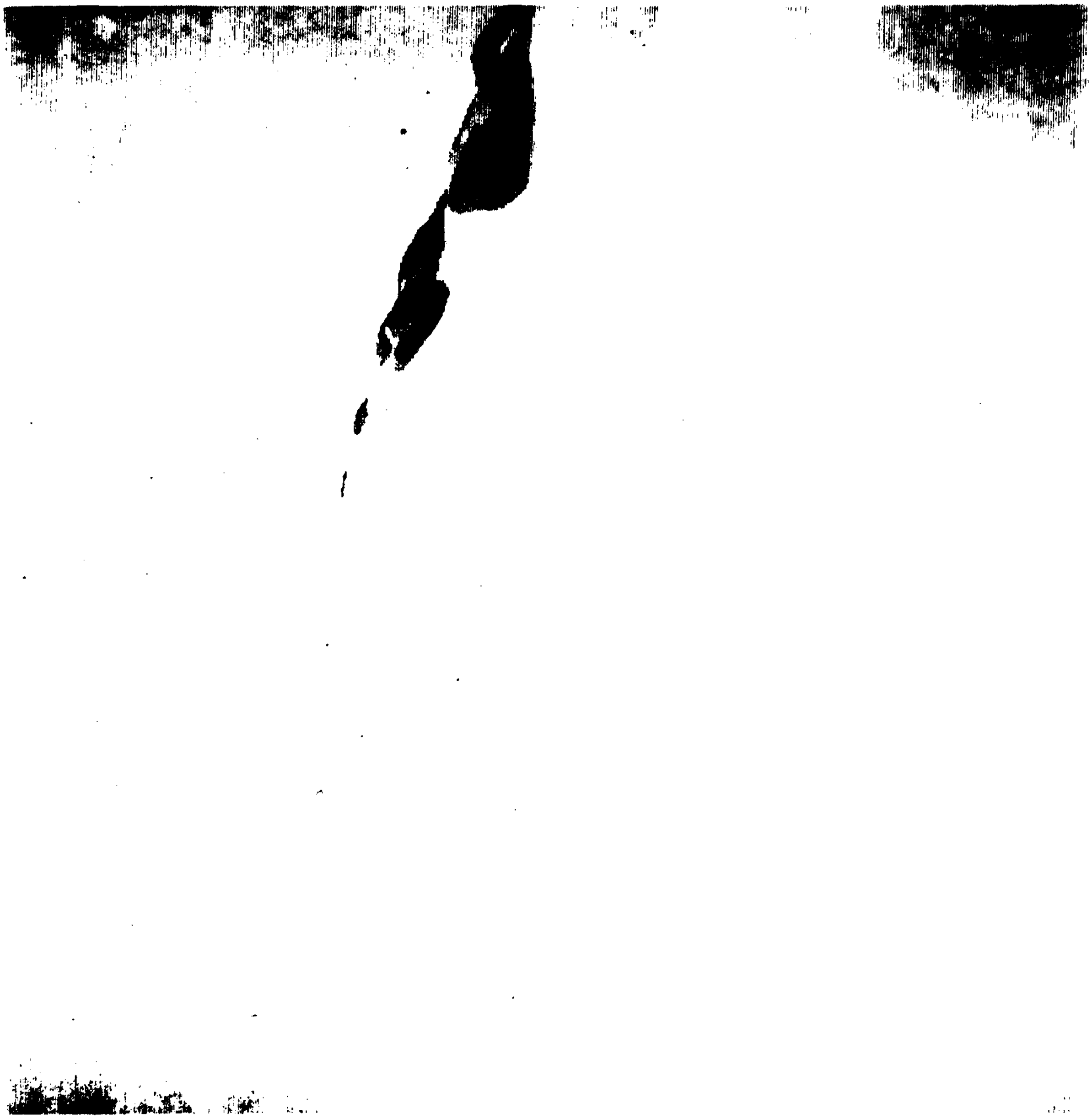
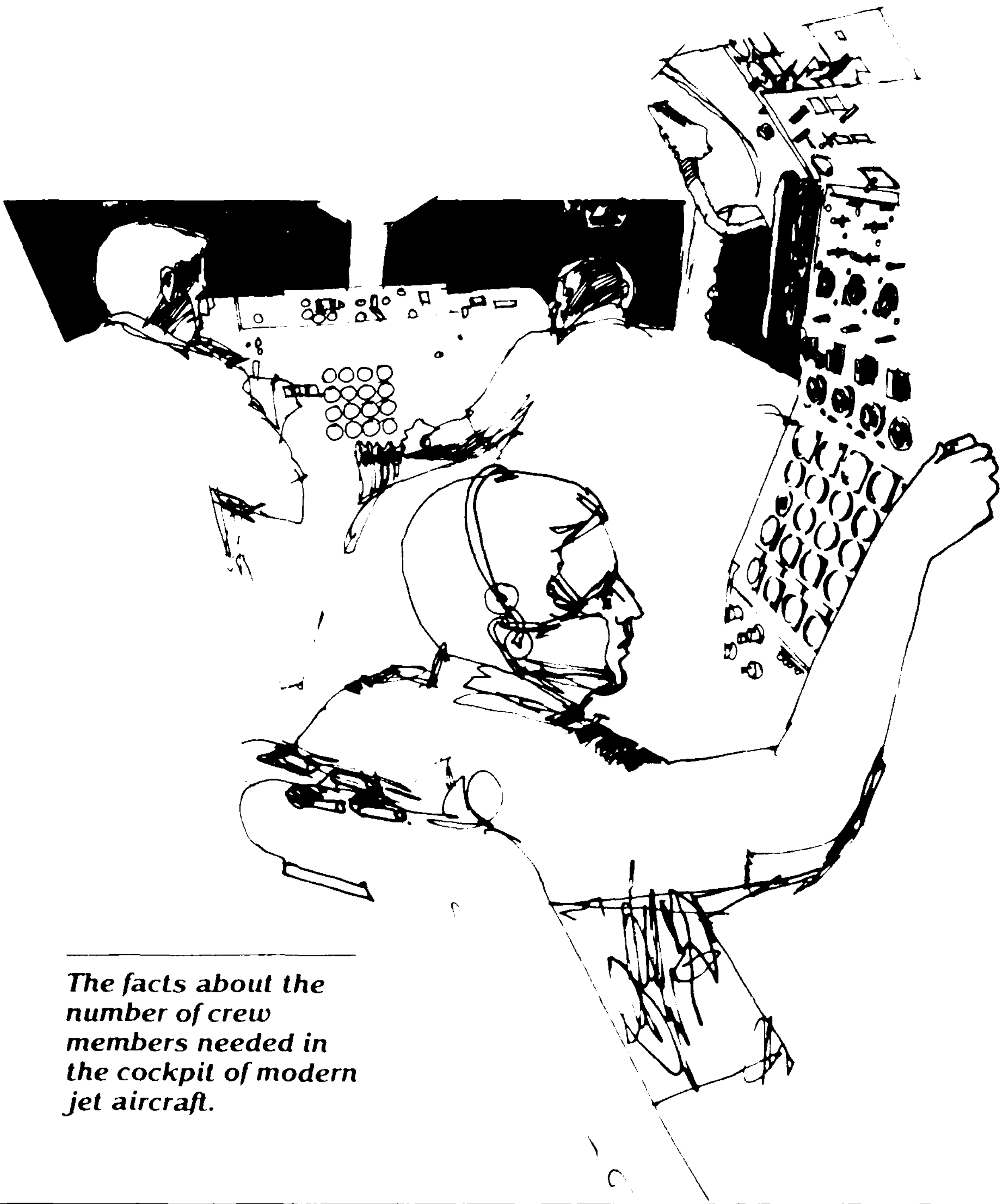




AIR SAFETY BOOKLET PUBLISHED BY THE FLIGHT ENGINEERS' INTERNATIONAL ASSOCIATION

The Issue Is Air Safety



The facts about the number of crew members needed in the cockpit of modern jet aircraft.

The Issue Is Air Safety

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FEIA

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Preface

The company was simply unwilling to submit its judgment on workload to anything approaching a "real world" test, and the FAA failed to meet its responsibility to require it.

Recently, the Federal Aviation Administration (FAA) certified the DC-9 Super 80 as an aircraft that could be flown with a cockpit crew of only two. The FAA took this action over the strenuous protests of both the AFL-CIO Flight Engineers' International Association (FEIA) and the AFL-CIO Air Line Pilots Association (ALPA). The two organizations took exception to the FAA decision because the crew workload tests to which the aircraft's cockpit was subjected were not sufficiently rigorous – and not sufficiently duplicative of actual airline flying – to justify its certification as a two-crew aircraft, instead of the three-crew requirement that such an aircraft warrants.

The dispute over certification of the DC-9-80, a super-stretch version of the DC-9, has served to highlight anew a longstanding controversy over the entire certification process. In the view of the FEIA and ALPA, too much of that process is under the control of sales-hungry manufacturers when it comes to the determination of crew complement and crew workload on any new aircraft type. Thus, before its certification by the FAA as a two-crew aircraft, the Super 80 was not tested intensively for crew workload under the multitude of conditions that can arise during actual airline flying, including operations in busy corridors in all types of weather, especially during hours of peak traffic. The entire crew complement testing on the Super 80 was completed with only 57 flights over only 70 block hours, which includes time spent taxiing to and from the runway.

McDonnell Douglas, the manufacturer, also rejected a proposal for a full-mission simulation to test the Super 80 crew complement under specific conditions which would realistically duplicate airline flying. For its part, the FAA questionably claimed it did not have the authority to compel such a test. Whether or not the FAA possesses the necessary authority is a matter of interpretation of the law, on which the FEIA and others disagree with the FAA. But no legal barrier stood in McDonnell Douglas' way. The company was simply unwilling to submit its judgment on workload to anything approaching a "real world" test, and the FAA failed to meet its responsibility to require it.

The FEIA finds the current certification process totally unacceptable. It believes firmly that the FEIA and ALPA, as organizations which represent the cockpit crewmembers who will fly the new equipment, must have a major role in decisions as to crew complement and crew workload, which is not now the case. Toward this end, the FEIA has called for a full-scale independent review of the present process by which new types of aircraft receive certification from the FAA, and is therefore pleased with the announcement that President Reagan has appointed a task force to look into the matter.

Such a review is urgently needed, because side-by-side with the dispute over certification of the Super 80 is the controversy over the impending FAA certifications for the next generation of turbojet aircraft.

The B-757 and the B-767, which are being built by the Boeing Company, and the A-310, which is being built by Airbus Industrie – all now in prototype construction – have cockpits designed for a crew of only two. These new aircraft types will be the first of the fourth generation of jets. All will be considerably larger than the Super 80 which, in turn, is considerably larger than the intermediate-range aircraft types that comprise the airline industry's second generation of jets.

The advocates of the two-member cockpit crew for the next generation of aircraft have spread considerable misinformation in their efforts to line up support for their position.

As was the case with the Super 80, the manufacturers are claiming that automation in this new generation of aircraft will eliminate the need for the third man, the Flight Engineer. The validity of this claim is being challenged not only by airline Flight Engineers and Pilots in the U.S., but by airline Flight Engineers and Pilots the world over, through their international organizations – the Flight Engineers' International Association and the International Federation of Air Line Pilots Associations.

The Flight Engineers and the Pilots agree that the manufacturers' claims are simply unrealistic. While the two groups favor the use of the latest technology in the design of the new aircraft, past experience has shown that the crew workload on each new generation of aircraft is not reduced. While some specific tasks may be eliminated, others are added. Moreover, past experience has also shown that the automated systems are never trouble-free and can, at times, serve to increase the workload. But more than anything else, the new technology is needed simply for the crew to keep up with a workload that grows constantly as the skies become more and more crowded.

The advocates of the two-member cockpit crew for the next generation of aircraft have spread considerable misinformation in their efforts to line up support for their position. That is why the FEIA decided to publish this monograph – to show how data have been misused and, as a consequence, the public misled.

There is, for example, absolutely no sound basis upon which to claim that an aircraft carrying a cockpit crew of two is safer than one which carries a crew of three. But advocates of the two crewmember concept have made that claim and have distorted aircraft accident statistics to support it. As this monograph demonstrates, if those statistics show anything, they show the reverse – that the accident rate among comparable aircraft types is lower when the cockpit carries a crew of three.

Thus, it is the purpose of this monograph to set the record straight. I believe it does that, and does it well. And I believe also that it leaves no doubt as to the advisability of the use of a crew of three in the cockpits of the next generation of jet aircraft – in order to maximize the safety of the passengers and the crew, in both the cabin and the cockpit.

William A. Gill, Jr.
President
Flight Engineers' International Association, AFL-CIO
March 1981

I/The Issue is Safety

The arguments advanced by the advocates of the two-crew notion belie any understanding of the real world of commercial aviation, or suggest a willingness to increase the risks associated with air travel.

Despite a growing body of literature on the measurement of workload, the determination of cockpit crew size on new aircraft continues to be approached by both the manufacturers and the Federal Aviation Administration (FAA) as an art rather than a science. The decisions are viewed essentially as judgment calls, with little need for serious scientific analysis as to whether the workload is or is not excessive.

As a consequence of that approach, the FAA last year certified the DC-9 Super 80 as airworthy with a cockpit crew of two. Moreover, manufacturers are designing the next generation of even larger jet aircraft – the B-757, the B-767, and the A-310 – also with cockpits for a crew of two, instead of the crew of three that would normally be the required complement in such aircraft. These decisions apparently rest on an assumption that technology and manpower are interchangeable, and that more of the former should mean less of the latter. The manufacturers have simply chosen to add technology and reduce crew size.

Having made this choice – and been challenged on it by the Flight Engineers' International Association, among others – the aircraft manufacturers have now turned their energies toward rationalizing the decision. They have apparently been moved to this course of action by the growing public sense that the next generation of aircraft – given their size and the complexity of their automated systems, to say nothing of the growing density of traffic in the air corridors – should have a cockpit crew of three. However, since the traveling public, whose interest is in maximizing safety, would find the truth totally unpalatable – the truth being that the decision was based on the economics of competition – the manufacturers, with the acquiescence of the airlines, are now seeking to use statistics on aircraft accidents to provide a "scientific" basis for their decision.

The manufacturers are, in effect, now seeking to use the accident data to promote the notion that, all other things being equal, a plane which is designed for, and flown with, a cockpit crew of two is safer than a plane which is designed for, and flown with, a cockpit crew of three. As will be demonstrated later, however, there are serious shortcomings in both the data and the analysis by which the supporters of this notion concluded that the traditional third man in the cockpit – the flight engineer – could be eliminated from these aircraft of the future.

The arguments advanced by the advocates of the two-crew notion belie any understanding of the real world of commercial aviation, or suggest a willingness to increase the risks associated with air travel. As any crewman can attest, flying a modern commercial high-speed jet aircraft is a complex and demanding task. In addition to the piloting that takes place, the operation requires constant cross-checking and monitoring of the multitude of critical systems within the plane, the environment in which the plane operates, and the conditions along the flight path.

Flight Engineers are primarily concerned with the safety of their aircraft. They check hundreds of items before take-off. During routine flight, they operate and monitor the operation of engines, the fuel systems, the hydraulic and pneumatic systems, the radio and electronic gear, the electric systems and a host of other power systems on which safe flight depends. Their monitoring and back-up functions can often mean the difference between safety and catastrophe during an emergency.

In flight or after landing, the Flight Engineer reports to maintenance crews any malfunctions observed during flight.

The Flight Engineer is a skilled technician who relieves the pilot and Copilot of stress, provides the necessary ability of a crew to perform multiple simultaneous duties, and takes on additional duties in the event of incapacity of other cockpit crewmembers.

These are a summary of the tasks the aircraft manufacturers claim they can safely automate in the next generation of jet aircraft, some of which will be large enough to carry twice the passenger load of the B-727, which operates with a cockpit crew of three. Even if the planned highly complex automated systems were to perform as designed – and it is predictable from past experience with new aircraft systems that they will not – there are still vital functions of the Flight Engineer that simply cannot be programmed.

When all is said and done, automated systems are no "smarter" than the programs that are built into them. Even the supposedly highly-sophisticated technology planned for the next generation of aircraft will permit the computer to monitor the aircraft's complex systems only to the extent designers of the computer programs have adequately anticipated the almost endless number of possibilities.

The unlimited faith the manufacturers are displaying in the ability of automation to displace the Flight Engineer assumes that the computer can be programmed for all of the abnormalities and failures that are possible in the aircraft's systems – including false alarms – and for all of the possible sequences and/or combinations of abnormalities and failures that might follow the first signal(s).

Reliance on the computerized system would be absolute. If something is amiss in one of the aircraft's systems, the computer – not the pilots – would decide what action is needed. Indeed, pursuant to its programmed instructions, a faulty system – even one that is falsely told by the computer that it is faulty – would switch itself off, and the pilots would learn of this only after the fact by the message displayed on a screen. It is only then that they would know of the need to take corrective action.

This procedure is frought with danger, because of the possibility of multiple simultaneous problems in one or more of the aircraft's systems. The computerized system will be able to react to the problems only sequentially, according to its pre-programmed determination as to the importance of each, and would not present the pilots with the "mix" of problems at one time. Not until the crew responds to notification of the first indicated system failure will the computer signal the next. In the event of simultaneous failures in the systems, the crew would not be given the full picture they need to enable them to cope as they think best with the totality of the aircraft's difficulties. The thinking would be done for them

When all is said and done, automated systems are no "smarter" than the programs that are built into them.

The automatic systems with their pre-programmed computer are simply not an adequate substitute for a flight engineer.

on the basis of information programmed into the computer.

As was indicated earlier, however, these computerized systems are not without problems. They can suffer breakdowns, and they can also give off faulty signals – to which they will respond because they are not "intelligent" enough to do otherwise. This happens even now with the highly-automated systems in the generations of turbojets that are currently flying. But in these instances the Flight Engineer is available to deal with malfunctions and/or faulty signals. By cross-checking with other readings on his instrument panel he can often detect faulty or misleading signals, whereas – left to its own devices – the computer will simply follow instructions and shut down the system, and this may then generate an entire sequence of faulty signals.

No matter what the aircraft manufacturers would have the American public believe, there is no such thing as 100 percent reliability in any automated system. Experience with nuclear generating plants, however low their accident rate, has made this clear. Their highly-automated systems, because of safety considerations, have been designed to assure as much error-free operation as is humanly possible. Nevertheless, they have suffered failures and have on more than one occasion been victimized by faulty signals from their automated monitoring systems. There have been accidents that the automated systems were not equipped to handle or, in spite of all of the pre-programming, did not handle as they should have.

The automated systems with their pre-programmed computers are simply not an adequate substitute for a Flight Engineer. Those automated systems should be used to back him up and help the crew make decisions. They should be used to supplement the Flight Engineer rather than to supplant him.

The manufacturers are simply refusing to recognize the essential need for a human monitor, just as they are refusing to acknowledge the invaluable contribution the Flight Engineer makes to safety by adding a third pair of eyes to the cockpit. This contribution is most important during the critical takeoff and landing phases of flights, particularly at busy airports. The crewmembers are aware – even if the others are not – of how key a factor this is, to the safety of the aircraft, especially since the takeoff and landing phases are the busiest of any flight for the Pilot and Copilot, both in connection with the craft's operation and the maintenance of essential communications with air traffic control. Because there is a Flight Engineer present, the entire crew has more opportunity to scan the skies for other aircraft that may be nearby and that may present a threat to the safety of the flight. Technology is simply no substitute.

The extent to which the third pair of eyes enhances the flight's safety was demonstrated during a six-month study of cockpit crew workload that was conducted by United Air Lines (UAL) and the Air Line Pilots Association (ALPA) with respect to the B-737. That study involved performance on 25,000 flight segments, with half the flights having been flown with a crew of three and half with a crew of two (with the third crewman present for safety reasons but not to participate in the normal operation of the aircraft).

One of the key findings of that study was that, over 50 percent of the time, neither the pilot nor copilot was looking out of the cockpit during climbs and descents. They were too busy with their other responsibilities.

Under these circumstances, it is not surprising to learn that the Flight Engineer was frequently the first crewmember to report visual sighting of other traffic. Thus, in that same study at UAL, the third crewmember on the B-737 was the first to see traffic reported by Air Traffic Control (ATC) 25 percent of the time, and *unreported* traffic 43 percent of the time. The Copilot detected traffic at about the same rate. Quite significantly, the study also showed that crews of three, sighted 37 percent more unreported traffic than crews of two.

The flight engineer was frequently the first crewmember to report visual sighting of other traffic.

Potentially, this represents a substantial differential in the safety factor, and it is safety – the safety of the passengers and the safety of the crews – which is the key issue in this dispute. Even the proponents of the smaller crews for the next generation of aircraft are aware of this. They realize that any attempt on their part to sell the public on the idea of the smaller crew size would be rejected if it meant some compromise with safety. Accordingly, the manufacturers have tended to soft-pedal the supposed cost-savings represented by the elimination of the third cockpit crewmember, and have instead sought to promote the idea that the proposed reduced crew size for this next generation of aircraft would entail no sacrifice of safety.

The arguments they make in support of their position are twofold. In the first instance, as indicated earlier, they claim the highly advanced technology being installed in the next generation of aircraft will make the third crewman superfluous. The new systems will be so automated, they say, that the job of Flight Engineer will disappear. Moreover, according to the manufacturers, because of the automation the workload for the remaining two crewmembers will not be increased, so there is no reason the next generation of aircraft – to be flown with a crew of two, if the manufacturers and the airlines prevail – should be any less safe than if they were flown with a crew of three.

Their second argument flows from the first, and was also touched on earlier. Advocates of the two-crew configuration for the next generation of aircraft have sought to achieve support for their position by reference to statistics on aircraft accidents. Boeing's analysis of the statistics led it to conclude – not merely that two-crew aircraft were as safe as aircraft flown with a crew of three, but – that "two-crew airplanes have a superior safety record to three-crew airplanes. . ."[1] (underlining added).

This latter claim – based in large measure on incorrect and/or distorted data – has served as a central feature of a promotion campaign that has been mounted by Boeing in search of support for the two-crew concept for its next generation of aircraft. Some of those data were produced by Boeing, and some by the FAA 1977-78 Task Force on Crew Workload.

[1] *Boeing Airliner*, July-September 1980, page 3

II/The FAA Task Force on Crew Workload

Despite the fact that the ALPA-UAL study covered six months of actual flying, in which the B-737 was flown for comparison purposes with both two- and three-member cockpit crews, the Task Force stated that the eventual decision to place a crew of three on United's B-737s was due to a "lack of a thorough understanding of the [FAA] certification process."

Actually, Boeing originally announced it was designing its next generation of aircraft types for a crew of three. Although the design even then anticipated that the latest in technology would be incorporated into the aircrafts' systems, the manufacturer nevertheless recognized the need for a three-crew cockpit.

Since then, however, two things happened. First, the French manufacturer, Airbus Industrie, announced it was designing the A-310 so that it could be flown with a cockpit crew of two. This action by a potential competitor must have had some influence on Boeing.

Then, in 1978, the FAA Task Force on Crew Workload issued its report. That report, which was nothing so much as a polemic in defense of the existing FAA procedures for certificating new aircraft types, obviously served to embolden Boeing in its efforts to justify the two-crew design for its next generation of aircraft. The manufacturer itself could not have expressed its position any better than the Task Force did, as in this example:

> ". . . In the past, it is possible that a rule relating a gross aircraft dimension such as weight, number of engines, or capacity to crew size may have been valid. But today, due to developments in automation, this is not the case. Either a large or small aircraft can be designed for either a two or three-man crew, depending on the application of modern control engineering. . ."[2]

Such a pronouncement, exhibiting unlimited faith in new technology, conveys little awareness of the hard realities of actual flying conditions, especially in skies that are becoming increasingly crowded.

In its report the Task Force discussed rather casually the findings of the ALPA-UAL workload study with respect to the B-737. This treatment of that study was pretty much a necessity for a report that was seeking to defend the current FAA certification procedures, since the ALPA-UAL project led eventually to a cockpit crew of three on UAL's B-737 aircraft—after the FAA, following its procedures and its approach to workload assessment, certificated that aircraft type as airworthy with a crew of only two. Despite the fact that the ALPA-UAL study covered six months of actual flying, in which the B-737 was flown for comparison purposes with both two- and three-member cockpit crews, the Task Force stated that the eventual decision to place a crew of three on United's B-737s was due to a "lack of a thorough understanding of the (FAA) certification process."[3]

[2] *Summary Report of 1977-78 Task Force on Crew Workload*, Federal Aviation Administration, December, 1978. Page 11.

[3] *Ibid.*, page 5.

The Task Force report leaves little doubt that its members are not prepared to countenance any role by the cockpit crewmembers or their associations in that part of the certification process which, in effect, entails an evaluation of the judgments of the manufacturer with respect to crew complement and crew workload on new types of aircraft. The off-hand manner in which the Task Force disposed of the six-month ALPA-UAL study – which, to this day, remains the only extensive comparative study of crew workload under actual flying conditions – is but one such example from the report.

Another example worth noting concerns a brief reference in the report to the problem of Pilot fatigue. In the opinion of the Task Force, some Pilot complaints about high workload and fatigue were due to conditions fostered by the collective bargaining agreements. Under those agreements, according to the Task Force, the crewmen "could bunch the month's flying in a small number of days."[4] The result, said the Task Force, was inadequate rest on layovers, and this – rather than workload – was the cause of the reported fatigue.

The problem of pilot fatigue is a serious matter, but the Task Force's reasoning is both tortured and wrong.

The problem of Pilot fatigue is a serious matter, but the Task Force's reasoning is both tortured and wrong. The fact is that those collective bargaining agreements serve to reduce the chance of pilot fatigue. Those agreements seek to assure that flight crews have more, not less, layover time than the FAA flight and duty time regulations require. The agreements prevent the employers from imposing the type of schedules and layovers that the Task Force presumably finds detrimental. In the absence of the restrictions imposed by the collective bargaining agreements, the maximum flight deck and duty hours would be controlled solely by the Federal Aviation Regulations. Oddly enough, the FAA is now proposing to increase flight time limitations.[5] In view of the Task Force's pronouncements, this is indeed ironic since such an increase would make the fatigue factor an even greater problem.

[4] *Ibid.*, page 18.

[5] See FAA Supplemental Notice of Proposed Rulemaking, Notice No. 78-3B; *Federal Register*, August 11, 1980, pages 53316-53332.

III/The Flawed Data on Accidents

Fortunately, the number of commercial aircraft accidents until now have been small, too small usually to provide much basis for any detailed statistical analysis.

The FEIA would be among the first to agree that the dispute over the size of the cockpit crew for the next generation of turbojet aircraft will not be resolved by analysis of the data on aircraft accidents, even those that are supposedly identified as crew-related. While the National Transportation Safety Board accident reports may be used to identify those incidents in which the crew was cited as a causal factor, those reports do not seek to isolate the influence, if any, of crew size.

Fortunately, the number of commercial aircraft accidents until now have been small, too small usually to provide much basis for any detailed statistical analysis. Accidents tend to involve a sequence of contributory factors, and it is often wrong to attribute them to a single factor such as the crew – let alone a single factor such as crew size. There are simply too many variables and too few accidents.

As was mentioned earlier, however, Boeing has used – or misused – statistics on accidents to support its claim that "two-crew airplanes have a superior safety record to three-crew airplanes." A substantial portion of the Boeing data – used in the company's world-wide marketing program to sell its aircraft – is based on material contained in the report of the FAA Task Force, which included a statistical analysis of crew-related aircraft accidents according to cockpit crew size. Those data, however, suffered serious shortcomings that need to be addressed – especially since they have been used by Boeing to reach an entirely invalid conclusion.

The Task Force analysis focused for the most part on the short- and intermediate-range aircraft types. These included the two-crew DC-9 and the three-crew B-727, the two short- and intermediate-range workhorses of the U.S. commercial fleet, as well as the B-737, the BAC-1-11, and inexplicably, the DC-8. As a long-range aircraft, the latter was clearly out of place. And since it had, in relative terms, a large number of accidents and few departures, its inclusion with the three-crew aircraft (the others are the B-727 and some B-737s) had the effect of raising artificially the crew-related accident rates for the three-crew aircraft.

The Task Force data analysis suffered from an additional flaw – one that had an even more pronounced effect in distorting the final results. This flaw stemmed from Task Force errors in classifying many of the accidents.

The Task Force statistics were derived by analyzing the accident reports of the National Transportation Safety Board (NTSB) for the 1967-76 period. But that Task Force analysis was glaringly superficial. It retained among the crew-related accidents a substantial number that could not be properly classified in such a category. Oddly enough, the bulk of the improper classifications were accidents involving the three-crew B-727.

The Task Force report states that its accident statistics were "normalized" to eliminate "accidents that cannot reasonably be attributed to the air-crew." These the Task Force defined as ". . .injuries caused by turbulence and additional accidents that occurred while the aircraft was on the ground, such as a deplaning passenger slipping . . . or a ground handling truck running into a stationary aircraft."[6] For reasons that are totally unclear, however, the Task Force in many instances ignored its own normalization criteria and incorrectly retained as crew-related a number of accidents that could not reasonably be attributed to the crew, let alone the cockpit crew. Following are several of the more gross examples of the Task Force's errors, with the accident descriptions as they appeared in the Task Force report:

The major flaw in the Task Force analysis apparently stems from the number of accidents it classified as crew-related.

NTSB File	Date	Nature of Accident
1-0055	12/13/69	Daughter of elderly passenger inadvertently seated her mother on retracted flight attendant jump seat. Mother fell.
1-0036	12/22/73	Evacuation due to bomb threat. Passenger injured jumping from leading edge of wing. Inadequate evacuation briefing by flight attendants.
1-0029	9/23/68	Precautionary landing at airport. Passengers injured when they jumped or slid from leading edge at wings. Possibility of dynamite aboard.
1-0008	2/19/72	Precautionary landing because of false fire warning. Passenger injured during evacuation.

A principal focus of the Task Force analysis involved a comparison of the data for the two-crew DC-9 and the three-crew B-727. While the Task Force concluded that the difference between the two aircraft types with respect to crew-related accidents was not statistically significant, Table 1 of its report shows that, of the two, the B-727 had a substantially higher crew-related accident rate—4.03 per one-million departures, versus 3.20.

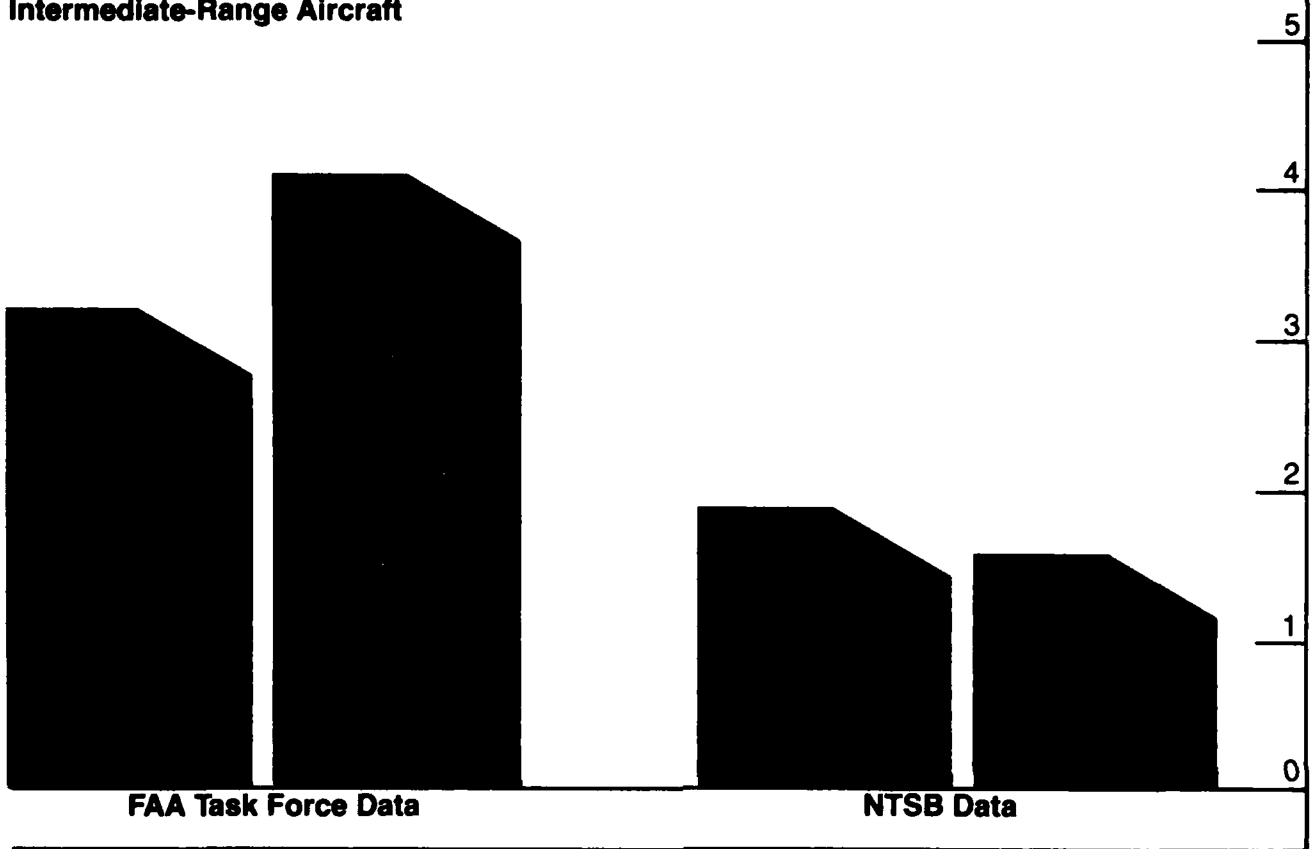
The fuzziness of this analysis was vividly demonstrated when the NTSB subsequently prepared its own report on accidents in which the *Pilot, Copilot,* or *Flight Engineer* was cited as a causal factor during the period of 1967-79. (The NTSB data analyzed by the Task Force went only through 1976.) Unlike the Task Force analysis, the NTSB data did not include incidents that were attributed to crewmembers assigned to the cabin. The NTSB analysis of the 1967-79 data on crew-related accidents was contained in a letter of September 30, 1980, from Board Chairman James King to Senator Howard Cannon, Chairman of the U.S. Senate Subcommittee on Aviation.

As Chart 1 shows, this NTSB analysis contradicts that of the FAA Task Force. In analyzing the data for the 1967-1979 period, the NTSB found a crew-related accident rate (per one-million departures) of 1.92 for the DC-9, but only 1.56 for the B-727. Thus, the Task Force's analysis

[6] *Ibid.* page 33.

U.S. Air Carrier Crew-Related Accident Rates for the Two Most-Widely Flown Short-Range and Intermediate-Range Aircraft

Accidents Per One Million Departures



Source: *Summary Report of 1977-78 Task Force on Crew Workload,* Federal Aviation Administration, December 1978, which analyzed accidents during 1967-76; and National Transportation Safety Board (Letter of September 30, 1980, with enclosure covering accidents from 1967 through preliminary 1979, from Chairman James B. King addressed to Senator Howard W. Cannon, Chairman of the Subcommittee on Aviation of the U.S. Senate Committee on Commerce, Science and Technology).

yielded a B-727 crew-related accident rate that was more than 25 percent greater than the rate for the DC-9, but the NTSB's analysis showed that it was the DC-9 which had the higher accident rate – and one that was nearly 25 percent greater than the rate for the B-727.

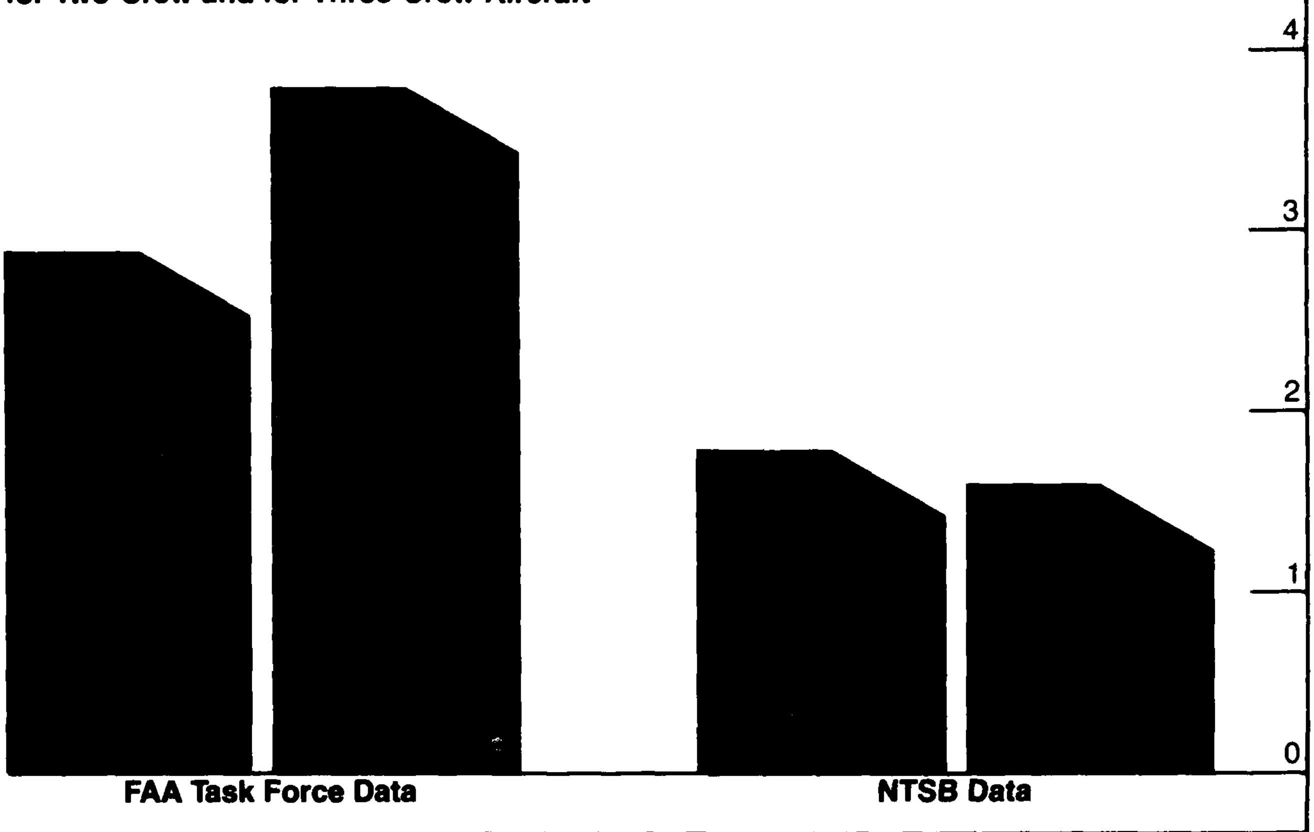
The major flaw in the Task Force analysis apparently stems from the number of accidents it classified as crew-related. In its review of the NTSB accident reports during the 10 years of 1967-76, the Task Force came up with 54 crew-related accidents for the three-crew B-727 aircraft, and 32 for the two-crew DC-9. The NTSB analysis, however, which accompanied Chairman King's letter and covered a 13-year time span, found that the crew was cited as a causal factor in only 30 B-727 accidents and 26 DC-9 accidents. While the Task Force overstated the number of crew-related accidents for both aircraft types, the over-statement was obviously far greater in the matter of the three-crew aircraft.

These errors in accident classification – together with the inclusion of the long-range DC-8 with the three-crew aircraft – distorted another set of data that appeared in the report of the Task Force. Thus, according to a table in the report[7] presuming to summarize the data on crew-related accidents for all of the aircraft types included in the Task Force's analysis,

[7] Table 2, page 37.

Chart 2

U.S. Air Carrier Crew-Related Accident Rates for Short-Range and Intermediate-Range Aircraft, Combined for Two-Crew and for Three-Crew Aircraft[1]



[1] Two-crew aircraft types: DC-9, BAC-1-11, and some B-737s. Three-crew aircraft types: B-727 and some B-737s.

Source: *Summary Report of 1977-78 Task Force on Crew Workload*, Federal Aviation Administration, December 1978, which analyzed accidents during 1967-76; and National Transportation Safety Board (Letter of September 30, 1980, with enclosure covering accidents from 1967 through preliminary 1979, from Chairman James B. King addressed to Senator Howard W. Cannon, Chairman of the Subcommittee on Aviation of the U.S. Senate Committee on Commerce, Science and Technology).

the crew-relateu accident rate for all of the two-crew aircraft types was 2.88 (per one million departures), while the rate for the three-crew aircraft was 4.18. Even if the statistics relating to the DC-8 are excluded, the Task Force analysis would show a higher crew-related accident rate for the three-crew aircraft.

As Chart 2 shows, this is not consistent with the data developed by the NTSB. The NTSB analysis (excluding the DC-8) produced a crew-related accident rate of 1.6 accidents per one-million departures for the three-crew aircraft, and a higher rate – 1.8 accidents per one-million departures – for the two-crew aircraft type. The latter include the DC-9, the BAC-1-11, and some of the B-737s. The three-crew aircraft include the B-727 and some of the B-737s.

The two-crew and three-crew configurations of the B-737 do not provide the basis foi an apt comparison of that aircraft's operation alone. For one thing, the statistical base is too small. That aircraft type had only 4.2 million departures (and only 6 crew-related accidents) during 1967-69, compared to 19.2 million B-727 departures and 13.5 million DC-9 departures. Moreover, in the three-crew B-737, the Flight Engineer's station is forward-facing, behind and between the Pilot and Copilot. That is to say,

In the absence of the side-facing control panel for the flight engineer, he often cannot perform his tasks without distracting either the pilot or copilot from theirs.

even when carrying a crew of three, the aircraft is essentially configured for a cockpit crew of two, as originally designed by Boeing.

Unlike the three-crew B-727, the two-crew B-737 does not have a separate side-facing panel of controls at the Flight Engineer's station. That separate side-facing panel at the Flight Engineer's station is a factor in enhancing the ability of the three-crew B-727 to achieve its superior safety performance over the two-crew DC-9. In the absence of the side-facing control panel for the Flight Engineer, he often cannot perform his tasks without distracting either the Pilot or Copilot from theirs. Such a physical arrangement maximizes neither safety nor efficiency in the cockpit's operations.

This is why the "cleanest" comparison of the crew-related accident rates for two-crew and three-crew aircraft types is that involving the two-crew DC-9 and the three-crew B-727. The former's cockpit is configured for, and flown exclusively with, a two-member crew; and the latter's is configured for, and flown exclusively with, a three-member crew. And each has had many millions of departures.

For its part, Boeing has embellished the flawed FAA analysis and, in its promotion program, injected some additional erroneous and misleading data. The company asserts, for example, that tests show that on the average flight "approximately 25% of each crewmember's total available time was spent doing observable tasks." In other words, crewmembers were not observably busy 75% of the time during the flights on which the tests were conducted.

This is a totally misleading statistic, which can only produce a meaningless conclusion. Averaging the workload over the duration of the flight makes no sense, because there are extended periods of little activity during most flights. The basic issue concerning the crew complement involves the possibility of work overload – including mental tasks that may not be "observable" to the onlooker – at critical points of the flight, such as takeoffs and landings. As every crewman – and, no doubt, Boeing too – knows full well, most of the work overload is likely to occur during those flight phases. It is primarily during those stages of the flight when the assessment of crew complement and crew workload has its greatest meaning. Thus, the exercise by which Boeing produced the data showing its "averages" could have been conducted only with mischief in mind.

IV Crew Size and ATC Violations

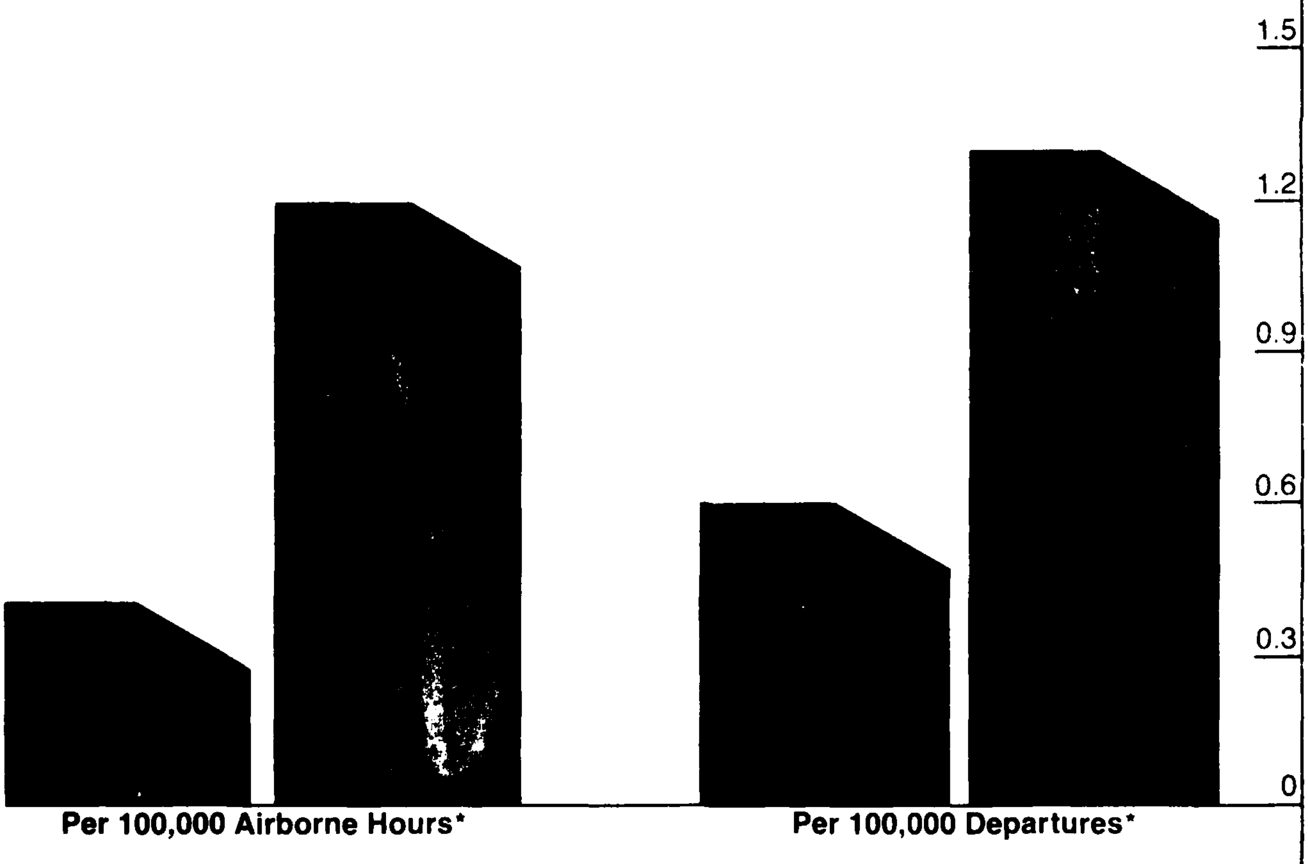
If the handling of the accident data represents errors of commission by Boeing and the Task Force, their failure to search for any other valid linkages relating crew size to safe performance represents a serious error of omission. Neither of those two analyses dealt, for example, with the issue of Air Traffic Control (ATC) violations.

The FEIA, however, did undertake to analyze the ATC violations rates for the two-crew DC-9 and the three-crew B-727. Its findings are disclosed in Chart 3, which shows that the violations rates for the two-crew aircraft are far in excess of the rates for the three-crew aircraft.

The violations data were measured in terms of both airborne hours and aircraft departures – for the years 1969-78 in the case of the former

Chart 3

Average Annual Rates of Air Traffic Control Violations Involving All DC-9 and B-727 Flights of Trunk Airlines and of Local and Territorial Carriers



*Average for 1969-78 with respect to data on airborne hours and 1971-78 in the case of data on departures

Source: Civil Aeronautics Board and Federal Aviation Administration

The position of the manufacturers in this crew complement dispute is not based on any sound analysis or on a valid body of supportive information.

and 1971-78 in the case of the latter. The use of different time periods was dictated solely by the data availability.

As Chart 3 shows, DC-9 crewmen had an annual violations rate of 1.2 per 100,000 airborne hours, while the rate for B-727 crewmen was only 0.4. Measured on the basis of aircraft departures, the disparity in the performance of the crew of these two aircraft types is only a bit less dramatic – a yearly average of 1.3 violations per 100,000 departures for the DC-9 crews and 0.6 per 100,000 departures for the B-727 crews.

These data suggest there is a difference in the performance of the two crews, and that the third crewman is the factor. Unlike the conclusion reached by Boeing and implied by the Task Force report, the conclusion one would lean toward on the basis of these violations data is that it is the three-crew airplanes which have the superior safety record – unless, of course, one wishes to suggest that ATC regulations have no bearing on safety.

V/ Technology and Workload[8]

If the computers fail, the crew must take over vital aircraft functions and, as of now, computer reliability is difficult to assess.

The problems associated with the new technology that is introduced with each new generation of aircraft are directly related to the issue at hand. Boeing and other manufacturers – as well as the airline companies – are basing their judgments concerning the crew complement for the next generation of aircraft on the assumption that the new technology will eliminate the need for the Flight Engineer. Supposedly, automation will reduce the total workload, so that two crewmen will suffice. In addition, Pilots are promised that they will benefit from improved cockpit layouts, new generation electronic flight management systems, and new computers which are responsible for image generation of flight instruments and which are able to control the flight path and navigation of the aircraft.

Aircraft manufacturers are basing crew workload and crew complement decisions on the operability of these systems. Yet, for all the advances which technology has made in the design of systems, there is a disquieting trend that such systems have been failing at an ever-increasing rate. Should this trend continue, the cockpit crew will soon face potentially hazardous workload situations on a regular basis; new technology will hinder rather than help.

New technology will do two things, both of which may increase, rather than decrease, workload. First, new systems will be dependent on the reliability of computers. If the computers fail, the crew must take over vital aircraft functions and, as of now, computer reliability is difficult to assess. R. Bernhard, in a recent article for the Institute of Electrical and Electronic Engineers, summarized the problem: "No generally accepted methods exist for validating the reliability of the super-reliable avionics computers. The Federal Aviation Administration has no exact reliability requirements for aircraft systems. . . ."[9]

The second, and more subtle, increase in workload comes from the shifting of crew duties from the physical operation of controls to the mental monitoring of systems. Although it may appear that crews are less busy since hands and arms are not moving, monitoring is more difficult. Previously, crews had to acquire aircraft status information, process the information to determine what the aircraft should be made to do, and take appropriate actions. Soon, in addition to these steps, before taking actions, crews will also have to compare their determinations to what the systems have decided. This extra step requires additional information acquisition and processing, resulting in an increase in the amount of time before a Pilot can act.

In light of the potential problems with complex systems, a thorough review was performed to determine how reliable newer technology has been and what impact technology can be expected to have on the future. The review was based on the FAA's Service Difficulty Reports (SDRs) system which lists reported inflight engine shutdowns, landing gear problems, fire, loss of brakes, fuel system problems, and

[8]From "Technology and the Future Aircraft," unpublished paper by Dr. Jack I. Laveson, October 1980.
[9]"The 'No-Downtime' Computer," *IEEE Spectrum*, September 1980, pages 33-37.

Because of problems with the performance of that new technology, the greater likelihood is for some increase in the workload for the cockpit.

structural problems. In addition, problems that result in emergency crew actions, or that have endangered or may endanger the safe operation of the aircraft, are reported.

Although there are inherent limitations in the use of SDR information, it does make it possible to assess the relative magnitudes of systems and technology problems. The analysis that was performed entailed an examination of the SDRs for the five years of 1974-78 and covered the following aircraft types:

		Year of Introduction
First Generation	Boeing B-707	1958
	Douglas DC-8	1960
	Boeing B-720	1960
	Convair CV-880/990	1961
Second Generation	Boeing B-727	1963
	BAC-1-11	1965
	Douglas DC-9	1965
	Boeing B-737	1967
Third (Wide Body) Generation	Boeing B-747	1969
	Lockheed L-1011	1971
	Douglas DC-10	1971

Categorizing by generation is convenient because it also serves to classify the aircraft according to technology level.

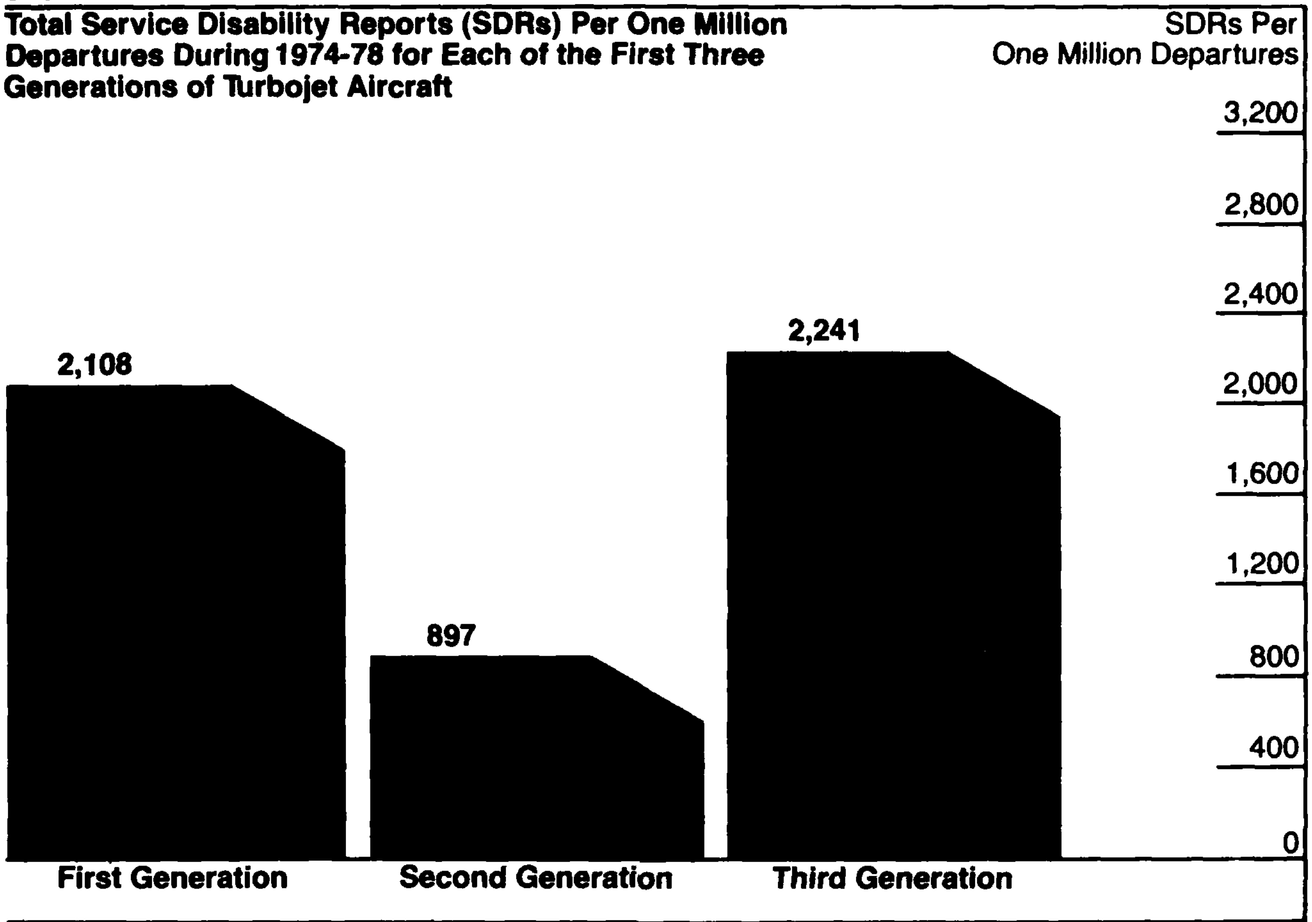
As Chart 4 shows, the first jet aircraft through the B-720 showed SDR rates of more than 2,000 (actually, 2,108) per one-million departures. The Convair 880/990 series has almost no SDRs because of few operations. During the period analyzed, the Convair 880/990 had only 3,430 departures compared to the next higher departure aircraft, the B-720, with 166,656 departures. For all intents and purposes, the Convair 880/990 is not a factor in the analysis and therefore was not included.

Aircraft after the B-720 and through the B-737 show large reductions in SDR rates. The technology in these second generation aircraft is a *refinement* of technology used on earlier aircraft. Since no *new* technology was introduced, the result is as expected. The SDR rates for these aircraft were about one-half the rates for the first generation of turbojets.

The third generation, however, shows a *sharp jump* in the SDR rates, even surpassing the rates for the first generation. The wide-body aircraft incorporated new avionics and high bypass engines. The "bugs" in this technology may be eliminated in the next generation of aircraft. But that next generation of aircraft, the manufacturers promise, will have additional and still-more complex technology. As a result, this next generation of aircraft may experience even higher SDR rates than the wide bodies.

Chart 4

Total Service Disability Reports (SDRs) Per One Million Departures During 1974-78 for Each of the First Three Generations of Turbojet Aircraft



Source: Federal Aviation Administration.

This finding has major implications for aircraft design and certification, since the only logical explanation for the high rates of SDRs on new generation aircraft is the new technology. Other factors, such as age and aircraft modifications, were considered as possible factors, but had to be discarded – the former because all aircraft, regardless of age, must meet FAA standards for airworthiness, and the latter because modifications, though continuous, seldom involve radical change. And, it must be emphasized, the SDRs relate to in-flight difficulties and not to ground maintenance, of which more may be involved in maintaining older equipment in proper condition.

The data base included 23,988 SDRs. Consequently, one can hardly suggest that the disparity between the different generations of aircraft types with respect to service difficulties might be accounted for by incomplete reporting.

In the absence of any other explanation, technology problems must be regarded as the reason for the differential in SDR rates, and it is hardly appropriate, therefore, to anticipate that the next generation of aircraft, with its use of still more new technology, will produce the reduced workload the manufacturers are promising. Because of problems with the performance of that new technology, the greater likelihood is for some increase in the workload for the cockpit.

VI/Need for Side-Facing Engineer's Panel[10]

The only sound design for a three-crew cockpit is one that has a separate, side-facing instrument panel for the flight engineer.

Because of the opposition of the Pilots and Flight Engineers throughout the world to the two-crew cockpit for the next generation of aircraft, Airbus Industrie had decided to design the A-310 so that a Flight Engineer's seat – if desired by the purchasing airline – can simply be added between and behind the Pilot and Copilot. Thus, the essentials of the two-crew configuration will be maintained – in much the same fashion that such a configuration has been maintained on those B-737s that fly with a crew of three. In this configuration, the Flight Engineer has no separate instrument panel and often cannot perform his role without intruding on the other two crewmen. In an aircraft designed for a crew of two, there is no alternative when a third crewman is added, because the basic design places all instruments and controls within reach and view of the Pilots. The cockpit is entirely forward-facing.

Such a forward-facing cockpit is unsatisfactory, even if it were to be designed for use exclusively by a crew of three instead of two. The forward-facing design eliminates the Flight Engineer's side-facing instrument panel that is common in all large jet aircraft. But many of the numerous controls and indicators that form the Flight Engineer's panel are not eliminated. In a forward-facing cockpit, such as that being designed into the A-310 to be operated by either a crew of two or three, those controls and indicators are transferred mainly to the overhead panel. Because of space constraints, that panel must be much smaller than the side-facing panel, with all of the controls and indicators correspondingly compressed to fit onto the overhead panel.

However, as much as the manufacturers might wish to make it appear otherwise, a forward-facing cockpit is essentially a two-crew design. It is totally unsatisfactory because it is not conducive to an efficient well-integrated flight deck operation involving a three-member crew.

The only sound design for a three-crew cockpit is one that has a separate, side-facing instrument panel for the Flight Engineer. There can be no shortcuts here. The crew complement must be matched with the cockpit design, for as the Task Force itself saw fit to stress, ". . . a flight deck designed for a three-crew member operation cannot be optimal for two and . . . a two-member flight deck crew will be unbalanced and inefficient if operated by three."[11] A forward-facing cockpit fits a crew of two.

As the operational requirements on modern air carrier aircraft become ever more stringent, the tolerance to which the flight crew must control the aircraft become narrower and narrower. While the sophisticated electronic equipment on these aircraft makes it possible to operate within these narrower tolerances, there are correspondingly greater demands on the crew to concentrate on their displays.

[10]From "No Compromise with Safety: The Crew Complement Question," published by Europilote and U.S. ALPA 1980, pages 17-19

[11]R. F. Hillman and J. W. Wilson, "Future Flight Deck Design," in *Proceedings of Symposium on Design of the Inside Out*, Royal Aeronautical Society, February 6, 1975, quoted on page 14 of the Report of the Task Force

A forward-facing cockpit is unsatisfactory, even if it were to be designed for use exclusively by a crew of three instead of two.

Therefore, it is becoming increasingly important to remove any controls and displays not directly related to controlling the flight path of the aircraft from the view of the Pilots. Flight path control is the most critical function in the cockpit and the task of systems operation must not be allowed to intrude upon it, lest the intrusion occur at a critical point and produce the potential for an accident. In the forward-facing cockpit, too many controls and indicators not directly related to flight path control are placed in front of the Pilots and are a continuous source of distraction.

While manufacturers may claim a forward-facing cockpit for a crew of three affords better crew integration and better monitoring, this is highly doubtful. In a forward-facing cockpit, the actions taking place on the pedestal or the forward panel can be monitored by all crew members. But the majority of actions of the third crew member, if performed within the Pilot's field of view – e.g., switching of the cathode ray tube display for systems monitoring, or adjusting cabin temperature or cabin pressure rate of change, etc. – can form a distraction. When a serious malfunction occurs, only one Pilot should monitor the Flight Engineer's actions. The other Pilot should not be distracted. Instead, he should be entirely engaged in controlling the flight path of the aircraft. In a cockpit designed with the Flight Engineer's panel facing sideward, the Pilot in the left-hand seat has only to turn his head to have a complete view of that panel, while the Pilot in the right-hand seat concentrates solely on flying the aircraft without distraction.

For duties to be performed on the overhead panel, the story is different. It is clearly established by human factor experts that an overhead panel is the worst panel to work on or to monitor. Moreover, both Pilots have a very flat angle of view of the overhead panel, which is low and partly behind them. To get a clear view they have to bend sidewards and rearwards and turn their heads to an unnatural position. In actual fact, therefore, a Flight Engineer working on the overhead panel will be far less monitored than on a sideward panel, where he can be monitored when necessary by the left-hand Pilot who simply has to turn his head.

In view of the little space available on the overhead panel, indicators and controls are small and located closely together. Many of the controls are similar pushbuttons. These facts, and the unfavorable position and angle of the overhead panel, make identification of the proper switch and its operation much more inconvenient and more time-consuming than a similar selection on a sideward facing panel. Operation of a pushbutton on the overhead panel requires bending the head and/or body to an inconvenient position, focusing the eye to read the small printed text on the switch, while looking at the switch for selection.

A swivel seat allows him to turn forward during the critical phases of flight, where flight path control is of prime importance, and enables him to monitor flight progress and to assist the pilots.

In the case of the side-facing panel, however, the panel is in front of the Flight Engineer, so no head or body turn is needed. In addition, switches are more widely spaced and of different shape, so that a momentary look is sufficient for operation.

The overhead pushbutton selection becomes critical in cases of lighting problems, smoke in the cockpit, or in turbulence. It is clear that the pushbutton technique is necessary to squeeze as much information and as many controls as possible into the space available. This, by no means makes the crew tasks easier. In fact, it increases workload.

Finally, it must be noted, the side-facing panel at the Flight Engineer's station does not deprive the cockpit of his important third set of eyes. A swivel seat allows him to turn forward during the critical phases of flight, where flight path control is of prime importance, and enables him to monitor flight progress and to assist the Pilots.

VII/Conclusion

Clearly, the position of the manufacturers in this crew complement dispute is not based on any sound analysis or on a valid body of supportive information. As this study has shown, their claims about the accident rates are wrong, and their assumptions concerning the ability of new technology to reduce workloads are questionable and not supported by past experience.

The position of the manufacturers in this crew complement dispute is not based on any sound analysis or on a valid body of supportive information.

As the data in this monograph have indicated, the crew-related accident rate, for aircraft with two crewmembers is not lower than it is for aircraft flown with a crew of three. It is, as the NTSB data demonstrates, higher. Moreover, the three-crew B-727 has also experienced a far smaller rate of ATC violations than has the two-crew DC-9.

Thus, the manufacturers are asking the public – and the air crews – to accept in the next generation of aircraft a cockpit configuration and a crew complement that can provide less safety than a three-crew configuration would provide.

It is not the crewmembers alone who find the proposition unacceptable. The public does not like it either.

Following the FAA certification of the Super 80 as a two-crew aircraft in late 1980, the FEIA commissioned a nation-wide public opinion poll by Opinion Research Survey, Inc., of Washington, D.C. The poll sampled opinions about arguments that had been advanced for and against the three-member crews. Here are a few highlights from the poll's findings:

- By a margin of nearly 2-to-1, those interviewed felt that new technology does not reduce workload, but merely helps air crews keep up with the added burden produced by the increase in air traffic.
- Four out of every five respondents said that, for safety reasons, human back-up is needed with the new technology.
- Three out of every four felt the presence of a Flight Engineer in the crew is worth the cost of that human back-up.

Quite clearly, the public is interested in the added margin of safety, as are the air crewmen. Perhaps the number in the poll in favor of maintaining the Flight Engineer as a member of the cockpit crew would even have exceeded 75 percent had they known how little the cost really is.

Any saving to the public that would result from a two-crew operation on this next generation of aircraft would be quite minimal, and much

The crewmen firmly believe that the next generation of jets must be designed for a cockpit crew of three—for their sake as well as the public's.

less than the manufacturers and the airlines have thus far indicated. According to an analysis by the FEIA, the savings would come to approximately three mills ($0.003) per passenger revenue mile, and would mean about $2.00 on a current ticket of $150.

From the point of view of the airlines, however, the aggregate profits that could flow from these small numbers could be great indeed. They carry millions of passengers and fly billions of miles. But that is something none of them mentions, just as the manufacturers who hope to sell the aircraft do not discuss the profits they stand to make – even while sacrificing some margin of safety.

If the position of the air carriers and the manufacturers in this dispute is clear, so, too, is the position of the air crewmen, including those who belong to the FEIA. The crewmen firmly believe that the next generation of jets must be designed for a cockpit crew of three – for their sake as well as the public's.

FEIA

Prepared by
Flight Engineers International Association
[illegible] N.W.
Washington, D.C. 20006

QUESTIONNAIRE DISTRIBUTED TO PARTICIPANTS IN WORKSHOP
ON AIRLINE OPERATIONAL ISSUES
AT THIRD HUMAN FACTORS WORKSHOP ON AVIATION

Whoever wishes to take part in the survey is encouraged to fill out the questionnaire and submit it to the following address:
Conference Office, DTS-930, Transportation Systems Center, Kendall Sq., Cambridge MA 02142

Human Factor Problems in Airline Operation

Please list by priority 1-32 and give reason why number one was selected over the other 31.

1. Human Factors in certification - what parameters are used?

2. How do the manufacturers and the FAA agree that acceptable levels of the external environment have been duplicated?

3. Once this acceptable level has been established, how is workload reduction measured?

4. Is this workload reduction measurement against a previous system and environment, or a different advancement in the state of the art to handle future saturation levels through the 1990's?

5. Circadian Cycle - can we measure it in simulation?

6. How important is nutrition in human factors? (circadian cycle, mental fatigue)

7. How do we identify a human factors problem?

    a) How do we measure it.
    b) How is acceptability defined.
    c) Establish a foundation of how to solve identification.

8. How much of a factor is motion versus no motion in simulation to identify human factor problems?

9. Communications - verbal and visual.

10. How do we effectively monitor flight deck automation?

11. Accidents/incidents - how do they fit into the human factors role?

12. CRT's - Will the multiple color CRT's pose a problem on Class I waiver medicals?

13. Man instrument interface - How do we handle pilots problems in today's environment?

14. Cockpit Management - Today's versus new generation - aircraft.

15. Complacency - Has the pilot been trained adequately to monitor or support the flight deck automation?

16. Predictive Risk - A major concern in human factors.

17. The liability associated with the predictive risk.

18. Economic impact of #16 and #17 on safety.

19. Fatigue - Are we measuring physiological degradation or safety?

20. Safety - What is an adequate performance versus optimum performance?

21. Human factor system - How do we establish the Joe average performance?

22. A need to develop a measurement system that establishes adequate, optimum, and overload performance levels in real world exercises.

23. Today's flight crew problem interfacing deck automation.

24. Establishing systems performance requirements for human factors.

25. The joint responsibility of PIC and dispatcher for aircraft operational control.

26. Higher requirements for licensing and experience for dispatchers for environment.

27. Better training for dispatchers.

28. Increased workload requirements due to computerized flight plans. Higher volume for less people.

29. Psychological fatigue due to time duration on CRT's.

30. Duty hours reduction from 10 to 8.

31. The problem with rotating shifts to sleep cycles.

32. Should LOFT be the standard in Human Factors simulation training?

Priority Selection Preference

1.	17.
2.	18.
3.	19.
4.	20.
5.	21.
6.	22.
7.	23.
8.	24.
9.	25.
10.	26.
11.	27.
12.	28.
13.	29.
14.	30.
15.	31.
16.	32.

Why number one was selected.

LIST OF ATTENDEES

THIRD HUMAN FACTORS WORKSHOP ON AVIATION

FINAL LIST OF ATTENDEES

Ronald Ace
Systems Engineer
Systems Control, Inc.
1901 - N. Ft. Myer Dr.
Suite 200
Arlington, VA 22209

James P. Andersen
Director, Office of Air and Marine Systems
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Karl Anderson
Vice President
Flight Engineers International Association
905 16th St., N.W.
Washington, DC 20006

Gary Babcock
Pilot
Airline Pilots Association
5727 Gardner Ct.
Hanover Park, IL 60103

Sheldon Baron
Vice President, Information Sciences
Bolt Beranek & Newman Inc.
10 Moulton St.,
Cambridge, MA 02238

Richard Bartel
President
Flight Resources, Inc.
8121 GA. Ave.
Suite 603
Silver Spring, MD 20910

Barry Bermingham
Aviation Safety-Operations
Flight Standards Division
Federal Aviation Administration
12 New England Executive Park
Burlington, MA 01803

C.M. Bertone
Chief, Human Factors Engineering
Sikorsky Aircraft
No. Main St.
Stratford, CT 06602

Roy A. Bird
Regional Sales Manager
de Havilland Aircraft of Canada
Limited
Garratt Blvd.
Downsview, Ontario M3K 1Y5
CANADA

Harold P. Bishop
Chief Behavioral Systems Branch
Transportation Systems Center
Kendall Square,
Cambridge, MA 02142

Neal A. Blake
Deputy Administrator
Engineering and Development
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, DC 20591

Stuart B. Burdess
Squadron Leader
United States Air Force
Wright-Patterson Air Force Base
(AFWAL/FIGR)
Dayton, OH 45433

Malcolm A. Burgess
Office of Flight Operations
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, DC 20591

Teresa Burke
Graduate Assistant
Wright State University
Dayton, OH 45435

Arthur F. Chantker
Program Manager Performance Measurement &
Analysis
Federal Aviation Administration
400 7th St., S.W.,
Washington, D.C. 20591

Arthur B. Childers
Helicopter Association International, Inc.
Suite 430
1110 Vermont Ave., N.W.
Washington, DC 20005

Diane Christensen
Senior Project Analyst
Biotechnology, Inc.
3027 Rosemary Lane
Falls Church, VA 22042

Douglas R. Clifford
Chief Engineer, Flight Management Systems
Boeing Commercial Airplane Company
P. O. Box 3707,
Seattle, Washington 98124

Mark Connelly
Research Electrical Engineer
Massachusetts Institute of Technology
77 Mass. Avenue, Rm. 35-421
Cambridge, MA

William C. Connor, Captain
Embry-Riddle Aeronautical University
Regional Airport
Daytona Beach, FL 32014

F. H. Conway
Program Analyst Air & Marine Systems
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

John R. Coonan
ATC Specialist
Transportation Systems Center
Kendall Square,
Cambridge, MA 02142

William J. Cox
Aviation Consultant
6455 Arlington Blvd.
Falls Church, VA 22042

Richard C. Crowell
Manager, Flight Operations
Air New England
Barnstable Municipal Airport
Hyannis, MA 02601

Mike Cuddy
Flight Manager
United Airlines
Los Angeles International Airport
P.O. Box 92245, World Way Postal Center
Los Angeles, CA 90009

Len Curreri
President
Corporate Wings
8 Andrea Drive
Braintree, MA 02184

Don DeMyer
Group Staff Engineer
Lear Siegler Inc., Instrument Division
414 Eastern
Grand Rapids, Mich.

Joseph Dumas
Manager Boston Office
Wilson Hill Associates
24 Federal St.
Boston, MA 02110

William W. Edmunds
Human Performance Specialist
Air Line Pilots Association
1625 Massachusetts Avenue, N.W.
Washington, DC 20036

Ted Eisen
Vice President of Research &
Planning
AOPA Air Safety Foundation
7315 Wisconsin Ave.
P.O. Box 5800
Washington, DC 20014

Charles Erdrich
Input/Output Computer Services
400 Totten Pond Rd.,
Waltham, MA 02154

Steven Farber
Engineer, Staff Assistant
Transportation Systems Center
Kendall Square,
Cambridge, MA 02142

Jim L. Fileccia
Group Leader, Crew Systems Technology
Wright-Patterson Air Force Base
Dayton, OH 45433

George W. Fraker, Captain
737 Chief Pilot
Federal Express Corp.
Box 727
Memphis, TN 38104

Thomas L. Frezell
Research Psychologist
U.S. Army Human Engineering
  Laboratory
Aberdeen Proving Grounds, MD 21005

Edwin V. Friend, Captain
U.S. Metric Coordinator
  for A.L.P.A.
Republic Airlines
P.O. Box 6363-25237 Horseshoe Trail
Scottsdale, AZ 85255

Joseph T. Fucigna
Executive Vice President
Dunlap & Associates, Inc.
One Parkland Drive
Darien, CT 06820

Reginald Furlonger
British Embassy
3100 Massachusetts Ave. N.W.
Washington, DC 20008

Robert G. Gadbois
Department Manager
Lear Siegler Inc.
4124 Linden Ave.
Dayton, OH

Eugene Galanter
Professor, Director
Columbia University
324 Schermerhorn Hall
New York, NY 10027

John Garren
Langley CDTI Program Manager
Langley Research Center
Hampton, VA 23665

David Gee
Staff Engineer, Craft
  Worthiness
Beech Aircraft
P.O. Box 85
Wichita, KS 67201

Richard Geiselhart
Program Manager
Aeronautical Systems Division
Wright-Patterson Air Force Base
Dayton, OH 45433

Charles Graham
Principal Experimental Psychologist
Midwest Research Institute
425 Volker Blvd.
Kansas City, MO 64110

W. Hackenberg
Director of Marketing
Cardion Electronics
Long Island Expressway
Woodbury, NY 11797

James Hallock
Senior Engineer
Transportation Systems Center
Kendall Square,
Cambridge, MA 02142

P.W. Hanson
Captain
Allied Pilots Association
P.O. Box 5524
Arlington, TX 76011

George C. Hay
Chief, Special Programs Division
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, DC 20591

John C. Heurtley
Chief, Systems Test & Evaluation Div.
Federal Aviation Administration
Technical Center
ACT-100
Atlantic City Airport, NJ 08405

J. H. Hill
Engineering Psychologist
Transportation Systems Center
Kendall Square,
Cambridge, MA 02142

Lloyd Hitchcock
Engineering Research Psychologist
FAA Technical Center ACT-200
Federal Aviation Administration
Atlantic City Airport, NJ 08405

A. F. Horne
Medical Officer
Office of Aviation Medicine
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, D.C. 20591

John Howarth
Deputy Sales Manager
de Havilland Aircraft of Canada Ltd.
Garrett Blvd.
Downsview Ontario M3K 1Y5
CANADA

Richard B. Hubbel
Director of Marketing
Cockpit Management Resources
85 Indian Trail
N. Scituate, MA 02060

Kenneth S. Hunt
Director, Office of Flight Operations
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, DC 20591

Steve Huntley
Engineering Psychologist
Transportation Systems Center
Kendall Sq.
Cambridge, MA 02142

Richard Jensen
Professor
The Ohio State University
Dept. of Aviation
Box 3022
Columbus, OH 43220

Walter A. Jensen
Vice President-Operations & Engineering
Air Transport Association
1709 New York Avenue, N.W.
Washington, DC 20006

Rudolph M. Kalafus
Chief, Hazard Detection Branch
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Jeffrey Katz
Analyst-Operations Research
American Airlines
P.O. Box 61616
Fort Worth Airport
Dallas, TX 75261

Robert Kenyon
Professor
Massachusetts Institute of Technology
Room 37-215
Cambridge, MA 02139

Glenn C. Kinney
Group Leader
MITRE Corporation
1820 Dolley Madison Blvd.
McLean, VA 22102

William M. Kitz, Captain
Human Factors
American Airlines
18 Williamsburg Dr.
Amherst, NH 03031

Preston Kohn
Manager
Computer Sciences Corp.
P.O. Box 737
Pomona, NJ

John Kreifeldt
Professor
Tufts University
Medford, MA 02155

Ezra S. Krendel
Professor
Wharton School
University of Pennsylvania
Philadelphia, PA 19104

Leonce Lansalot - Dasou
Transportation Councillor
French Embassy
1050 17th St., N.W.
Washington, DC 20036

Jack I. Laveson
President
Laveson Associates
4423 Elan Court
Annandale, VA 22003

Russell S. Lawton
Assistant Vice President
Operations & Safety
Aircraft Owners & Pilots Association
7315 Wisconsin Ave.
Bethesda, MD 20014

James Lewis
Head, Crew Station Design Section
Johnson Space Center - NASA
NASA Rd 1.
Houston, TX 77058

Gary Link
Manager, Regulatory Affairs
Boeing Aircraft Co.
1700 N. More St.
Arlington, VA 22209

Gary S. Livack
Manager, Technical Activities
General Aviation Manufactures Assoc.
Suite 517, 1025 Conn. Ave, N.W.
Washington, D.C. 20036

George E. Long
Senior Scientist
FAA Technical Center
Federal Aviation Administration
Atlantic City, NJ 08405

James P. Loomis
Manager, Transportation Systems
Section
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Walter F. Luffsey
Associate Administrator for Aviation
Standards
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, DC 20591

M. F. Medeiros
Chief, Computer Applications Branch
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Hideki Miyazono
Flight Operations Engineering
Representative
All Nippon Airways Co., Ltd.
c/o Boeing Company
P.O. Box 3707 M.S.OC-92
Seattle, WA 98124

Melvin D. Montemerlo
Manager, Human Factors & Simulation
National Aeronautics & Space
Administration
RTE-6 NASA Hdq.
Washington, DC 20546

Robert D. Moreland
Sr. Director Flight Standards
Air New England
Boston, MA

Homer Mouden
Vice President, Technical Affairs
Flight Safety Foundation
5510 Columbia Pike
Arlington, VA 22204

Robert W. Mudge
President
Cockpit Management
Resources, Inc.
P.O. Box 969
Center Harbor, NH 03226

Robert L. Mumford
Operations Analyst
Transportation Systems Center
Kendall Square,
Cambridge, MA 02142

Ramal Muralidharan, Phd.
Senior Scientist
Bolt Beranek & Newman
10 Moulton St.,
Cambridge, MA 02139

Harold E. Nord, Jr.
President
Aviation Management Advisors, Inc.
41 South Road
Rye Beach, NH 03871

Harry Orlady, Captain
Orlady Associates, Inc.
312 South Park Rd.
LaGrange, IL 60525

Robert H. Orr
Executive Officer
Federal Aviation Administration
Air Traffic Service
800 Independence Ave., S.W.
Washington, D.C. 20591

James Parker
President
Biotechnology, Inc.
3027 Rosemary Lane
Falls Church, VA 22042

H. M. Parsons
Manager, Human Factors Projects
Human Resources Research Organization
300 North Washington St.
Alexandria, VA 22314

M. Perrine
Director
Sigma Research Inc.
45 "G" St.
Boston, MA 02127

Paul J. Quilty, Captain
Cockpit Management Resources, Inc.
11 Over Rock Road
No. Scituate, MA 02060

Robert A. Richardson
Executive Director
Helicopter Association International
1110 Vermont Ave., N.W.
Suite 430
Washington, DC 20005

Linda Orlady Rings
Graduate Teaching Associate
The Ohio State University
Dept. of Aviation
Box 3022
Columbus, OH 43210

Malcolm L. Ritchie
Professor
Wright State University
Dayton, OH 45435

John B. Roach
Deputy Director
Federal Aviation Administration
New England Region
12 New England Executive Park
Burlington, MA 01803

Walt Rossbach
Communications Director
Helicopter Association International
1110 Vermont
Washington, D.C.

Allan Rossmore
Aircraft Dispatcher
International Association of Machinists
Eastern Airlines Dispatchers
12370 S.W. 22 Lane
Miami, FL 33175

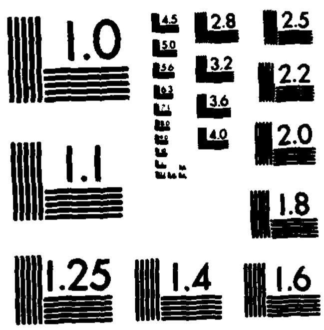
Jackson Royal
Engineering Psychologist
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Derek Ruben
Airworthiness Division
Civil Aviation Authority
Barbazon House
Redhill, Surrey
ENGLAND RH1-1SQ

Charles E. Ruckstuhl
Box 676
Groton, MA 01450

Robert Rudich
Engineering Pyschologist
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Kathy Russo
National Safety Co-ordinator
Association of Professional
Flight Attendants
2008 E. Randol Mill Rd.
Arlington, TX



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Jack A. Sain
Chief, Flight Standards Division
Federal Aviation Administration
New England Region
12 New England Executive Park
Burlington, MA 01803

Gene F. Sharp
Staff Vice President Flight Operations
Piedmont Airlines
P.O. Box 2720
Winston Salem, NC 27102

John Sigona
Computer Specialist
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Michael J. Simons
Professional Air Traffic Controllers Organization
Suite 820
444 North Capitol St., N.W.
Washington, DC 20001

Paul G. Stringer
Helicopter Program Officer
Federal Aviation Administration Technical Center
Atlantic City Airport, N.J. 08405

D.D. Strother
Chief, Human Factors Engineering
Bell Helicopter-Textron
P.O. Box 482
Ft. Worth, TX 76101

Richard L. Sulzer
Human Factors Engineer
Wright - State University
204 Hemlock Drive
Linwood, N.J. 08221

Leland G. Summers
Principal Scientist
Douglas Aircraft Co.
3855 Lakewood Blvd.
Long Beach, CA 90846

Lester Susser
L-1011 Flight Station Technical
  Manager
Lockheed California Co.
P.O. Box 551
Burbank, CA 91520

Charles J. Theisen, Jr.
Program Manager Air Systems
ESSEX Corp.
Suite A 103
65 W. Street Rd.
Warminster, PA 18938

D.F. Thielke
Vice President, Air Safety &
  Engineering
Flight Engineers International
  Association
905 Sixteenth St., N.W.
Washington, DC 20006

William Thievon
Program Manager
Federal Aviation Administration
M.M. Aero Center
Oklahoma City, OK

Henry G. Tinsley
Technical Program Manager
Special Programs Division
Office of Aviation Safety
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, DC 20591

Archie Trammell
Executive Vice President
AOPA Air Safety Foundation
7315 Wisconsin Ave.
P.O. Box 5800
Washington, DC 20014

David Traynham
Professional Staff Member (Aviation)
Committee on Public Works &
  Transportation
House of Representatives
Washington, DC 20515

Harry A. Verstynen, Jr.
Chief, Langley Engineering &
Development Field Office
Federal Aviation Administration
NASA-Langley Research Center
MS 250
Hampton, VA 23665

Gerrit J. Walhout
Chief, Human Factors Div.
National Transportation Safety Board
800 Independence Ave., S.W.
Washington, DC 20594

Eric Werkowitz
Industrial Engineer
AFWAL/FIGR
Wright Patterson Air Force Base
Dayton, OH 45420

Robert Wisleder
Chief, Communications &
Automation Division
Transportation Systems Center
Kendall Square,
Cambridge, MA 02142

G.L. Witter, Jr., Captain
Manager, Flying Operations-Technical
American Airlines, Inc.
Flight Academy
American Airlines Plaza
Ft. Worth, TX 76125

Laurence R. Young
Professor, Department of Aeronautics &
Astronautics
Massachusetts Institute of Technology
Room 37-219
Cambridge, MA 02139

William L. Young
Engineer
United States Air Force
Wright - Patterson Air Force Base
Dayton, OH 45433

Carlo Yulo
Chief, Systems Simulation & Analysis
Division
Federal Aviation Administration
Technical Center
Atlantic City Airport, NJ 08405

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