UNITED STATES OF AMERICA
NATIONAL TRANSPORTATION SAFETY BOARD

**PUBLIC HEARING CONCERNING AVIATION IMAGE RECORDING**

Board Room and Conference Center
National Transportation Safety Board
Washington, D.C.

Tuesday, July 27, 2004

APPEARANCES:

Members of the Board of Inquiry:

CAROL CARMODY, Chairman
DR. VERNON ELLINGSTAD
RON BATTOCCHI
ROBERT MacINTOSH
JAMES CASH

National Transportation Safety Board Technical Panel:

DOUG BRAZY
DR. DEBORAH BRUCE
DR. EVAN BYRNE
DENNIS GROSSI
CHRISTOPHER JULIUS
SARAH McCOMB

On behalf of the Federal Aviation Administration:

STEVE WALLACE

On behalf of the Air Transport Association:

BASIL BARIMO

On behalf of the Regional Airline Association:

DAVID LOTTERER

APPEARANCES: (Continued)

On behalf of the Air Line Pilots Association:

CAPTAIN LINDSAY FENWICK

On behalf of the Allied Pilots Association:

JOHN DAVID

On behalf of the National Air Transport Association:

JACQUELINE ROSSER

I N D E X

P R O C E E D I N G S

9:00 a.m.

OPENING REMARKS AND INTRODUCTIONS

CHAIRMAN CARMODY: Good morning, ladies and gentlemen. My name is Carol Carmody, and I am a board member of the National Transportation Safety Board. I'm also chairman of this Board of Inquiry.

We're convening a two-day hearing on the subject of cockpit image recorders. I welcome all of you here today and those of you who may be watching on our webcast, which is www.ntsb.gov.

The purpose of today's hearing is to explore the feasibility, potential benefits, and drawbacks of requiring crash-protective cockpit imaging systems, often called video recorders. Over the next two days, we will hear from regulators, manufacturers, investigators, and pilots to consider the issue from various points of view.

Subjects to be explored in the hearing include the following:

The technical feasibility and cost associated with capturing, storing, and analyzing image data obtained from commercial aircraft cockpits;

The applicability of technologies like data encryption and how this technology may be used to protect and secure image data;

The potential accident investigation benefits of image recorders;

The legal and privacy concerns of flight crews, air carriers, regulatory agencies, and international organizations; and

The regulatory difficulties surrounding implementation of image recorders.

This is not a new issue for us at the Safety Board. Over the past five years, we have conducted several symposia where individuals from industry, union, and government have made presentations pertaining to the issues of cockpit image recording.

The first of these was conducted in May 1999, the International Symposium on Transportation Recorders. This symposium prompted the FAA to form a committee which was composed of industry, labor, and government experts to examine emerging flight data recorder technology, including cockpit image recording devices.

This committee, known as the Future Flight Data Collection Committee, issued its final report in December of 2001, and concluded the technical advances made image recording feasible.

A second NTSB symposium was held in April 2000, entitled Transportation Safety and the Law. As the title suggests, it specifically addressed privacy issues and employee rights regarding recorder data, and the need to install cockpit video recorders.

Finally, in June of 2003, the Safety Board and the Society of Automotive Engineers cosponsored the SAE Vehicle Recorder Topical Technical Symposium. It provided significant input regarding the merits of video and image recording devices, as well as the data privacy issues.

All right. These symposia and the work of the Future Flight Data Collection Committee have significantly expanded the transportation community's understanding of the technical and public policy issues inherent in the use of video recorders.

The Safety Board has issued two sets of recommendations aimed at requiring cockpit image recorders: one for smaller, turbine-powered aircraft that currently have no flight recorders of any kind; and the other for large, transport-category aircraft that are equipped with data and voice recorders.

The Board formally recommended crash-protected image recorders on February the 8th, 2000, following the investigation of a 1997 crash of a Cessna near Montrose, Colorado. The accident aircraft was operated under Part 135 as an on-demand charter. The accident airplane was neither equipped nor required to be equipped with a flight data recorder or a cockpit voice recorder. There were no recorded communications between the aircraft and air traffic control, or between the aircraft and other aircraft.

These limitations on the data available hampered investigators in their ability to reconstruct the events that led to the accident. They were able to come up with a probable cause, but it was considerably complicated by the delays in obtaining information.

The Safety Board therefore issued safety recommendations asking the FAA to incorporate recorder standards which had been developed by the European Organization for Aviation Equipment, and to require the installation of such recorders on all turbine-powered, non-experimental, nonrestricted-category aircraft in Part 135 operation that were not currently required to be equipped with a flight recorder.

Since these recommendations were issued, the Safety Board investigated more than 100 additional accidents involving commercial aircraft not equipped with recorders, including most recently the October 2002 crash of the King Air which killed Senator Paul Wellstone and seven others.

In December 2003, the Board expanded its earlier recommendation by asking the FAA to require a crash-protected image recording system on all turbine-powered, non-experimental, nonrestricted-category aircraft manufactured after January 1, 2007, that were not equipped with an FDR and that were operating under Parts 135 and 121, or that were being operated full-time or part-time for commercial purposes under Part 91. The Board also recommended retrofitting image recorders in those same types of aircraft manufactured before January 1, 2007.

In 2000, the Board addressed the larger category aircraft, and in Recommendation 0030, asked the FAA to require the retrofit of existing aircraft operating under Parts 121, 125, or 135, that were currently required to be equipped with a CVR and an FDR to be also equipped with a crash-protected image recorder system. The same recommendation was made applicable to newly manufactured aircraft.

These recommendations were based on the Board's investigations of a number of accidents in which CVR and FDR data alone did not provide definitive information on crew actions, the cockpit environment, or graphic information displayed to the flight crews in the instruments. These accidents included the 1996 crash of ValuJet, the 1997 crash of SilkAir, the 1998 crash of Swissair, and the 1999 crash of EgyptAir. These accidents claimed 550 persons aboard the four aircraft.

The Board has added the issue of cockpit image recorders to our list of Most Wanted Safety Improvements.

At this point, I'd like to introduce the other members of the Board of Inquiry:

Dr. Vernon Ellingstad, Director of Research and Engineering, on my left;

Mr. Ron Battocchi, the General Counsel of the NTSB, on my right;

At the far right is Robert MacIntosh, Chief Technical Advisor for International Safety Affairs for Aviation Safety;

At the far left, Jim Cash, Chief of the Vehicle Recorder Division and hearing officer for today's hearing.

The Board will be assisted by a technical panel consisting of the following Safety Board staff:

Doug Brazy, Office of Research and Engineering;

Dr. Deborah Bruce, Office of Research and Engineering;

Dr. Evan Byrne, Office of Aviation Safety;

Dennis Grossi, Office of Research and Engineering;

Christopher Julius, Office of General Counsel; and

Sarah McComb, Office of Research and Engineering.

Also here today is my special assistant, Mr. Jack Orlando.

I would like to recognize a couple of my colleagues who are here today, fellow board members who are observing:

Vice Chairman Mark Rosenker and Member Dick Healing. Appreciate your being here. I know you both have a keen interest in this subject.

Mr. Ted Lopatkiewicz from the Safety Board's Public Affairs Office is here to assist with members of the news media. Mrs. Carolyn Dargan and Jan Delorge are present to provide administrative support as needed. They will also be providing copies of exhibits for the witnesses.

The Safety Board's rules provide for the designation of parties to a public hearing. In accordance with these rules, those persons, agencies, companies, and associations whose participation is deemed necessary in the public interest and whose special knowledge will contribute to the development of pertinent evidence are designated as parties. The Safety Board designated the parties assisting in this hearing in accordance with these rules.

As I call the name of each party, would the designated spokesperson please identify yourself and give your name, title, and affiliation.

Starting with the Federal Aviation Administration.

MR. WALLACE: Steven Wallace. I'm the director of the Office of Accident Investigation for the Federal Aviation Administration.

Madam Chairman, would you like me to introduce at this table the others at the table with me?

CHAIRMAN CARMODY: Why don't you.

MR. WALLACE: David Hempe, manager of the Aircraft Engineering Division; Mr. Steve Vantrees, manager of the Avionics Systems Branch; and Mr. Tim Shaver, transportation industry analyst in the Avionics System Branch.

Thank you.

CHAIRMAN CARMODY: Thank you, Mr. Wallace, and thank you for introducing your colleagues.

Next, the Air Transport Association.

MR. BARIMO: My name is Basil Barimo. I'm the vice president of operations and safety for the Air Transport Association. With me today is Patty Higginbotham, who is our assistant general counsel.

CHAIRMAN CARMODY: Thank you.

Regional Airline Association.

MR. LOTTERER: Hi. I'm David Lotterer. I'm vice president, technical services, with the Regional Airline Association.

CHAIRMAN CARMODY: Thank you, Mr. Lotterer.

Air Line Pilots Association.

CAPTAIN FENWICK: I'm Lindsay Fenwick, the Accident Analysis Group chairman for ALPA. With me at the table is Mr. Michael Huhn, senior staff investigator; Mr. Chris Baum, manager of Engineering and Accident Investigation; and Captain John Cox, executive air safety chairman for ALPA.

CHAIRMAN CARMODY: Thank you.

Allied Pilots Association.

MR. DAVID: Good morning. My name is John David. I'm the deputy chairman of the Allied Pilots Association, National Safety Department. Also with me is Captain Michael Leon, the chairman of the Allied Pilots Association, National Safety Department.

CHAIRMAN CARMODY: Thank you.

National Air Transportation Association.

MS. ROSSER: Good morning. My name is Jackie Rosser. I'm the manager of flight operations for National Air Transportation Association, and I am joined by Eric Byer, our director of Government Industry Affairs.

CHAIRMAN CARMODY: Thank you.

On July 14th of 2004, a few weeks ago, the Board of Inquiry held a pre-hearing conference in this facility. The Safety Board's Technical Panel and representatives from the parties attended the conference. At that time, we outlined the areas of inquiry and the scope of the issues to be explored at the hearing, and finalized the selection of witnesses to testify on these issues.

Copies of the witness list developed at the pre-hearing conference are available outside in the foyer. There are numerous exhibits that will be used in this proceeding. We also have a statement that was submitted by the Aircraft Victim Families Group which is available. Copies of the exhibits may be ordered through our Public Inquiries Branch at 202-314-6551. Copies of presentations at this hearing will be found on the Board's website, which I said earlier is www.ntsb.gov.

The witnesses will be questioned first by the Board's Technical Panel, then by the designated spokesperson for each party to the hearing, finally followed by members of the Board of Inquiry.

As chairman of the Board of Inquiry, I am responsible for the conduct of the hearing. I will make all rulings on the admissibility of evidence, and all such rulings will be final.

The record of the investigation, including the transcript of the hearing and all exhibits entered into the record, will become part of the Safety Board's docket and will be available for inspection at the Board's Washington office. Anyone wishing to purchase the transcript, including parties, should contact the court reporter directly.

Now I'd like to turn to the hearing officer, Mr. Cash, and ask you to call the first witness.

MR. CASH: Thank you, Madam Chairman.

We'd like to call the first witness, Frank Hilldrup from the NTSB.

INVESTIGATIVE USES

Statement by Frank Hilldrup, NTSB

MR. CASH: Mr. Hilldrup, for the record, would you please state your name, title, place of employment, and a brief statement of academic or employment qualifications that you have that qualifies you as an expert in your area.

MR. HILLDRUP: My name is Frank Hilldrup. I am an investigator in charge in the Major Investigations Division for the Office of Aviation Safety at the NTSB. I've been with the Safety Board for almost 16 years now in various positions, as an Engineering Group chairman, and probably for the last five years as an investigator in charge.

I have a private pilot's license with an instrument rating, and an aerospace engineering degree from Virginia Tech.

MR. CASH: Thank you.

And the witness does have a statement. We will do questions after --

MR. HILLDRUP: Okay. Thank you.

Good morning, Madam Chairman, members of the Board of Inquiry, ladies and gentlemen. I was asked to provide some comments this morning on the benefits of cockpit image recorders, but before I discuss this, I think it's important to remember the history of flight recorders and how useful they have become to aviation accident investigation.

The Safety Board and its predecessor organization, the Civil Aeronautics Board, or CAB, have been investigating aircraft accidents since back in the 1930s, and from most accounts, I believe it has done a very good job. Through the efforts of the regulatory and safety agencies and the aviation industry, accident rates have continued to decline over the decades, though less so in recent years.

As much as we might like to think that nothing beats good old-fashioned investigating of physical or forensic evidence, fondly referred to as tin-ticking, the introduction of data recordings has become an invaluable tool to investigations.

The first on-airplane flight data recorder was mandated following recommendations by the CAB in the late 1950s. As hard to believe as it sounds today, these FDRs utilized foil as a recording medium for capturing its few parameters.

In 1960, following a recommendation by the CAB, the FAA conducted a study that established the feasibility of cockpit voice recorders. Subsequent regulations led to incorporation of CVRs on certain airplanes by the mid to late 1960s.

FDR requirements remained essentially unchanged until 1972, when the rules for certain transport category airplanes were amended to require a digital flight data recorder system. The Safety Board continued to submit recommendations calling for such things as the replacement of all foil recorders, expansion of FDR parameters, and recorder requirements for certain air taxi and corporate aircraft.

In the late 1980s, the FAA issued rule changes encompassing other areas, and in the 1990s, they further expanded the list of required FDR parameters.

More recently, during the investigation into the crash of a Swissair MD-11 in 1998, the Safety Board and the Transportation Safety Board -- recommendations calling for dual FDR recorders and independent and separate power supplies.

My point in reviewing some of the history of on-board flight recorders is to show how government agencies and the aviation industry have continued to recognize and take advantage of available technologies for the benefit of safety, which brings us to the issue of cockpit image recorders.

In 2000, the Safety Board made its first recommendations to the FAA for incorporation of cockpit video recorders in certain aircraft. This was prompted by several accidents in which the available data was insufficient to fully determine events in the cockpit and crew actions. The Board's recommendations also recognized that the technology for cockpit image recorders had become more feasible and economical.

As Member Carmody already mentioned, some of these accidents referenced in the recommendations include ValuJet Flight 592, SilkAir Flight 185, Swissair Flight 111, and EgyptAir Flight 990. The circumstances of these events should be well known to most, so I'm not planning on discussing them in greater detail.

Needless to say, it's likely that a cockpit image recorder would have aided each of these investigations and allowed more precise and timely findings. I might add that I'm currently working on a foreign air transport accident in which good data exists for both the FDR and the CVR, yet crucial questions remain about certain cockpit displays and settings.

I think it's also important to note that some of our international counterparts have also issued recommendations for the incorporation of cockpit image recorders.

The Safety Board has also investigated numerous accidents in recent history involving Part 135 and Part 91 flights in which neither data nor voice recorders were required. I'd like to discuss a few of these to further illustrate the potential benefits of a cockpit image recorder.

On October 25th, 2002, at about 10:22 in the morning, a Beech King Air 100 operated by Aviation Charter, Incorporated, crashed while the flight crew was attempting to execute a VOR approach into Eveleth, Minnesota. The two pilots and six passengers, including Minnesota Senator Paul Wellstone, were killed, and the airplane was destroyed by impact forces and a severe post-crash fire.

The airplane was being operated as an on-demand passenger charter flight as part of Senator Wellstone's reelection campaign. Instrument meteorological conditions prevailed for the flight, and the airplane was not equipped with any flight recorders.

Because of the lack of available information, the investigation was unable to determine the crew's actions on the approach. The Safety Board determined that the proper course for the VOR approach was not established and the approach speed was never fully stabilized. Investigators were unable to determine the degree of coordination between the two pilots or even who the flying pilot was.

Furthermore, the investigation was unable to positively determine whether the pilots were able to establish adequate visual cues for continuing the approach. Although the Safety Board determined that the flight's inadequate air speed led to an aerodynamic stall, investigators were unable to precisely confirm the indicated speed of the airplane just before the loss of control. These questions might have been answered if a cockpit image recorder had been installed.

The next accident I'd like to talk about that formed the basis for the Safety Board's first recommendations on cockpit image recorders, and I think Member Carmody already made reference to this, the accident involved a Cessna 208, operated by the Department of Interior, that experienced a loss of control and collided with terrain near Montrose, Colorado, on October 8th, 1997. The pilot and all eight passengers were killed.

After climbing at a normal rate of climb to 15,400 feet, the airplane abruptly disappeared from radar. The radar plot of the aircraft during the climb above 10,000 feet indicated several course changes and then a sharp turn just prior to the rapid descent. The wreckage exhibited evidence of a steep flight path angle and damage consistent with a stall-spin event.

Investigation revealed no indication of airframe or flight control anomalies, and the powerplant and propeller damage was consistent with engine operation at moderate to high power.

The Safety Board determined the probable cause of this accident to be the pilot's failure to maintain sufficient air speed for undetermined reasons while maneuvering the airplane near the maximum gross weight and aft CG in or near instrument meteorological conditions, resulting in the loss of control and entry into a stall spin.

Several different scenarios were considered as possible reasons for the pilot's loss of control. For example, the pilot may have induced a stall in an attempt to maintain altitude. He may have unintentionally entered cloud conditions and become disoriented. He may have entered clouds and accumulated sufficient ice to degrade the airplane's aerodynamic qualities and induce a stall. Or, his flying or decision-making skills may have been impaired due to the lack of oxygen.

Unfortunately, no scenario could be verified with the available evidence. An image recorder may have provided information to help answer some of these questions.

The last accident I'd like to discuss involved a Beech King Air 200 that crashed near Strasburg, Colorado, on January 27th, 2001. The accident airplane carried a pilot, an inexperienced pilot observer, and eight passengers, all members of the Oklahoma State University basketball team and staff. All were fatally injured. The flight was being operated under Part 91, and the airplane was not equipped with any flight recorders.

The aircraft entered the clouds almost immediately after taking off. Radio transmissions and radar returns reveal nothing unusual until about 15 minutes later, when the Mode C transponder returns ceased. The airplane's ground track then began to deviate, and the airplane experienced a descending spiral to the ground.

Examination of the wreckage revealed that a complete loss of AC electrical power occurred aboard the airplane for some reason. This would have disabled the pilot's flight instruments. In the highly fragmented and heavily burned wreckage, investigators found an altimeter reading stuck at 23,000 feet, an RMI card stuck on the last steady heading, and an AC volt meter at its lowest indication, all indications of an AC power failure that was not remedied at any time prior to impact.

The question then became, why did the power fail. Several possibilities existed: a single inverter failure that the pilot did not remedy by switching to the good inverter; a dual inverter failure; an inverter switch failure; an inverter select relay failure; or an avionics inverter select relay failure.

A cockpit image recording of even the last few minutes of the flight might have allowed us to eliminate one or more of the possible power failure scenarios, perhaps by observing the annunciator panel or seeing whether the pilot activated the inverter switch or not.

We could have answered questions about how the pilot interfaced with the other pilot in the right seat, who had supposedly had an operating set of flight instruments in front of him. Was there a transfer of aircraft control; did he further exacerbate an existing problem. We will never know, but data from a cockpit image recording of the event may have allowed us to do so.

The Safety Board determined that the probable cause of the accident was the pilot's spatial disorientation after a loss of electrical power causing a partial loss of flight instrumentation. Although I believe that the evidence fully supports this probable cause, video of the cockpit environment would have allowed us to be more precise.

There continue to be numerous aircraft accidents in which investigations are hindered by the lack of flight recorder data. In fact, within the last two months, the Safety Board has investigated 11 accidents involving turbine-powered aircraft that were not equipped with any type of crash-survivable flight recorders. These accidents resulted in the loss of 13 lives and involved seven Bell 206 helicopter accidents, three Eurocopter 350 helicopter accidents, and one MU-2 accident. While all of these accidents are currently under investigation, the Safety Board is severely hampered by the lack of recorded data.

Fortunately, two of the Eurocopter aircraft were fitted with an on-board videotape recorder unit which provides the passengers with a taped souvenir of the flight. The video recorder records a pilot-selectable image of either the passenger cabin or a view out the front of the aircraft, along with a pilot narration and passenger audio track.

From these audio and video records, the investigators have been able to document things such as the weather and wind conditions and the pilot's handling of the aircraft. This information may prove to be invaluable as the investigations continue.

In closing, I believe it is clear that cockpit image recorders would greatly enhance investigators' ability to more precisely and quickly determine the circumstances of aviation accidents and incidents. Of course, as with cockpit voice recordings, restrictions would have to be incorporated to ensure that these image recordings are not used for disciplinary purposes against individuals, are viewed only by those investigators who have a legitimate need, and are not made public. But these are not obstacles that cannot be overcome if technology exists, and the need is here now.

Thank you, Madam Chairman. That completes my statement.

MR. CASH: Thank you, Mr. Hilldrup.

The Technical Panel has no questions for this witness.

CHAIRMAN CARMODY: All right. Thank you.

Normally, we do not have the NTSB witness answer questions, but in response to requests from a couple of the parties, I've decided to allow it. This is not a precedent, but this is a hearing where we're seeking some facts and I thought it might be useful.

I would remind the parties, however, that Mr. Hilldrup, who has given a statement relating to his expertise and his experience as an investigator, their questions should be related to that. Any other issues should be directed to other witnesses.

Starting with the FAA, Mr. Wallace, do you have any questions for Mr. Hilldrup?

MR. WALLACE: Just a few.

First, let me say, Madam Chairman, thank you for granting a request which I made, joined by some other parties, that we question the NTSB witnesses, and we will try to adhere to the rules you've set. I'm sure you'll stop me if I don't, so.

Mr. Hilldrup, the normal -- you talked about the use of the FDR and the CVR together, and I would just like to ask a few questions about how that works in a typical investigation, and then maybe we can talk about how it might work in -- if a video or image recorder were available.

Perhaps, if you could start -- you're an IIC -- describe the general role of the IIC in a CVR and FDR readout vis-a-vis the people who are really the specialists in those areas.

MR. HILLDRUP: Well, as with all of our

groups that we might form during an investigation, each of the FDR and CVR groups will be headed by an NTSB group chairman, and as part of our party process, we look for expertise from the various parties to be on the groups to help us document and interpret, perhaps, the evidence that we're finding.

MR. WALLACE: The rules and the protections for CVRs and FDRs are different, and so I'm wondering about the case if we had an image recorder which effectively could replace both in some cases. Would you envision that this data would somehow be separated, that which is essentially replacing a CVR from that which is essentially replacing an FDR?

CHAIRMAN CARMODY: Mr. Wallace, I think this is a question for, perhaps, the Legal Panel, and I also think it has a regulatory implication which perhaps could be directed to the FAA later. So I'd ask you to move on.

MR. WALLACE: I have no further questions.

CHAIRMAN CARMODY: All right. Thank you.

Air Transport Association, Mr. Barimo.

MR. BARIMO: Just one question, Mr. Hilldrup. You mentioned a couple of times that imaging would yield -- make sure I say it right -- more timely and precise findings in the investigation. Are there any investigations, either out there pending or historically, where the NTSB has been, or you personally have been, unable to determine probable cause?

MR. HILLDRUP: Personally, no. I believe there have been some investigations in our past where we did not establish probable cause, but I'm not familiar with those cases.

Let me just extrapolate on the timeliness issue a little bit. I think that we certainly do not wait until the end of an investigation before we come forth with recommendations. The timeliness issue is -- certainly, if we can establish things as clearly as possible, that we could come out with recommendations as soon as possible to address safety deficiencies that we might see.

MR. BARIMO: Thank you.

CHAIRMAN CARMODY: Is that it, Mr. Barimo?

MR. BARIMO: Yes, that's it.

CHAIRMAN CARMODY: Regional Airline Association, Mr. Lotterer, any questions?

MR. LOTTERER: Thank you.

Just a follow-up to ATA's question. You mentioned the two Eurocopter aircraft that had these particular videotapes on board. In those particular accidents, was there a more timely recommendation that resulted from those accidents as a result of this equipment?

MR. HILLDRUP: I can state clearly -- I'm not the investigator in charge on those. I don't know all the circumstances, and in fact, those accidents are very recent. I don't believe there's been any recommendations at this time from that.

Again, I think my issue or my statement with respect to this is a broad, general statement. It certainly doesn't address issues in those two accidents.

CHAIRMAN CARMODY: Thank you.

ALPA, Air Line Pilots Association, Captain Fenwick, please. Any questions?

CAPTAIN FENWICK: Thank you, ma'am.

Mr. Hilldrup, I have several questions. The first set refers to your statement regarding image recorders and that they would have allowed more precise and timely findings in a number of accident investigations that the Board and you have cited today.

To get down to specifics, reference the ValuJet accident, could you give us, perhaps, some examples of what would have been discerned if an image recorder had been installed, and would it have changed the course of the investigation, the determination of probable cause, or the safety recommendations which the Board made?

CHAIRMAN CARMODY: I think that's a little broad, Captain Fenwick. I said earlier when I agreed to allow this that we didn't want to start reexamining past accidents.

If Mr. Hilldrup wants to comment on the kind of information you might have gleaned from the cockpit voice -- I'm sorry, from a video recorder, go ahead, but I don't want to get into discussing probable cause and what might or might not have affected that.

Thank you.

MR. HILLDRUP: Let me try to answer the first part of that question.

I did work on that accident. I was not the investigator in charge, but my recollection would be that some of the issues were, you know, would -- is it possible that the -- whether the cockpit door remained open or was open, and when smoke -- whether the introduction of smoke into the cockpit, what kind of a role that may have played. I don't know if that would have been captured on the image recorder or not, but that's certainly a possibility.

Perhaps the use of goggles or oxygen masks by the crew. I don't know how definitive we were in that accident. That may have helped, if we had had that -- an image recorder.

And perhaps any use and the effectiveness of any smoke clearing procedures, perhaps, by the crew.

CAPTAIN FENWICK: Regarding the EgyptAir accident which is being cited by the Board, if image recorders were mandatory and installed in the United States airplanes, how might that have affected the EgyptAir accident?

MR. HILLDRUP: Certainly, I think some of the issues there that we had questions about was, who was in the cockpit, what were the circumstances, who was manipulating the flight controls and other controls in the cockpit.

CAPTAIN FENWICK: I probably wasn't very clear, Mr. Hilldrup. I was sort of, in a roundabout way, getting to the fact that a -- if they were mandated on N-registered airplanes, it would not necessarily have affected a foreign-registered airplane operating into the United States.

If I can cite the Wellstone accident, which you have referenced and the Board has referenced many times, it has been implied by the Board that had an image recorder have been installed, that it would have enabled an assessment of the conditions outside the airplane, perhaps, that the pilots were confronting.

I referenced ED-112, which is Exhibit 4, and the FFDC RTCA committee findings and their discussions are also another exhibit that's been entered. I could find no mention or recommended use of the image recorder in that capacity.

So I was a little bit curious, as an investigator in charge, this particular use, does the Board contemplate that an image recorder could be used to assess visibility conditions, precipitation, or the general environment?

MR. HILLDRUP: I think that's a valid point. I think my statement with respect to that would address more so, given the fact that we had no recorders on this airplane, perhaps conversations or comments by the flight crew to that point, of whether they may have detected the airport, what the visibility may have been in their eyes.

So I think from that standpoint -- I'm not sure what the technology would enable from that standpoint. I think my statement in reference to the Wellstone accident was really more about the conversations they may have had between each other.

Certainly, from the standpoint of from

weather and the weather environment, the icing condition, you certainly might be able to detect icing accumulation on the windshield, perhaps.

CAPTAIN FENWICK: Okay. Thank you.

And sticking with the Wellstone accident for a minute, Mr. Hilldrup, would you agree that had there been a rudimentary flight recorder installed along with a CVR on that King Air that it would have made the Board's job a whole lot easier?

MR. HILLDRUP: I would say if we had other flight recorders on board, sure.

CAPTAIN FENWICK: In reference to the Department of Interior Caravan accident, how might image data have enabled investigators to assess the flying and decision-making skills of the pilot in this case?

I realize that's a little bit vague, but I'm curious as to how that might work in practice.

MR. HILLDRUP: Well, I want to be a little bit cautious here, because I did not work on that accident and I feel a little bit less appropriate in responding to that, but since I included it in my statement.

Again, I think the reference there is what kind of manipulation of any controls that the pilot was doing, since we didn't have recorder information in that case.

CAPTAIN FENWICK: Okay. You made the claim a minute ago, the assertion, that on the Department of Interior accident that an image recorder would have enabled the detection of how much ice, perhaps, the airframe was accumulating and its subsequent effect on the airplane's performance. That's also a creative use of the image recorder that I've not come across.

Is that the Board's position, that this is a particular application that would be useful?

MR. HILLDRUP: Yeah. Well, I certainly can't speak for the Board, but I think from the reference, airframe icing accumulation may not be exactly representative of what's accumulating, perhaps, on the windshield, given perhaps window heat or anything else that may have been used to combat that. But I think that, personally, that would be my -- a reference to address that question would be any accumulation of ice around the windshield.

CAPTAIN FENWICK: And again, the same accident, the installation of a very basic flight data recorder and CVR, I am assuming the Board would find that a more useful solution, perhaps, than the installation of an image recorder?

CHAIRMAN CARMODY: Captain Fenwick, let me just remind you that, as Mr. Hilldrup says, he really can't speak for the Board. He's a talented investigator, but the Board would have to make a decision on which is more valuable. So I would ask you to not put him in that position.

Is there anything else, or can we move on?

CAPTAIN FENWICK: Just one final question, if I may.

CHAIRMAN CARMODY: All right. Thank you.

CAPTAIN FENWICK: Mr. Hilldrup, can you imagine any means by which image recorder information might be utilized proactively to prevent accidents in a manner similar to that which we use a flight data recorder today?

MR. HILLDRUP: I can't think of anything right now. I'm sure there must be.

CHAIRMAN CARMODY: That may be a question for another witness, as well. Thank you.

ALPA, Air Line Pilots Association. Mr. David, any questions for the witness?

MR. DAVID: Yes, ma'am.

Having seconded Mr. Wallace's request, I would like to thank you -- give you my thanks and my association's thanks for allowing us to learn from Mr.

Hilldrup's expertise.

Sir, at the conclusion of your statement, you said the need is here now for a cockpit image recorder. This is a fairly stressful economic time for airlines. As an experienced investigator, what do you feel about -- would we gain more benefit from a cockpit image recorder or from more robust DFDRs which record parametric data, including greater sampling rates and more parameters?

CHAIRMAN CARMODY: Again, I don't think that's a fair question to ask Mr. Hilldrup, and I wouldn't ask him how he feels, anyway, about it. It's -- the Board is on record for recommending these recorders and I think we'll stand with that.

Anything else?

MR. DAVID: Yes, ma'am. I would have --

CHAIRMAN CARMODY: All right.

MR. DAVID: (Off mike)

CHAIRMAN CARMODY: I'm having trouble hearing you, too. It may be my ears, but if you could speak into your microphone. Thank you.

MR. DAVID: (Off mike)

MR. HILLDRUP: I'm not sure I can fully hear you.

CHAIRMAN CARMODY: We're not hearing you.

I'm not sure --

MR. DAVID: Let's try that. Is that good enough?

CHAIRMAN CARMODY: There you go.

MR. DAVID: Thank you. It may have been a little button discomfort.

Swissair 111 had a fire in the retrofit video system and the crew was unable to remove power from that system and thereby allowed the fire to get out of control. The Board's recommendation for cockpit image recorders recommends that the circuit breakers be out of the pilot's cockpit area.

In light of that Swissair fire and the fact that you may have a similar type of incendiary event with that system, how can we recommend the circuit breakers not be where the pilots can have the most rudimentary means to remove power from the aircraft system?

MR. HILLDRUP: I would say that's a valid point, but I would imagine the FAA will examine that in their evaluation of incorporating that system. I can't speak to that direct question. I did not write the recommendation. I did not adopt the recommendation.

MR. DAVID: Thank you, sir.

CHAIRMAN CARMODY: Thank you, Mr. David.

Ms. Rosser, any questions from NATA?

MS. ROSSER: No questions, ma'am.

CHAIRMAN CARMODY: All right. Thank you.

I believe, then, we are going to the Board of Inquiry. Are there any questions up here? I think not, since this is our witness.

Dr. Ellingstad.

DR. ELLINGSTAD: Frank, there's sort of a sense that the Board resolves accidents, establishes probable causes, and kind of keeps score, and that's reflected in the questions of how many, you know, we didn't come to that conclusion on.

Could you speak just a little bit more -- you mentioned in your testimony the comments of needing to establish more precise kinds of bases for determining probable cause, but also, you referred to the basic purpose that the Board is in business for, and that is to make recommendations for improvements.

So, could you speak just a little bit, amplify what you had talked about with respect to precision and coming up with reasonable recommendations that will prevent accidents in the future?

MR. HILLDRUP: Well, again, as a user, I think we're all in this -- in this room, we're all users of accident information and evidence. This would be -- a cockpit image recording would be another tool that we could all use. It complements other data that we would obtain during an investigation. So, again, as a user or as an IIC, I'd welcome any other evidence, and I consider this to be a valuable asset in our efforts.

From the standpoint of more precise information, I think it's important that we certainly get as much as we can, reasonably, and also, I think, from the standpoint of recommendations, it allows us to make better recommendations. And I think it carries with that to the FAA and to the industry perhaps the ability to realize what we see and the comfort level of where we're going with those recommendations. I think it brings more momentum to those recommendations.

DR. ELLINGSTAD: Thank you.

CHAIRMAN CARMODY: Anyone else?

(No response)

CHAIRMAN CARMODY: I think not. Thank you, Mr. Hilldrup, for your testimony.

MR. HILLDRUP: You're welcome.

CHAIRMAN CARMODY: Mr. Cash, would you call the next witness, please?

MR. CASH: Thank you.

We'd like to call Ken Smart from the Air

Accident Investigation Branch in U.K., and Mr. Kevin Wood from the Naval Air Systems Command.

Whereupon,

KEN SMART

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

Whereupon,

KEVIN WOOD

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

MR. CASH: Mr. Smart and -- well, it's the same question to both, but could you please state your name for the record, title, place of employment, and a brief statement of academic or employment qualifications that you have that qualifies you as an expert in your area.

Ken.

MR. SMART: I'm the United Kingdom's chief inspector of air accidents, and I have -- my background is -- my early part of career in aviation was in the U.K. research establishments. I joined the AAIB in 1975 as an investigator, and I've spent many years as an IIC and subsequently deputy chief inspector, before my appointments as the U.K.'s chief inspector of air accidents in September 1990.

My other qualifications are that I chair the Board of -- U.K. Board of Transport Accident Investigations, which is the board which explores best practices and synergies between rail, marine, and air investigation branches. And I am European president of the International Society of Air Safety Investigators.

I'm also a visiting professor of transport safety at the Cranfield University in the U.K.

MR. CASH: Thank you.

Mr. Wood.

MR. WOOD: My name is Kevin Wood. I'm a DOD civilian working for the Naval Air Systems Command.

MR. CASH: It's got a button on it that has to be up.

MR. WOOD: Yes, my name is Kevin Wood. I'm a DOD civilian employee working for the Naval Air Systems Command, Program Management Air, PMA 209, which is Air Combat Electronics, working with the Flight Operations and Safety Systems group, and specifically, I'm the integrated product team lead for flight information recording systems.

MR. CASH: Thank you.

And Mr. Smart has a statement, and Mr. Wood has a presentation.

CHAIRMAN CARMODY: Please proceed.

Statement of Mr. Ken Smart

MR. SMART: Thank you very much, Madam Chairman, and good morning, ladies and gentlemen.

The U.K. Air Accidents Investigation Branch, the AAIB's first foray into safety recommendations on the subject of image recording took place in 1985, following an accident to a Boeing 737 of British Airways at Manchester International Airport in the U.K. Fifty-five people died in that accident. And the safety recommendation was focused on providing crews with an external view of their aircraft.

The Civil Aviation Authority, our regulator, accepted the recommendation, and -- which was focused on providing a proof of concept, a feasibility study if you'd like, for image recording in -- the aircraft.

That study was conducted in conjunction with our national aerospace research establishment, and an aircraft, the BAC 111, was equipped with cameras and the proof of concept was completed satisfactorily. Other aircraft were also installed with image cameras: Jet Star and a Citation.

Four years later, in 1989, we had another serious accident with a Boeing 737, this time at Kegworth in Leicestershire in the U.K., when 39 people died when the aircraft undershot the runway and ended up on one of our main highways in the midlands of the U.K.

Our safety recommendations in that accident called for our Civil Aviation Authority to expedite the research program they had been conducted and extend it to encompass cockpit image recording as part of that program. The reason for that was that the actual investigation that we were conducting there encompassed a range of human performance issues associated with the crew's interpretation of the engine instrumentation on that aircraft in particular.

The CAA, again, accepted that recommendation, and the result was that they instituted a joint engineering trial in conjunction with British Airways, where they installed cameras on a Boeing 747 this time that was actually being operated in line service. That program ran for some considerable time, and the Civil Aviation Authority subsequently extended the program by commissioning a research program to look at the benefits of cockpit image recording, in particular with respect to the understanding of human performance issues associated with accidents.

Now, understand that the Civil Aviation Authority's interim findings on that research program have been tabled here as a paper by Pippa Moore, who is the officer of the CAA who is responsible for that.

That program is expected to be completed by September of this year, and the Civil Aviation Authority informed me that the report will be published at that time.

If I can go back now a couple of years to May 2002, I had a meeting at that time with Marion Blakey, who is the -- here in Washington, who was the -- then the chairman of the NTSB. We had joint concerns about the slow pace of progress with image recording, and in particular one of the sticking points that we identified was the Air Line Pilots Association's concern about the misuse, as they saw it, of the evidence from these recording systems.

And following that meeting, or at the meeting, we agreed that I would approach the -- the then president of the International Federation of Air Line Pilots Associations, Ted Murphy, with a proposal for ALPA to look at the prospects of using encryption as a means of protecting the recorders. And by that means, I'm looking, as we saw it, of freeing up the development of these systems in airline use.

That -- my letter to Ted Murphy and -- and its suggestions -- they were just suggestions for the table that we thought they might consider, which included multiple key encryption processes. In that letter, there is a suggestion that perhaps the keys could be held by different parties.

The suggestion there was that perhaps the accident investigation organizations ought to have one key, the manufacturers of the recorder would have one key, and perhaps if ALPA could also hold a key, and only when the -- all the three parties were happy that the replay -- the state in which the replay was going to take place had adequate protection for those recordings, then would the three keys come together to allow the recordings to be replayed.

That was a suggestion that we put on the table. We were conscious at that time that the EUROCAE committees were looking at specifications for recorders, and as part of that program they were considering encryption processes anyway.

So IFALPA tabled that letter at the June meeting of the Action Analysis Committee, which took place in South Africa that year, 2002, and I think it's fair to say that the formal process was that they noted the suggestion and it was considered perhaps a little bit too radical at that time for them to reply on it, at that stage anyway.

It's clear to me from my position in the U.K.

that the length of the time the CAA research program has been running, the agendas of -- the difficulties that the air line pilots associations around the world have with this subject. Whenever it is discussed in ICAO, this subject is also one in which some considerable difficulty is encountered.

ICAO uses language like, if the subject is not yet mature enough for consideration at this time. This is -- this is standard ICAO language for something that we can't agree on effectively.

It seems to me that this particular ball has been kicked into the long grass, and one of the reasons I was grateful for the invitation to come here to present this evidence was that it's a subject which is dear to my heart. I see this process, this public hearing, as part of the, perhaps, the start of retrieving our ball from the long grass and perhaps getting it back into play.

Finally, my -- my thoughts are that if our industry is serious about our intention, our declared intention, to more fully understand the human performance issues associated with accidents as a means of reducing accidents in the future and enhancing public safety, then my view is that cockpit image recording is an essential part of achieving that aim.

It will provide a missing link in the information chain that helps our understanding of these accidents, and it will provide essential evidence in those thankfully few cases where we -- accident investigation organizations around the world really struggle to understand the cause of the accidents that fall into that particular category.

But having said that, image recorders will also provide essential information on almost all the accidents that we investigate insofar as they provide additional information. I would not -- I would not suggest that they should ever replace cockpit voice recording or flight data recording. They're complementary methods of recording. They're not mutually exclusive -- they're not substitutes for either recording.

I have a number of examples that I can quote as examples where image recorders would have assisted our investigations, ones that the AAIB have been involved with. These reports are available.

It starts with Kegworth, and you can see the arguments we deployed for our safety recommendations there.

In 1999, we investigated a catastrophic accident to a Korean Air Boeing 747 taking off from

London's Stansted Airport. The aircraft was departing on a standard instrument departure. On its first turn at a few hundred feet, the aircraft continued to roll until it was 90 degrees banked. The nose dropped and it flew into the ground at full power.

We were fortunate enough to be able to identify one of the primary causes of that accident, which was that the captain's attitude director indicator had failed. However, our understanding of why a crew of three individuals on that aircraft didn't pick up the warnings from the comparator -- the comparator warnings that went off from that flight deck and the visual light that was present on the flight deck, we did not fully understand that.

And despite having a very good flight recorder for the aircraft type and a cockpit voice recorder, very little was said during that very short flight. I have no doubt whatsoever that a flight -- cockpit image recording would have assisted us to understand the human performance issues there.

We had a major input from the AAIB into the Concord accident in Paris in the year 2000, and I know my colleague in -- my European colleague in France, Paul Arslanian, the chief investigator there, strongly believes that our understanding of the human performance issues during that short flight would have been enhanced by image recording. The crew were struggling with a large number of ambiguous warnings in that case.

And I've brought along -- unusually, as an accident investigation organization primarily set up to deal with civil aircraft accidents, the AAIB has a longstanding involvement with military aircraft accidents. And I've got a military example which is perhaps an infamous one from a U.K. perspective.

In 1994, we had a Boeing B234 crashed on the Mull of Kintyre. It killed 11 senior directors of our intelligence agencies, and it has become a cause celebre in the U.K., moving to the highest levels of government insofar as former prime ministers are regularly quoted on the subject. The current prime minister is also quoted.

We have had committees of our upper house sit in judgment on this accident. And as I speak here today, the issue is probably heading for the European Court of Justice.

Since 1994, the amount of resources that have been expended on this accident, because we do not understand what went on on that flight deck, probably runs into millions and millions of dollars. I suspect that, as a military example, this is one of the worst that we could cite as being able to be more adequately resolved at least by image recording.

Madam Chairman, that's all I had prepared. I'd be happy to answer any questions that the Board or the -- might wish to put to me.

CHAIRMAN CARMODY: Thank you very much, Mr. Smart. I think we'll go ahead and take Mr. Wood's statement, and then we'll have questions of both of you.

Statement of Mr. Kevin Wood

(PowerPoint presentation)

MR. WOOD: First, I'd like to start off by just having a brief presentation and give you a little bit of an overview of our Navy projects and programs involving flight information recorders and specifically what involvement we have with image recording.

As I said previously, I'm the integrated product team lead for flight information recorders, and responsible for the acquisition and life cycle support of those products for the Navy and the Marine Corps.

Next slide.

That's my public affairs office disclaimer in regard to the presentation.

Next slide.

This gives you an overview of what's contained in the presentation itself.

Next slide.

This is our organization within PMA 209. I work for Mr. Bill Wescoe, who is the flight operations deputy program manager for flight safety systems, and we have integrated product teams that deal with each of the various flight safety systems that are procured and acquired and used by the Navy and the Marine Corps.

Next slide.

Basically talks about -- this slide talks about our capabilities process and our requirements and how we transition our requirements into capabilities and products for the Navy.

Next slide.

This is one of the slides that kind of indicates the issues and the problems that the Navy is facing right now. Even though we've maintained pretty much a standardized mishap rate of two mishaps per 100,000 hours of flight hours, we're still having a problem with increased cost per mishap, where the cost of the mishap is really increasing a lot because of the cost of the aircraft.

Next slide.

These give you a breakdown of the causal factors that we have regarding the mishaps. It's pretty well recognized within the Navy that 80 percent of our incidents have human factors relationships or causal factors, and these are one of the areas that our crash survival flight information recorders are very important in helping us determine the cause of those crashes.

Next slide.

These -- this outlines some of the CNO and DOD mandates and guidance we're getting in regard to implementing flight information recorders in our Navy and military aircraft.

Next slide.

These are three of the primary systems and equipment that we are working with within our group at PMA 209, and the one I'm responsible for is the CSFIR product down at the bottom.

Next slide.

These are the areas in the human factors causal analysis that the CSFIR products have been determined to add value or benefit in the recreation and playback in these accidents and incidents.

Next slide.

These are the current products that we're installing on our Navy and Marine Corps aircraft, and these are all primarily CSFIR, cockpit voice -- cockpit voice recorders and flight data recorders.

Next slide.

These are the various aircraft that we're installing those particular products on.

Next slide.

These are two small business innovative research products that we're working on that we started back in the March 2001 time frame. These products here are designed to be data-centric recorders that are multimedia recorders that we're looking at doing image recording with, voice recording, and flight data recording in a single product. As you can imagine, size and weight are very critical factors with military aircraft, and the -- the commercial environment that's out there right now really is kind of geared toward civil aviation, with larger flight recorders that don't really fit the military requirements profile.

Next slide.

These are some of the key issues or benefits of the SBIR products that we're trying to develop. We refer to the products as Digital Data Download. One of the big challenges of doing image recording is, the download of the data has to be timely and done in a -- in a quick fashion so that the organizational level maintainer can get it done and not spend large amounts of time trying to download data from a flight recorder.

The product that we're trying to develop with the SBIRs would address our current CSFIR obsolescence issues and SDRS, the structural data recording system, that we're also responsible for.

The current form factor would have an increased capability up to two hours per channel of four independent video recording sources, provide secure data capability, provide reduced number of on-board data recorders, and consolidate a lot of the products that are out there now. We're having a pretty large proliferation of recorders for separate applications, what we normally refer to as stovepipe recorders or stovepipe solutions, that the SBIRs are kind of designed to consolidate those into a single box.

And again, mentioning the reduction in data download time, and then would support our future project program efforts in what we call military flight operation quality assurance. The civil aviation community, I guess, is working in those areas with flight operation quality assurance or flight data analysis, and we have efforts ongoing in those areas, also.

Our future platforms that we had submitted and requested funding for in our Program Objectives Memorandum for '06 for the aircraft listed below.

Next slide.

I guess, in summary, the safety systems are the cornerstone of survivability for the aircraft. Current safety systems address the majority of Class A mishap causal factors.  The secretary of Defense has basically challenged all the services to try and reduce their mishap rates by 50 percent, and PMA 209, which is our group, is trying to take a proactive stance on improving current safety systems, and we're proposing new programs and products to address those issues.

Next slide.

These are our points of contact:  myself; Carol Van Wyk, who is our SBIR program coordinator with NavAir; and we work pretty closely with the Naval Safety Center.  Mr. Chip Brown is our accident and mishap investigator we work with.

That should be it.

CHAIRMAN CARMODY:  That completes your presentation?  Thank you, Mr. Wood.

Why don't we turn now to the Technical Panel for questions of the witnesses.

Who's going first on the Technical Panel?

Mr. Brazy, thank you.

MR. BRAZY: I'd like to go back to Mr. Smart and just dive right in. I understand that on-board video recordings aren't required for carriage on any airplanes in the U.K., but nevertheless, have -- has your agency uncovered any video recordings during the course of accident investigations that were on board and operating for any other purpose? And if -- if you have, did you find that video recording information to be useful in any way in the course of your accident investigation?

MR. SMART: The answer as far as civil aircraft accidents are concerned is no, it's not a requirement, and we haven't had an accident to an aircraft which had a video system installed.

We do come across videos in some of our later military aircraft on occasions, and the answer to your question is yes, they are very, very useful.

MR. BRAZY: And could you give an example of some of the things -- types of information that might have been gleaned from those -- from the video recordings on those military airplanes involved in accidents?

MR. SMART: The -- one of the primary pieces of information that's recorded is the head-up display, which is -- effectively gives a view through the -- through the flight deck as well as the head-up display. So you have got the instrumentation that is presented to the -- to the pilots available to you, rather than the recorded information, which may or may not be the same -- taken from the same point in the system.

MR. BRAZY: Along those lines, have you discovered any discrepancies between information that's displayed to the pilots versus what's recorded parametrically on something similar to a flight data recorder on military airplanes?

MR. SMART: No, I haven't, but then I -- my involvement in military boards of inquiry these days is not as strong as it used to be, when I was investigating or as an IIC. So perhaps there are others in my organization we could direct that question to.

MR. BRAZY: I'm sorry. In terms of civil airplane or aircraft -- civil aircraft flying in the U.K., although you said that you haven't discovered any systems that were installed on airplanes for the purposes of video recorders, but have you come across any video recordings that might have been from hand-held cameras of passengers or something similar to the system Mr. Hilldrup mentioned this morning for tour operators that provide a souvenir for the passengers to take home with them? Have you had any experience or seen any recordings like that in accident investigations?

MR. SMART: No, we haven't. The only recordings I've seen are those associated with the research programs that I referred to in my statement.

MR. BRAZY: Okay. Thank you.

To expand upon an area that Dr. Ellingstad mentioned with Frank Hilldrup earlier, would you be able to give us any examples of conclusions that you developed that may have been lacking in their precision or had some amount of uncertainty that could have been improved or resolved if video data had been available, not only in terms of establishing the probable cause of an accident but in establishing findings or conclusions that led up to that probable cause?

MR. SMART: Yes. I mean, the examples I gave you are ones where that applies. I think the Korean Air accident where we struggled with Oriental culture as an issue in the -- in the findings of that -- that investigation, and the human performance issues, which we had very sparse evidence for, was a primary example there of, I think, image recording being able to provide a lot more information on the human performance issues associated with that particular crew at that time.

There were a lot of distracting factors in that accident. They were taking off into a squall. It was very bad weather and the noise levels were quite high. So these are issues that are not fully explored, if you like, from the flight recorder and the cockpit voice recorder as we have that evidence.

As I said, image recording complementing that evidence that we have there would have enhanced our ability to explore those issues.

MR. BRAZY: Along those same lines, can you -- can you tell us what types of information that an image recorder can offer beyond that typically provided by a set of -- a CVR and an FDR set of recorders in the following three different areas:

Establishing or confirming information about the cockpit environment, number one;

Two, human performance, as you've just mentioned. Are there any specific human performance issues that you think might be able to be investigated deeper or further with the use of an image recorder;

And airplane data. Is there any other airplane data that -- that may be available from an image recorder that's not available on flight data recorders and cockpit voice recorders, display of information, things of that nature.

MR. SMART: Let's take the last one first. The -- understanding what the crew is looking at and the condition of the information that they are receiving is -- was an important factor in the Kegworth accident I mentioned, because there was very high vibration. The flight data recorder information doesn't give you an adequate indication of the -- the issues that were presented to the crew in those circumstances. So there's an example where that information is important.

Also, the -- the pickup for the data recorder is upstream, if you like, of the -- of the -- the feed for the flight deck instrumentation, so they may or may not be the same in certain circumstances. Knowing what the crew are looking at is very important, and as I said, the condition of the -- the information they're presented with.

As far as human performance issues, the concerns -- all those that have experience of modern flight decks will understand that there's a great deal of nonverbal communication that goes on between crews, and we are not able to get at that through cockpit voice recording or data recording. Image recording will provide that.

And it's quite -- relatively common to hear words like "look at this," and we're stuck there wondering what "this" is, whereas image recording would perhaps give us a good chance of capturing exactly what they were referring to in those circumstances.

So those are the issues that I find would be -- we would have enhanced information in those circumstances if we had image recording available to us.

MR. BRAZY: Thank you.

In the -- in the category of airplane data, do you think that a video recorder could be used to capture information like TCAS display data, not just a resolution advisory or an alert but the display itself, maybe the weather -- color weather radar, if that's available on the airplane, ICAS warnings?

You mentioned earlier in your presentation about, I think, some confusion about the source of an audible alarm, what -- what caused that audible alarm to go off, I think you mentioned, because multiple things can set off such things as master caution or master warning. Without the -- without capturing on the DFDR what it is that set that off, or in what order if multiple things were occurring, do you think a video recorder might help resolve some of those issues in the course of an accident investigation?

MR. SMART: Absolutely. It gives you an opportunity to see what the crew are presented with. As I've said before, this is the -- this is the primary advantage of image recording, is being able to see what the crew are presented with. That is not always information in the pure form that we often see it on the flight recorder. It's distorted by a range -- vibration is an obvious one, lighting conditions, and so on.

All these things can affect the way that the information is transferred from the system to the crew. And image recording is perhaps the best chance we have of trying to assess those issues.

In answer to your earlier -- the first point you made about the various systems on the aircraft, the answer is yes, yes, and yes. You have -- have the option of -- opportunity to capture all that information on the -- the cockpit video recorder.

MR. BRAZY: Have you ever had any trouble determining which of the two pilots were operating the airplane during the course of an accident sequence?

MR. SMART: It is an issue that comes up regularly, and that's, again, another advantage of image recording. Often, particularly when you -- when things start to go wrong, it's not unknown to have both crew trying to make an input to the flight controls, and the ability to be able to determine that is what is going on is something we would not capture necessarily from the other recording systems we have available at present.

MR. BRAZY: If -- if a flight recorder was -- if an airplane was configured with a flight recorder to capture all flight control input forces as listed in the final rule in the United States for flight data recorders for transport category airplanes, would that tell you who is manipulating those controls, if one or both?

MR. SMART: That -- that is data which is useful to determine, and that is where -- in the majority of aircraft flying today, we don't have that information available. That is quite a big step for many of the aircraft operating out there. And an expensive one, I suspect.

MR. BRAZY: You had mentioned an accident that occurred in 1994 that had some intelligence officials that were killed in the accident, and you estimated that a large amount of money was -- was spent on that accident investigation that may have been --

video recorders may have helped save some of that money.

But also, do you think that -- that video recorders could help reduce the amount of time spent on accident investigations, and if so, why; and if not, why not?

MR. SMART: In the particular circumstances, absolutely. It would have saved a huge amount of time, perhaps resolved -- saved a lot of money as well in terms of the total resources the Ministry of Defense in the U.K. has deployed to try and address some of the issues. The court time, our parliament's time addressing this, my organization's time, having to give evidence to these various inquiries.

And one thing that strikes me as I've been talking to you that hasn't been mentioned so far is that it would have resolved for the families of those that died -- it would have prevented the long, drawn-out heartache that they've had where there is apparently no real understanding of the primary causes of that accident. So that's an issue I think which is important for us to consider in this circumstance.

MR. BRAZY: Could you cite any specific examples, either in the -- in the accident investigations that you -- that you have already mentioned or in others that you haven't, where a video recorder might be used to compel or convince a regulator or other recommendation addressee to take corrective action either sooner or -- or at all, where they might have otherwise been reluctant to -- to the recommendations that you issue?

Do you think a video recorder might help prove your case, I guess, to a regulator or a recommendation addressee, and if so, how; if not, why not?

MR. SMART: I don't see any difference between the evidence presented in cockpit image recording and that presented in cockpit voice recorders or flight data recorders or the evidence that we gather on accident sites. It's all evidence that we -- we have to use to influence a number of different parties to -- to affect change, to -- to make, hopefully, aviation safer.

Our business in accident investigations is all about influence. It's how we -- how we gather the evidence together and present it to influence the outcomes that we are seeking in our safety recommendations. So in that sense there is no -- nothing special in that sense about cockpit image recorders. It's -- it's more evidence which can help to convince those that have the responsibility to enforce change, perhaps.

MR. BRAZY: Thank you.

I have two more questions. Is there enough time to allow for those, or should I conclude and move on to Mr. Smart?

CHAIRMAN CARMODY: Well, if they're important questions, but let's -- let's move on quickly. Go ahead.

MR. BRAZY: Mr. Smart, you mentioned the research that's being done by the CAA that is -- we have some paperwork from Pippa Moore about, and I read -- I read in that -- in that paper that there were some concerns over the appropriate analysis of video data in the study: was it -- was it reviewed properly or -- or was it subjective or could errors be introduced in -- in the reviewing of the video.

And I noticed that there were two that were cited, and -- and one error was a video analyst had reported that one of the flight displays had gone out after takeoff when it really occurred 18 seconds before, or the other way around. And the other error that was made was a misidentification of who was flying.

Are you familiar with those -- those errors that occurred in that study? I'm curious as -- as to whether or not it was a -- a mistake made by the analyst or was the video so ambiguous that -- that it was -- he was unable to tell what had occurred. Do you have any other information about those errors cited in Pippa Moore's paper?

MR. SMART: Yes, I'm aware of the -- that -- those issues. I think in retrospect the -- the way that that aspect of the research was set up was -- was -- could have been better done, put it that way. The particular analysts were given the recordings in total isolation with no other information available.

That is not a representation in any shape or form of an accident investigation scenario. It was done that way so no influence could be brought to bear on -- on the individuals. They were just looking purely at the subjective evidence they had in front of them.

My organization was asked to review the -- the evidence there, and you'll see in the paper there's -- there's an addendum which goes some way to explaining our thoughts on the -- the methodology used in that sense. I don't think -- it doesn't reflect a normal accident investigation in any sense, where it's a team-based activity. It's not -- you don't -- you don't give out information to somebody, lock them in a cupboard, and say, come out when you've got the answer, which is more or less what happened.

So I think that's a better way I can explain it, and I would draw your attention to the -- the appendix in the -- in the report.

MR. BRAZY: Sorry. One more, and then we'll -- I'll be done, I promise.

During flight tests, there are typically many more parameters recorded during a flight test than are on a typical FDR with instrumentation recorders, and they're frequently recorded more often. More parameters more often than -- than at least what's required in this country. Yet, invariably, one or more video cameras are used in almost all flight tests I've had experience with.

Can you explain why, from your perspective, video would be added, despite the fact that the -- that the instrumentation recorders are recording so much information? And, what benefit would that video provide beyond what was captured with the instrumentation recorders?

MR. SMART: Yes, it's -- it's no coincidence that when flight test work is conducted -- I know from my own previous experience in the research establishments where I was involved in flight test work. The answer very simply is that it provides more information that you don't get from the -- the other forms of recording. And that's what we are seeking to achieve here with -- with the safety recommendations I know the NTSB had made and my organization has made. That's what we see as the advantage of cockpit image recording.

MR. BRAZY: And in your experience, has any of that additional information proven useful in the flight tests which you may have been a part of?

MR. SMART: Yes, invariably. In flight test work, where you're exploring an envelope, often when you get to the edges of that envelope, things do not go as expected and unusual occurrences crop up which -- where information is needed. And the video recordings in those circumstances often play a vital part in the understanding of what has actually happened.

And in that respect, that part of the flight test work is not dissimilar, if you like, to accident investigation. These are unexpected events, these are not normal operations, and that additional information plays a vital part in our knowledge of the events.

MR. BRAZY: Thank you, Mr. Smart. I don't have any further questions.

CHAIRMAN CARMODY: All right. Thank you, Mr. Brazy.

Dr. Byrne, do you have any questions?

DR. BYRNE: Just one, Mr. Smart. You've -- you've discussed many benefits today about this technology, image recording. As an accident investigator, what negatives exist, or limitations exist, with the use of this technology?

MR. SMART: The down side of recording is nearly always in -- outside the direct evidence, it's -- it's the issues that are -- that concern the Allied Pilots Association. It's the misuse of this information when it's available. I -- I fully understand their concerns, and I'd mirror Frank Hilldrup's words at the end of his presentation where he said that we need to address that aspect of it in terms of legislation. I guess this is one of the things we're going to be considering tomorrow.

Other than that, as I sit here, I can't think of too many issues on the down side, apart from the normal factors that beset us in an investigation in that, you know, the camera angle that we really wanted was obscured for some reason or another, that side of things.

But the -- the positive aspects of image recording will vastly outweigh anything negative in that sense.

DR. BYRNE: Thank you, Mr. Smart.

Madam Chairman, no more questions.

CHAIRMAN CARMODY: Thank you, Dr. Byrne.

Okay. Moving from the Technical Panel, then, to the parties, we'll start with the FAA.

Mr. Wallace, do you have any questions for the witnesses?

MR. WALLACE: Yes, thank you.

Mr. Smart, going back to this -- this fascinating encryption concept that you described, the three keys, I hadn't heard that before, but I would ask you, how -- how does that -- how do you see this reconciling with the, you know, ICAO Annexes, which fundamentally dictate that the country of occurrence takes responsibility for an investigation.

MR. SMART: Well, as far as that was concerned, it was -- the country of occurrence would have one key, the accident investigation. So it would have one key. But the replay -- the thinking there -- and this was just a proposal thrown on the table. The thinking there was perhaps until all three keys came together in the jurisdiction where the recordings could be protected, then the replay wouldn't be available.

It would only be available in certain jurisdictions.

MR. WALLACE: And did this concept get any discussions within the ICAO forums or international forums otherwise?

MR. SMART: I've discussed it informally. This has not seen the light of day in ICAO because, as I indicated before, the subject has not been discussed at these sorts of levels.

As usual, ICAO, we like to see things in a more mature state before -- before it gets onto the meetings.

MR. WALLACE: It's quite a -- it's an outside-the-box concept. I mean, we're here -- our hosts here are not used to asking anyone's permission to listen to a cockpit voice recorder, and it would certainly be a departure. You know, I envision a situation, perhaps, where there was an accident with a U.S. aircraft in -- in Paris or something and suddenly we have to have -- I was just wondering what sort of consensus you felt you would be able to work toward internationally.

MR. SMART: These are -- these are difficult issues. It's -- otherwise we would have resolved them some considerable time ago, I suspect. But it was -- it was one attempt to get some discussion over the process of encryption.

Other than that, we fall back towards the same issues that confront us on cockpit voice recordings today. And I know in many states the protection afforded to those recordings is virtually nil. They will go -- some of my European colleague states have -- have virtually no protection. The -- the recordings go straight from the accident site to the judicial authorities.

MR. WALLACE: Right.

MR. SMART: I'm sure this is something we will be discussing tomorrow.

MR. WALLACE: Right. You're on that panel as well, I know.

We have -- at the FAA, we talk about moving from sort of the fix-and-fly paradigm of safety improvement to getting out ahead of data and information. I mean, that refers, really, to the tremendous success which we've all shared in the developed world with -- with commercial aviation safety, where we have an accident rate which is so low that in most fields of endeavor they would sort of round it off to zero and say we're done. But of course, we don't -- we don't do that.

And -- and we view the way to do even better is -- is to -- is through programs like Mr. Wood mentioned, MFOQA, RFOQA, and ASAP programs. I haven't heard very much discussion here about use of this data in -- in those kinds of programs. I'd like your thoughts on that.

As is often observed by people analyzing the cost benefits, you know, a recorder never prevents the accident that it's recording, but of course, we'd all like to see recorders used exclusively for precursors and trend analysis which prevents -- prevents accidents.

I haven't heard much, nor from Mr. Hilldrup and from you, about that use. I'd like your thoughts on that.

MR. SMART: I think this is a difficult issue to address in terms of image recording because the same criteria apply here as apply to cockpit voice recorders. Cockpit voice recorders are not used in that context, either. So you can put those two types of recordings together and say, sensitive information, not available for, in general terms, for the FOQA type quality programs.

However, that information would get back into those programs by virtue -- through the accident investigation authorities in terms of the -- the use of that information, back into the reports and the safety recommendations, and so on. So -- so it's -- it's -- you can't say it won't have an impact on those programs anyway. It will, in the same way that the cockpit voice recordings and the study of human performance does from that information.

MR. WALLACE: Do you think --

MR. SMART: If you want a good example of how recording systems have dramatically improved flight safety, we -- we have a very hostile offshore oil support environment, very hostile in winter. And our accident record going back, what, 15 years, was very poor. We -- we suffered two -- two or three ditchings which were often fatal every year with helicopters supporting the oil industry.

I'm pleased to say that since the fitting of -- use of these monitoring systems, which are a combination of data and cockpit voice recorders, our safety record in the North Sea has improved immeasurably. Orders of magnitude, actually. It's a very good example of what can be achieved by -- by providing additional information.

And what cockpit image recording will do is provide additional information, so it advances that cause, if you like.

MR. WALLACE: Well, the FAA requires no convincing of the value of data for advancing safety, and again, while traditionally thought of as an accident investigation tool, I think ultimately we would all prefer to see it used as a trend analysis tool and, really, an extension of the FOQA concept, where data is -- flight recorder data is used in a protected, non-punitive way.

Would you envision that that concept could be extended to voice and image recorders?

MR. SMART: I'd like to think it could, but in the current litigious environment, which seems to be increasing rather than decreasing, I -- I think that's a little bit of a pipe dream as we sit here today. I can't see that situation in the near future, in the foreseeable future, even.

MR. WALLACE: Thank you very much.

CHAIRMAN CARMODY: Thank you, Mr. Wallace.

Mr. Barimo, any questions from the Air Transport Association?

MR. BARIMO: No questions.

CHAIRMAN CARMODY: Regional Airline Association, Mr. Lotterer?

MR. LOTTERER: Thank you.

Mr. Smart -- yes. Mr. Smart, your -- your discussion, as I understand it, primarily focused on the recommendation to provide supplemental video data recorders for aircraft that are already equipped with flight data and cockpit voice recorders, as opposed to the other recommendation before us about aircraft that don't have any recorders at this time, is that correct?

MR. SMART: Yes, that's -- that's right.

MR. LOTTERER: Okay. The -- in terms of what you foresee in terms of a benefit, for the most part the accident investigations with respect to equipment malfunctions can be correctly addressed. When we get in the area of human performance, particularly with the pilots, and some of those issues, we have had accidents in the past that -- that have made various changes to -- to the system, the operation, within it.

In terms of this added tool providing an additional benefit, what could you envision within the pilot regime that -- in terms of human performance that we could do that we haven't already done?

MR. SMART: I didn't quite get the gist of your question. Are you suggesting that image recording would -- would not provide additional information, or are you suggesting you -- that the pilot fraternity has done as much as it possibly can in providing the information that we need?

MR. LOTTERER: I guess what -- what I'm suggesting is that it's -- as, let's say, technical people, it's easy for us to quickly identify equipment malfunctions and quickly correct those to make the skies safer. When it comes to human performance, we've -- we've initiated a number of recommendations as a result of past accidents in training, training techniques, and so forth.

But I guess what -- what I find puzzling about, let's say, the -- a greater understanding of the human performance of pilots during crashes -- and we have FOQA programs, we have ASAP programs within the states to understand pilot performance -- ongoing pilot performance. What additional benefit do you see to the system in greater understanding as -- as a result of an accident associated with human performance?

MR. SMART: The answer to that is, because by -- by definition an accident is a set of circumstances that was not foreseen. Most of the programs that you referred to are normal operations in that sense, and you -- we don't necessarily get much of a feel for normal crew -- crew performance in exceptional conditions in -- from FOQA programs more generally. You pick up common errors, operational standards issues that you -- that -- that's where the value of FOQA programs is.

From an accident investigations standpoint, you -- you're dealing with a very different set of circumstances, and being able to understand how we perform -- how we'd all perform, perhaps, in those circumstances is -- is what image recording will help us to -- to achieve, rather than the current information we have available to us from flight recorders and cockpit voice recorders.

MR. LOTTERER: Thank you.

CHAIRMAN CARMODY: Thank you.

ALPA. Captain Fenwick.

CAPTAIN FENWICK: Thank you, ma'am.

I'll start with -- with Mr. Smart, and I'll move the microphone so I can see you there.

I know you were heavily involved with the Concord accident from your side of the Channel. I notice that the BEA reiterated the recommendation that image recorders would have been useful.

Can you give us some clarification of how that might have affected the determination of probable cause or the safety recommendations that flowed from that?

MR. SMART: I think what my French colleagues were referring to there in the recommendation is the confusing warnings that the crew were presented with in those circumstances, where it was thought that there was a lot going on on that flight deck, that it could not be understood from just the flight data and cockpit voice recorders, and they would have liked to have had the opportunity of seeing how the crew were trying to deal with this set of circumstances.

It's -- it's the sort of example that I was referring to before. The data recorder and the cockpit voice recorder do not give an adequate representation of what the crew are trying to confront in those circumstances. It's the -- to get a good feeling for -- for -- get an understanding of how they're trying to handle these things is the best shot, I suspect, at the moment anyway, is probably video recordings.

CAPTAIN FENWICK: Certainly I think that the good feelings would be nice, but in terms of its effect if there had been a image recorder installed, its potential effect on the course of the investigation, do you see that that would have been markedly different?

MR. SMART: The answer is, I don't know. It's -- I was not directly involved in the investigation. I -- I was involved in the politics surrounding that investigation, which were interesting enough, thank you very much. But -- perhaps we'll get to that tomorrow.

But the -- the causes of what more information could have been got I guess is, to some extent, a chicken-and-egg sort of question. You don't know until you -- until you see, and I suspect our understanding of what that crew were confronting, that particular issue at that particular time, could have been -- would have been enhanced with cockpit image recording. That's certainly the view of the French investigating body.

CAPTAIN FENWICK: The Concord had a relative -- a surprisingly unsophisticated flight data recorder in terms of the number of parameters and the sample rate. Would you agree that a -- a newer generation recorder would have been much more useful for you investigators during the course of that accident investigation?

MR. SMART: The answer is yes, but in those circumstances -- the same applies to the Kegworth accident. Those were very unusual circumstances with a lot of dramatic events taking place all at one time. And to capture that and to understand it properly, I don't think the -- even modern, the latest generation if you like, flight recorder systems and cockpit voice recorder systems would necessarily give you the information you're seeking.

CAPTAIN FENWICK: I was interested in the dramatic effect that the installation of a CVR and a DFDR in the FOQA capabilities that enables the real reduction rate that you've had in the North Sea with the turbine helicopters.

I contrast that with the NTSB recommendation where they believe that, for turbine helicopters and King Airs and Caravans and that class of airplanes, that a stand-alone CIR, stand-alone image recorder, would give them most of what they need.

I deduce from your comments earlier that your opinion would differ in that regard?

MR. SMART: As I said earlier, I believe the image recorder is complementary to the other two recorders. Now, technology can enable us to combine some of the -- the recording, as we've seen.

But image recording is better than -- than nothing. Data recording and cockpit voice recording is -- is better than nothing at all as well. The balance between what recorders you'd fit if you only had the option of fitting one or two is a question I think needs a bit more study. But, you know, they're complementary recording systems.

CAPTAIN FENWICK: Thank you.

My next question is for Mr. Wood. Can you give us a feel for what percentage of the fleet -- that would be Navy and Marine Corps airplanes today -- are fitted with digital flight data recorders?

MR. WOOD: I guess we had some questions from Doug later, but do you want to start mine now or wait for Doug to --

CHAIRMAN CARMODY: Why don't you answer this one? I'm going to have to circle back to Mr. Brazy because I didn't realize he had more to ask you. So if you would, please answer this one.

MR. WOOD: Okay.

CHAIRMAN CARMODY: And if we need to go back, we will. And don't forget your microphone, Mr. Wood.

MR. WOOD: All right. Right now, at the present time, all of our passenger-carrying and troop-carrying aircraft have crash-survival and flight data recorders and cockpit voice recorders. We are completing installation of our CSFIR product that's manufactured by Smiths Aerospace with the F-18 CD aircraft on Lots 10 and 13. A lot of the F-18 aircraft after that are getting what they call deployable flight information recorders manufactured by DRS.

CAPTAIN FENWICK: That's probably as deep as I needed at this point.

What I'm interested in is the worthy goal that your organization has of reducing the accident rate by 50 percent, and the new generation combi recorders are presumably going to be a part of that endeavor. To what extent is your accident rate reduction, the expectation, going to hinge on the video component as opposed to the proactive use of the DFDR, the FOQA side of it, to identify trends and exceedances, that sort of thing?

MR. WOOD: Right now, I guess, we haven't really done any calculations or determinations in regard to how much would be reduced by -- by video recording capability. And right now, at this present point in time, the Navy doesn't have a validated requirement to do video recording capability. We're in the process of developing the potential, the capability. Whether it gets applied and used or not is yet to be seen.

CAPTAIN FENWICK: Thank you.

CHAIRMAN CARMODY: Thank you, Captain Fenwick.

Mr. David with the Allied Pilots, any questions for the witnesses?

MR. DAVID: Yes, ma'am.

Mr. Smart, you said that knowing what the crew is looking at has a very definite human performance benefit. Reading in the Moore study from the CAA, it said that the cockpit image recorders can't tell what the crew is looking at. Doesn't the -- doesn't that lead to a supposition that you know what the crew is looking at simply by reviewing the video?

MR. SMART: The answer is no, we don't know what the crew are looking at, apart from when their attention is drawn to it, and I talked about a number of communication. Often crews will point to instrumentation and you can -- you can draw conclusions they -- they will be looking to that instrumentation.

The point I was making there was, looking at the condition of the -- the image that they're looking at is as important as the information. All we have at the moment is the information that's recorded on the flight recorder, and the assumption is made that that is as valid as the information presented to the crew. Not always true, particularly in high-vibration environments and other circumstances.

MR. DAVID: What about the assumption that simply because it's presented in the video that the crew is seeing it, in fact where their attention may be diverted elsewhere?

MR. SMART: Well, these are issues that

accident investigators have to -- have to address in all investigations. It's to -- whether the -- whether the indication is within the -- within the normal scan, whether it was -- their attention was drawn to that information with -- with other warnings and so on, these are issues you -- you draw conclusions on.

The point I was making earlier was that understanding what the crew are presented with and the condition of that information is -- is important evidence that can be provided by cockpit image recording.

MR. DAVID: I see. Also, from that U.K. CAA study, you cited numerous human performance benefits. The CAA presented definitive evidence that monitoring people while they perform a complex task has a negative effect on their ability to perform tasks. Won't that fact impair pilots' normal performance in the daily course of their duties?

MR. SMART: I -- I saw that, yes, and I -- I questioned it, also. I'm going to answer the question with a question: does the installation of cockpit voice recorders impair the performance of crews? I think not.

MR. DAVID: I wouldn't have any idea on that, sir. I just read what the U.K. CAA stated.

MR. SMART: I know what they stated, and I don't necessarily agree with it.

MR. DAVID: Thank you, sir.

One final question, also from the study. They say that the cockpit image recorders are limited in their information on cognitive work load, where they're looking, and flight crew stress. So, what specific benefits do you mean besides seeing the work load? What else can we glean from that, due to the limitations that the Pippa Moore study argues?

MR. SMART: Yes. I mean, the -- the human performance issues there are interesting. I just -- just remind you that it's an interim report and may well change in its final form. There is a great deal of discussion going on around that.

But the -- skills that are -- are addressed in that issue -- in that report are important -- important to -- to look at and address in the context of any accident investigation: what -- what is being manipulated by the crew, how it's being done, and so on, is information which is valuable which we don't get necessarily from any other recording system.

MR. DAVID: Thank you.

I also have a question for Mr. Wood, ma'am. Would you like me to wait or address it now?

CHAIRMAN CARMODY: No. If you have a question for Mr. Wood, why don't you address it now? We're questioning both the witnesses at once. Thank you.

MR. DAVID: Mr. Wood, do you have experience in -- with the head and shoulder multi-video recording equipment which has already been installed in a variety of aircraft and has been installed in the past? And if you do, do you have an idea of the resolution of the technical problems that we had with those organizational-level installations?

MR. WOOD: No, I don't. I don't have any familiarity with those particular installations and how they're being used, Inspector.

CHAIRMAN CARMODY: All right. Thank you, Mr. David.

Ms. Rosser, any questions from NATA?

MS. ROSSER: Yes. Thank you.

Mr. Smart, starting with you, following on some of the other questioning here, the preliminary -- I recognize it is preliminary -- study stated that the recording should always include more information than just the stand-alone video recording, that you can have misleading results if you rely on single source information. Can you talk a little bit more about what the misleading elements are?

MR. SMART: Yes. I mean, there's no difference in concept there in -- in the context of video recording to -- to any other form of evidence that we gather as accident investigators. We always looking to validate the information by -- by other sources, and that's the natural process of investigation.

So, yes, I -- it's -- I said -- I've said a number of times already that I see these recorders as complementary recorders because it's -- it's taken in conjunction with other evidence that starts to build up a picture of what was happening. So -- so I'd just say that there's nothing unusual about that in this context. It's something that takes place every -- all the time in accident investigation teams.

MS. ROSSER: How would you see, then, the value of a stand-alone image recording system being impacted in single-pilot situations?

MR. SMART: An image recording system where you had no other information from a flight recorder or a cockpit voice recorder will provide evidence that you could -- you would have available to you. The weight you put to that evidence in particular circumstances would depend on what those circumstances were and whether or not there was supporting evidence from other sources. It's possible in certain circumstances that you might. In most cases, I suspect you wouldn't. It would be stand-alone.

But it was -- it would be information that you wouldn't have by any other means, so it's valuable in that sense.

MS. ROSSER: Thank you.

Mr. Wood, you discussed the development of integrated CVR, FDR, and image recording systems, and I'm wondering what the impact weight penalty-wise is. Our members fly traditionally smaller aircraft: the Caravans, the King Airs, and a big concern that we have then is -- is the weight and the ability to develop a crash-protected unit. And in your work with fighter jets, I assume it is a similar problem with weight and center of gravity issues.

How -- how have you addressed that, and what are the size of these units that you're developing?

MR. WOOD: Right now, the products that we're working on with our small business integrated research efforts, we're working on a product that's 10 pounds or less and nominal -- the size and dimensions are like four by five by seven inches. Fairly small and compact.

MS. ROSSER: Thank you. No questions.

CHAIRMAN CARMODY: Thank you, Ms. Rosser.

Now, Mr. Brazy, I must apologize to you. I thought you had asked your questions of the entire panel when I went to the parties. So, if you still have questions that have not already been asked of Mr. Wood and you would like to ask them, you may do so now.

MR. BRAZY: Thank you, ma'am. I would. I'm sorry. I went out of order.

CHAIRMAN CARMODY: Okay. And I hope they won't be too lengthy.

MR. BRAZY: They won't, I promise.

CHAIRMAN CARMODY: Thank you.

MR. BRAZY: Mr. Wood, you mentioned two small business innovative research programs, both of which have some sort of video capability associated with them. And -- and I think you mostly answered my question in an earlier response, but could you give us a very brief description of those two systems, any large key differences between them, and -- and why it was chosen to have the video recording capability developed for them?

MR. WOOD: When we were initiating this SBIR effort, we were aware of the emerging technology to be able to do digital video recording. So we naturally incorporated that in part of the consolidation effort, anticipating that there may be a future need or requirement to do video recording for the Navy and the Marine Corps.

We were also aware of mission requirements to do video recording that do exist, and to an extent, part of our data-centric effort to try and consolidate recording into a single product, we wanted to try and include as much capability into that single product that we could.

So as part of these SBIR efforts, being innovative as they are, we tried to push the commercial sector for the best technology or best capability that we could come up with.

Two vendors came in with good proposals on the phase I part of the SBIR effort, one being Physical Optics Corporation and the other being Management Sciences, Incorporated.  Physical Optics is actually here and, I guess, will be working with the NTSB later in the hearing.

But we're in phase II now with these development efforts and working to try and go into enhanced phase II and try and complete the development efforts to develop and build a first article product that we could actually test and possibly integrate and put on a naval aircraft.

The differences between the two efforts, both efforts are oriented toward trying to develop a data-centric recorder that could be used for the Navy and Marine Corps aircraft. The Physical Optics efforts actually have a lot of analog and discreet interface capabilities, along with Mil Standard 1553 data bus capabilities. But the box itself was pretty much oriented to use more on legacy aircraft, where they're not always digitally bus, where you get your data off a digital bus, so that we could use it with analog and discreet interfaces.

The MSI product was pretty much oriented for digital aircraft and our future generation aircraft, where they would all be digitally bussed and get all our data for the flight data recording applications, other than voice recording, off of data buses.

MR. BRAZY: So, in both programs, the -- the one that's geared toward legacy aircraft, existing aircraft that are out there flying now, as well as aircraft that are foreseen to be procured in the future, you've incorporated video as a -- something that could be recorded on both those two different classes of airplanes, that's correct?

MR. WOOD: Yeah, that's correct. Each --

each box presently is designed to have two-video-channel-recording capability. The Physical Optics product is capable of recording up to four hours of digital video recording capability with their compression techniques that they've developed. We have to test and verify that yet, but that's the intended design and end state.

MR. BRAZY: You mentioned -- you mentioned earlier that you work with the Naval Safety Center in some of the products that you have developed or install. Have they -- has someone from the Naval Safety Center or the appropriate spokesman from the Naval Safety Center made apparent to you what their position on -- is on using recorded video in accident investigation in the light of the two SBIR, small business innovative research, programs?

MR. WOOD: Well, the one accident investigator, mishap investigator, that we work with on a regular basis, Mr. Chip Brown, has indicated to me that he is definitely in favor of and supports video recording capability as a tool that would be very beneficial to the mishap investigator to do their work for collaboration purposes and validation of what actually transpired in some of the incident investigations, and would be a very good time-saving tool from their perspective on doing collaboration of their analysis and determinations.

MR. BRAZY: Thank you, sir.

It's my understanding that there are videos being recorded on a number of airplanes in the Navy as -- currently, not in the future but actually right now. And my understanding is also that data is not -- it's not crash-protected, but it is installed and flying on airplanes.

Is there a requirement -- has a validated requirement been established for why that video is being recorded versus the lack of one that the SBIR projects -- well, they don't have one, but they're intending one to come. Is there one already in place for other purposes on other -- on other aircraft flying in the Navy now?

MR. WOOD: I guess, presently, the T45AB8, the F-18, F-14, and several other aircraft do have digital video recording capability in the aircraft right now, but those applications are either mission-related or training-related and not necessarily safety-related.

So when I -- I refer to no validated Navy requirement to do digital video recording or video recording, it's more toward the safety-oriented aspect.

There are mission-related requirements to do video recording and training, you know, requirements that have been validated. Otherwise, the equipment wouldn't be installed on the aircraft.

MR. BRAZY: And to your knowledge, has the Naval Safety Center used any of that video that happens to be available on these airplanes for mission-oriented purposes as well as in the training environment, which I find very interesting -- has the Naval Safety Center had any experience in using that data that may have been available after a mishap or an accident, even though it's not -- it's not crash-protected?

MR. WOOD: I guess, before I came down for the hearing, I gave Mr. Chip Brown some information about the questions that you were interested in asking, and he did specify one incident that he had encountered in the past where he had the T45s that had a hood camera installed using mission debrief applications. And he was basically in the process of doing one investigation where they had a runway departure Class A mishap.

And the aircraft behind the mishap had the video camera recording capability and filmed and had records of the -- the aircraft in front departing and leaving the runway, and had a record of the pilot ejection. And he basically indicated that was a very good evidence or example of use of video recording, even though it wasn't in the aircraft that was involved in the mishap.

MR. BRAZY: Thank you, Mr. Wood. I don't have any further questions.

CHAIRMAN CARMODY: Good. Thank you, Mr. Brazy.

Now we would go to the Board of Inquiry, but I think, in view of the fact we've been sitting for over two hours, I'd like to declare a 10-minute break, and then we'll resume with the same panel, if that's all right.

I also want to recognize our third and most distinguished board member, our chairman, Ellen Engelman Connors, just came in. I recognized the two board members earlier today.

We're glad you could join us, and appreciate your interest.

We'll be back in 10 minutes. Thank you.

(Brief recess)

MR. WALLACE: Mr. Wood, you were asked a question earlier about the weight of these combination recorders. The weight -- my question is, are -- are you contemplating installation of these combination recorders on aircraft which already have recorders, flight data recorders, cockpit voice recorders?

MR. WOOD: Our primary plan would be to put them on aircraft that do not have them right now and provide the equipment, government-furnished equipment, to other prime vendors or manufacturers of aircraft, like Boeing or Northrup Grumman, and provide those as GFE products.

What we're trying to do is develop common avionic products for solutions for the cockpit voice and video and data recording requirement that we have so that we can take advantage of economy of scale and reduce our logistics support costs for the product that we're putting on our aircraft.

MR. WALLACE: So it's not simply a matter of the little box, but rather all the wires and sensors to all the control surfaces and everything you're measuring, is that correct? Or maybe as part of that same question, are you talking mostly here about hydromechanical type aircraft?

MR. WOOD: Well, the actual installation of the box into the aircraft and getting the wiring work and cabling and connections to the sensors is the biggest cost or the biggest problem with implementation or putting these recorders on the aircraft, and one of our biggest challenges with legacy aircraft.

When we work with the new aircraft builds or a major remanufacture or upgrade of the aircraft, it's a time frame when we can work with those prime vendors or manufacturers and get them to add in the wiring and connect these GFE products and put them in at that time.

MR. WALLACE: And just one final. Do you -- do you have separation or redundancy requirements, meaning do you need two of things or do you need to separate different types of recorders under your specifications or requirements?

MR. WOOD: We have reliability and performance requirements that we would have in place for a recorder product. We don't normally put in, like, two recorders so we make sure that one works. We usually get one good one and make sure that one works.

MR. WALLACE: Okay. Thank you.

CHAIRMAN CARMODY: All right. Thank you, Mr. Wallace.

Now we'll go to the Board of Inquiry. I'll start with Mr. MacIntosh.

Do you have any questions of the two panelists?

MR. MacINTOSH: Yes, Madam Chairman.

Mr. Smart and, I think, Mr. Wood, we'd like to approach the -- the issue of international arena.

Mr. Smart, you've told us that you have about 30 years' experience in -- in this business in an international arena. I'm sure you've had the duty as an accredited representative and also as an advisor to an accredited representative. You're currently supervising a staff that does that duty.

And I'd like to -- to have you address the issue of flight recorders and rush to judgment, and the issue of -- of good investigative practices versus learning something from the recorders and the rush to judgment that might take place. Do you feel that the image recorders contribute to such a practice, and if so, what can we do about it?

MR. SMART: Yes, you're -- you're absolutely right. There is certain jurisdictions -- certain states have accident investigation practices -- best way to describe it, perhaps -- that are -- lead to pressures on investigators that do lead to, as you call it, a rush to judgment.

The flight recordings -- I've seen many states where the -- having the -- the first replay of a flight recorder, sometimes with the data not properly validated, judgments are made about performance of crew, manufacturer, maintenance, and so on, that turn out to be very, very wide of the mark when the data has been validated, assimilated with other information, and a proper judgment has been made in due course.

You're absolutely right. Some -- some states -- some organizations are prone to this. It's not what ICAO envisioned in the spirit of Annex 13 at the Chicago Convention. Accident investigation is a team-based, multidisciplinary activity where the information from all sources comes in, is considered carefully, and judgments are made in -- in slower time than knee-jerk type reactions.

So, yes, I -- I recognize the scenario that you -- you paint. I've come across it many times. I continue to come across it with certain organizations that we work with, and it -- it does present a risk to -- when we start talking about installation of systems like this, because it's sometimes the bad examples which get remembered, rather than the -- the good -- the good practices that happen as a matter of course in the, shall we say, more developed parts of the accident investigation world.

MR. MacINTOSH: Thank you.

And, Mr. Wood, regarding the -- the same issue of a rush to judgment, as -- as your service has moved into the recorder business, do you see this tendency, and what do you do about it, how do you control it?

MR. WOOD: I guess, in my experience, I'm pretty much working in the Acquisition Program Office and am responsible for the -- the procurement and the life cycle support of the product, so I'm not -- not involved in the investigative aspects. And actually, I'm not privy to a lot of the information that the investigators have. They are not free to really discuss that with the individuals outside the investigative community.

MR. MacINTOSH: That gives us an opportunity for another hearing, I guess. Thank you.

CHAIRMAN CARMODY: Thank you, Mr. MacIntosh.

Mr. Battocchi, any questions?

MR. BATTOCCHI: Thank you, no questions.

CHAIRMAN CARMODY: Mr. Cash, I'll go to you, and then finish up with Vern.

MR. CASH: I have one -- one question for Mr. Wood.

Could you give us some idea on -- I assume you did some kind of a cost analysis when you looked at legacy airplanes, especially -- whether it was cheaper to put on conventional recorders or to go the route that you did go and develop a whole new recorder generation? Can you give us some idea of the costs involved and what led you to that decision?

MR. WOOD: Right now, our crash survival flight information recorder programs were actually CNO-directed. I guess they were in result of congressional direction based on the Ron Brown incident.

So our efforts are primarily get the job done, work out the issues of the cost and the installation and the acquisition. We were primarily directed to use COTS (commercial off the shelf) products, for the most part, and to an extent we didn't do a lot of cost analysis. We were just basically directed that the work had to be done and the product had to be implemented in the fleet.

In regard to some of our MFOQA program efforts, there's been some analysis done. During the January '98-September '03 time frame, they went back and looked at the Class A mishaps that had occurred, and what they did was try to make a determination on what flight operational quality assurance aspects would have benefitted or could have prevented, being proactive, doing prognostics and diagnostics using the data. And they came up with like a 12 percent projected reduction in those mishaps, and calculated that there would have been like a $300 million savings over that five-year time frame if they'd had MFOQA in place.

MR. CASH: That's it.

CHAIRMAN CARMODY: Dr. Ellingstad?

DR. ELLINGSTAD: Yes, just one question for Mr. Smart.

What proportion of the smaller turbine-powered fleet in the U.K. are equipped with either a flight data recorder or a cockpit voice recorder?

MR. SMART: The U.K. administration, the CAA, enforced the ICAO standards as far as that's concerned, so we have either a cockpit voice recorder or a flight data recorder fitted on -- on aircraft within those -- those limitations, those standards.

DR. ELLINGSTAD: So the issue of a video recorder or an image recorder in lieu of a flight data recorder isn't the issue in the U.K. that it is here?

MR. SMART: I mean, fitting -- fitting video recorders in any event -- to add that to the schedule of equipment that needs to be fitted would require a change of legislation. But that's -- that would be all.

DR. ELLINGSTAD: Thank you.

CHAIRMAN CARMODY: Thank you.

I have no questions for the panel, so I think we'll dismiss you with our thanks. We appreciate your testimony and your taking our questions. Thank you very much.

(Whereupon, the witnesses were excused.)

CHAIRMAN CARMODY: Mr. Cash, you may call the next witness.

MR. CASH: The next witness is Mr. John Cox from the Air Line Pilots Association.

Whereupon,

JOHN COX

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

Testimony of Captain John Cox

MR. CASH: Mr. Cox, could you please state your name, title, and place of employment, and any brief statement of academic or employment qualifications that qualifies you as -- for your testimony?

CAPTAIN COX: Yes, sir. I'm Captain John Cox. I'm the executive air safety chairman for the Air Line Pilots Association. I've held that job for about four years.

Additionally, an Airbus A-319, -20, and -21 captain for U.S. Airways. I’ve been employed by them for 24 years. Type rated in the Airbus family, Boeing 737, Fokker FK28, Cessna Citation, jet transports. I hold an airline transport pilot certificate.

I've been a pilot -- licensed pilot for 34 years. I've got a relatively extensive accident investigation and safety background. I'm accredited through the University of Southern California in their Aviation Safety Program, as well as an extensive training program through the Air Line Pilots Association.

MR. CASH: Thank you.

And Captain Cox has a statement and a PowerPoint that goes with it.

CHAIRMAN CARMODY: You may proceed.

(PowerPoint presentation)

CAPTAIN COX: And the next slide, please.

My goal today is to give you a pilot investigator's perspective on cockpit image recorders. More specifically, I'll examine image recorder uses in the framework of the industry's needs, the Board's declared goals, and the recommendation that the Board has made.

Next slide.

First, let me step back and recognize why we're here. ALPA shares the Board's goal of improving air transportation safety. In the Board's case, you do it through accident investigation, a reactive process. But there are other proactive means to enhance safety.

Now, to borrow from the NTSB's Most Wanted List, the Board's goal is to determine accident causation in a rapid, effective, and efficient manner. You do that by obtaining as much relevant information as possible that enables you to develop more precise safety recommendations.

To use more of the Board's quotes, cockpit image recorders would provide critical information about cockpit activity for small aircraft and information to supplement existing recorded data for larger aircraft.

So the question we have to answer is, will cockpit image recorders capture significant information that is not currently available to investigators, thus enabling them to solve accidents more definitively and efficiently. If only it were that simple.

Could the image recorder be the silver bullet that its proponents proclaim? We agree that it's all about improving safety. The real question we should be asking is how best to get there.

The first point I'd like to make is, the industry paradigm has shifted, and rightly so. Today, the emphasis is clearly on prevention and much less on investigation. This is not news to many air safety advocates in the audience. My own organization has retained an investigation capability, but our resources are now focused on proactive air initiatives.

This should not come as a surprise. All 64,000 ALPA pilots are more interested in accident prevention than kicking -- kicking tin after the accident has occurred. Airline pilots have a very personal stake in air carrier accidents.

But to get back to the question of possible value of a CIR, our newer large aircraft are equipped with DFDRs recording close to 1000 parameters at high sample rates. This is objective data, the type that investigators need. It is not investigation that is subject to conjecture or speculation. A great many of the pilot inputs are recorded, along with a vast array of aircraft systems and performance information.

Knowing this, I was skeptical of the claim that image recorders would add a great deal to investigations where extensive recording capabilities already exist, but I wanted to better assess the claim that CIR installations would potentially enable the resolution of unsolved accidents.

So I asked ALPA's Engineering and Air Safety

Department to compile a list of air carrier accidents in the United States in the last 20 years which remain unsolved. They could not come up with a single accident.

Certainly, it's a credit to the Board, but it's a clear indication that CIR installations won't make a dent in the already low accident rate for air carrier aircraft.

Let me give you a personal example. I've been intimately involved in a number of accident investigations. The most dramatic and traumatic had to be the US Air 427 accident. During that investigation, and to this day, there are those who claim if we had had a cockpit image recorder we would have been able to tell if the pilot was pushing on the rudder pedal or was the pedal pushing on the pilot.

To make such a claim for a CIR reflects a very poor grasp of the physics involved, not to mention the human performance issues. The fact is, with the video as a guide and without more detailed DFDR information, we might well have reached the exact wrong conclusion and critical safety deficiencies would still exist today.

Another 737 which is involved in -- is cited by the Board was the SilkAir accident. The Board cited this event for its advocacy for image recorders. But this was a case where the existing recording capability was intentionally disabled and the video camera is easily defeated with something as simple as a piece of tape.

The obvious lesson is here is where cockpit occupants have devious or criminal intent, no amount of recording capability will affect the outcome. The crash will still occur.

Now, there are some ALPA pilots in Canada flying smaller aircraft without the benefit of a DFDR. We owe them and their passengers a data recorder. Could an image recorder be the answer to this segment of the industry?

I refer to the U.K. study, the conclusion that image recorders as a stand-alone device is not likely to be of much use to the investigator. Their words, not mine.

What do we do then for smaller turbine aircraft? We must continue the quest for reasonably priced yet robust parametric recorders for these aircraft. Augmented GPS recorders show promise, with the added bonus that they may be useful as a FOQA-capable recorder, enabling proactive safety-enhancing initiatives. There are other technologies to be explored.

In summary, Madam Chairman, ALPA shares your passion for flight safety and the quality of accident investigation. We are convinced, however, that the cockpit image recorder is not the answer. Let us follow the Board's recommendations for enhanced parameter digital flight data recorders.

On the surface, it would appear that image recorders could be the answer to the investigator's desire for the perfect tool. In reality, it just does not deliver. We can and must spend our precious safety dollars where they will yield the greatest safety benefit, not just on investigations but on proactive safety matters. In fact, the industry has already started doing that, and the results show that we're on the right track.

The accident that doesn't happen won't make the 10:00 news, and we'll never have a public hearing for it in this room. But the accident that we can prevent is where our true focus should be.

Thank you.

CHAIRMAN CARMODY: Thank you, Captain Cox, for your statement. We'll move now to the technical panel, and I believe, Dr. Byrne, you were going to start the questioning.

DR. BYRNE: Yes.

Good morning, Captain Cox.

CAPTAIN COX: Good morning, sir.

DR. BYRNE: I'd like to expand on some of the elements of your presentation and address some of the issues involved in this hearing. I'd like to start by asking you to describe your experience using video recorders in flight training.

CAPTAIN COX: Over the last several years, four or five, a number of the airlines, including my employer, have incorporated video recorders in simulator training specifically with what is known as line-oriented flight training. And the -- this gives an opportunity for the crew to review in a carefully controlled environment their performance after the simulator session. I've done I'm going to estimate probably 20 of those over the course of the years.

DR. BYRNE: And these are in the role of a pilot or a student going through that training, or as an instructor or check airman?

CAPTAIN COX: I have been a check airman in other aircraft, not specifically that use video recorders. This is primarily as a student or as an evaluator for doing the investigation of the U.S. Air 427 accident. We worked in cooperation with the Board and FAA and Boeing to develop procedures that could help -- that had a fully deflected, uncommanded rudder. And so we used the video cameras in the assessment of crew performance.

DR. BYRNE: Based on your experience as a pilot undergoing flight training using video recorders, would you describe your -- the benefits that that provided you?

CAPTAIN COX: Yes, sir, I'll do my best. I've been a bit disappointed in the value of the video. What we came to learn was that the audio portion of the recording provided more usable data, more significant data, than the video did. And as the crew recreated or discussed and the instructor pointed out in addition to their notes, the video image itself proved to be of relatively little value.

This has been found in some other airlines, and I know in the case, or I'm told in the case, specifically United Airlines has gone away from video recording now, as they found it not -- not necessary to get the quality of training that they needed.

So over time, my experience has been the -- the usefulness of the image recorder itself has gone down. The audio portion provided us more data.

DR. BYRNE: Where were the cameras located in these examples?

CAPTAIN COX: Primarily, they were behind the pilots, looking forward.

DR. BYRNE: Was it a problem that the resolution of the cockpit environment wasn't sufficient to allow for actions or activities of the flight crew to be resolved?

CAPTAIN COX: There weren't particularly resolution issues that I recall. It became that it wasn't relevant to the discussion. The audio portion cleared up very quickly, you said this or you called for this checklist, or the procedures that were undertaken. The video just didn't add anything to it. The part that it really failed to -- that the crew interviews or the crew discussion was what was going on in the mind of the crew.

Just the images themselves didn't -- I didn't see that they particularly -- in places, they were actually a bit misleading. As an example, a large number of pilots, myself included, when they go through checklist items, will reach and touch towards a specific gauge or switch, and enhanced parameter DFDR clearly shows if that switch was activated. There -- it is a very subjective call whether on an image that switch was moved or not.

The crew knows, but in the case we saw in the simulators, we had to be a bit careful about, did you actually turn that on or off, because there was -- it was misleading images. That's part of the reason that we tended to go away from using the images themselves and more concentrated on the audio portion.

DR. BYRNE: Are there any ways that you could have improved the images or improved the situation to improve the utility of the cockpit -- the images in the simulator environment?

CAPTAIN COX: I think it's -- technology. It's always improving. You could improve resolution, but I think the questions of interpretation would always still be there. The subjectivity of the image would still be there.

DR. BYRNE: As an investigator -- I'd like you to put your investigator cap on at this point -- how are current recording methods, cockpit voice recorder and flight data recorder, limited in their abilities to document crew actions?

CAPTAIN COX: The cockpit voice recorder gives us a good insight into the cadence and what's going on in the cockpits, and also work load. As an investigator, what I've found and one of the most frustrating things that I've experienced in my career, was the quest for needed data. That's specifically true in U.S. Air 427. That was a very difficult accident to understand, and we needed data.

What we needed specifically was objective data to understand what happened to that airplane, and the cockpit voice recorder gave us many, many, many clues, as did the DFDR, and as did engineering analysis. And as we combined this entire package together to get an overall understanding, it slowly became clear what had happened.

I believe that we would have stood a serious possibility, as I mentioned in my statement, that a cockpit video recorder could have led to the wrong conclusions because they are so subjective. Quite simply, was the pedal pushing the pilot or the pilot pushing the pedal? A force transducer would answer that question definitively. That, in my opinion, is where we needed to be.

DR. BYRNE: Moving away from flight data recorders, could you compare the difficulties involved in the analysis of a cockpit voice recording and the analysis of a proposed video recording?

CAPTAIN COX: Both are going to be a bit subjective and they're going to require careful review. But I think that they are a single element to an overall understanding. As we have found and we have seen over the years, the proper use and evaluation of a cockpit voice recorder combined with a digital flight data recorder gives a good understanding. And that is evidenced by the fact that we have no unsolved accidents in the last 20 years for air carrier aircraft.

I question the additional -- whether -- I question whether we would be better served by going to cockpit image recorders as opposed to additional parameters on the flight data recorders. I think that would give us a better understanding.

DR. BYRNE: As a pilot, you -- as a pilot, if you were involved in an accident, you'd clearly have a vested interest in the outcome of the investigation, that it was done accurately, precisely, and that meaningful safety recommendations were made. What benefits exist to you as a pilot in this case with the installation of a cockpit image recorder?

CAPTAIN COX: I hope I'm never involved in an accident, for a start.

If that situation were to arise, I would far prefer to be in a modern digital airplane that had a lot of enhanced flight data recorder parameters as opposed to an image recorder for the reasons previously cited of the subjectivity. I'd rather the investigators have the maximum amount of objective data, and I believe that that would lend itself to the finding of -- to an accurate finding of probable cause.

DR. BYRNE: Chairman Carmody, I have no further questions. Mr. Brazy has just a few.

CHAIRMAN CARMODY: All right. Please go ahead, Mr. Brazy.

MR. BRAZY: Captain Cox, in reference to your experience in flight training in the simulator environment, were you -- did you ever encounter a review of a video recording that more accurately reflected what occurred or the order in which events occurred than did the students' recollection?

CAPTAIN COX: There are always cases where the recollection of the crew, the student crew, will vary among themselves and with the instructor. And as mentioned previously, what we found to be of greater benefit was the audio more than the video. The audio was definitive on a timeline of when a particular event started, a checklist was called for, a procedure was initiated.

There was -- there was not very much ambiguity about that, and that tended to lead to a more in-depth and fruitful discussion of the training elements of, yes, I understood why you did that, or you might have waited to hold that procedure a little bit for this reason.

But increasingly over time -- and I was quite -- actually, I was surprised by it -- the -- the importance of the audio outweighing the images became clearer. And then, over time, they were -- the images were, don't worry about what it looks like, let's talk about what you said at that moment. That -- that has been said many times in many debriefing rooms that I've been involved in.

MR. BRAZY: And is video still being used at your company in the training program in simulators? Has it been discontinued or --

CAPTAIN COX: It has not been discontinued. It's still in use.

MR. BRAZY: You mentioned that a better solution may be to have more -- more parameters recorded on the flight data recorder. Do you have any suggestions for what those additional parameters might be beyond the lists that are established in I believe it's the '97 final rule? We don't have to read the whole list, but are there things that are in the list that are lacking that you believe should be added?

CAPTAIN COX: Like any investigator, the more objective data that we can get, to some degree, the better. And I realize that in the new data bus airplanes that we can tap into a large number of parameters pretty easily.

We supported, and I personally supported, then NTSB Chairman Hall's support for enhanced flight data recorders to understand flight control movements, and I think that that is important. We have seen the benefits of those in subsequent major accident investigations. I think an understanding of -- of autoflight systems in the increasingly complex fly-by-wire aircraft that are in our future is essential.

So I think that we've -- we've got a good challenge, and I think that it is being met with the new generation of digital flight data recorders in that they have increased their sampling rate along with the enhanced parameters. So I guess initially I would -- I would refer you to the upcoming airplanes with the 1000-plus parameters. That's a good start.

MR. BRAZY: In the -- in the list for the final rule, the highest number of parameters and how you count is a little bit different left and right. Is that -- two separate parameters. But it's 88 parameters, is the list -- the number of parameters that are required for newly manufactured airplanes built after August 19th, 2002.

For airplanes that are manufactured prior to that time, the list is much shorter. The next list for airplanes manufactured after August 18, 2000, goes down to 57, and after -- between '91 and 2000, it goes down to 34. Those lists as we go backwards in time for airplanes being older and older and older are providing less and less information than the new 1000-parameter airplanes that are out there today.

Do you feel that retrofitting those older airplanes, which will probably be in service for quite some time now, to augment the flight data recorders is a better or maybe less expensive or easier alternative to putting an ancillary image recorder in transport category airplanes?

Sorry. That was a long question.

CAPTAIN COX: I think it would be a better use of our very precious air safety dollar because I think it would give us the objective data that the investigators in the field could best use. I would like to see the older legacy airplanes brought forward with increased parameters first.

If you go back even to, say, the United 585 accident of some years ago, that was, I think, a five- or seven-parameter recorder. We've come a long way, but it's a stepping stone along a much further -- a much longer journey as we get the data that we need for the investigators off the airplanes.

The success of objective data is proven. We've seen accident rates decrease, and part of it is because of the ability to use this type of objective data proactively through FOQA and so that we can then tailor training or determine specific issues that airplanes are having, design problems or maintenance problems or whatever it is. We can use those proactively. So the more enhanced parameters we have, the better use of that objective data we're going to be -- we're going to have.

MR. BRAZY: My last -- I'm sorry. The last question that I have is, do you see any benefit in the use of video recorders in terms of showing the data that's presented to the crew versus the data that's recorded on the flight data recorder?

Mr. Smart indicated in several examples that the data that goes to the flight data recorder and the data that gets presented on the instrumentation in the cockpit may not necessarily come from the same place, number one, and due to some malfunction or something going wrong with the airplane, may be different. There may be a different presentation to the crew than is what -- than what is captured by the flight data recorder.

Do you see any benefit of video in capturing that potential discrepancy in a hypothetical accident investigation?

CAPTAIN COX: Early on in the electronic flight instrument airplanes, the class airplanes, there was concern about the displays to the crews because we were going to lose the old steam gauge slap marks where the needle would actually hit and contact the back of a gauge. And we were going to lose that, and there was concern if we were going to be losing data. And technology has once again served us well in that, with the increased parameters, we're getting the data that the old slap marks used to get. We're just now getting it electronically.

So I personally am unaware of a case where there is serious discussion about what the pilots were being shown as opposed to what the flight data recorder was being shown in the newer generation airplanes. I think the technology has grown so that we can get accurate information into the flight data recorder and once again be able to use that not only for an accident investigation but proactively.

MR. BRAZY: Those are all the questions I have for this witness. Thank you.

CHAIRMAN CARMODY: We'll move, then, to the parties, and we'll start with the FAA.

Mr. Wallace.

MR. WALLACE: Thank you, Madam Chairman.

Captain Cox, your concerns expressed are focused on the -- on the usefulness of the image recorder primarily, and I haven't heard you address the protection issue, which, although there's sort of another panel on that, I did note that -- that Mr. Smart discussed the sort of three key encryption system.

What is your position on -- let's assume that the consensus is reached and the rule goes out and we have image recorders in airliners become a fact. What would you view as a suitable encryption or protection?

CAPTAIN COX: The protection issues, I think, are probably best going to be addressed by Mr. Jim Johnson from ALPA tomorrow. He's our resident expert, and I would defer to his expertise.

But I think that the tragic events of December of 1995 in Cali, Colombia, show that the best intended legislation cannot protect in all cases a flight -- a cockpit voice recorder in a foreign country. I think the recognition of the difficulty that the ICAO has had getting its member states to agree on even the simplest things such as ATC phraseology indicate that trying to get a common worldwide standard for the protection of CVRs or, even worse, CIRs makes it unlikely, in my view, that that would occur.

So once the airplane leaves the 12-mile limit and becomes an international airplane, I have serious concerns about the capability to keep it off the Internet or, worse, to have it exposed inappropriately.

MR. WALLACE: Nothing further.

CHAIRMAN CARMODY: All right. Let me move now to ALPA, and then we'll come back to the RAA and the ATA.

Captain Fenwick, any questions for Captain Cox?

CAPTAIN FENWICK: Yes, ma'am.

Captain Cox, could you explain for us, please, the -- the linkage between the FOQA data obtained from a routine flight or, should we say thousands of routine flights, and how that connects to accidents or prevented accidents?

CAPTAIN COX: Yes, sir. FOQA data is extracted, usually, through a secondary recorder just before the flight data recorder. So it's the same actual data that's being evaluated. It's then put through and scrubbed through a complex system that evaluates excursions or exceedances that are preset by an individual airline. Each individual airline's culture is a bit different, so those exceedances need to be customized.

But out of that, you can then focus training real-time to your particular airline so that you're addressing what's actually occurring and it's no longer a best guess of what pilots need. You can see it and you can tailor an emphasis program for your particular airline and prevent the problems that you're seeing as a result of the FOQA program. It's a real-time ability to understand what's going on at your airline day in, day out.

CAPTAIN FENWICK: Could you give us an example from your carrier or through your experience where a fairly shall we say egregious or high-risk practice has been curbed through the use of FOQA data?

CAPTAIN COX: I think every airline that operates modern jet airplanes has an issue with high, hot approaches, airplanes that are higher than they should be and faster than they should be when they arrive close to the runway. This is particularly important and significant -- at airports with significant terrain issues or short runways.

That can be a focus that comes up -- and it certainly occurred at my airline and it certainly occurred at every other airline that I'm aware of -- is, if you start to see a slow increase in the number of high, hot approaches, it will become a focus item at the next training syllabus or next training opportunity, and the number will turn back down.

Then, the capability of a flap overspeed. If we're seeing a number of flap overspeeds, that will become an area of focus.

Those are just two examples, and what you see is, once the training is adjusted, the problem diminishes. So it's -- it's tailormaking your training to your individual --

CAPTAIN FENWICK: Thank you. Switching gears for a minute, Captain Cox, could you comment on the rationale behind the NTSB's recommendations that circuit breakers for a variety of -- a variety of recorders, including the proposed image recorder, be inaccessible to the cockpit?

CHAIRMAN CARMODY: I'm sorry. Could you repeat the question? I just didn't hear it all. Thank you.

CAPTAIN FENWICK: Yes, ma'am. I asked if

Captain Cox could give us some comments or his opinion on the rationale behind the recommendation that the circuit breakers be made inaccessible.

CAPTAIN COX: One of the scariest things to me that there is in aviation is an in-flight fire. I cannot think of anything immediately that would cause me more concern for my crew or my passengers. The inability to isolate a potentially troublesome electrical circuit causes me concern.

The idea that that will prevent the recorder from being disabled fails in my mind because an image recorder can be disabled with a piece of tape or a spot of paint or any -- there are several means to disable it, and a voice recorder, same way. It can be muffled, it can be closed off. If you choose to -- to be involved in an intentional, a deliberate, or criminal act, the fact that you don't have a circuit breaker recorder is not -- is no deterrent.

So I think in the overall balance of risk we risk the in-flight fire capability or in-flight fire problem without an ability to disable it and we don't gain very much because there are other means to disable these recorders.

CAPTAIN FENWICK: Thank you.

With regard to the SilkAir and the EgyptAir crashes, the accidents, if you will, that the Board frequently cites in their image recorder recommendations, if you make the assumption that these were intentional flight crew actions, and that has been the investigative authority's conclusion, what difference do you think a CIR, if it had been installed, would have made in these accidents and the safety recommendations, if any, that may have derived from such investigations?

CAPTAIN COX: I don't believe there would have been any difference, particularly with the SilkAir airplane. Once that airplane left Seattle, it to my knowledge never again saw the United States. So it would not have come under a federal aviation regulation requirement, were there to be one, for an image recorder.

Secondarily, as I previously mentioned, an image recorder is very easily defeated, and if someone has taken the time and has the notion to commit such an atrocity, disabling the recorder is going to be just a very small part of it.

In the case of Egypt Air and the controversy that swirled around it, I would have much preferred to have seen objective data so that there would be no controversy about it. The force transducers, that would have answered the question.

But regardless of that, I think that it would not have prevented the accident in any way, to have an image recorder, because of the, as I've mentioned previously, the ease with which they're disabled.

CAPTAIN FENWICK: You mentioned your familiarity with the use of cockpit video cameras within simulators in the flight training environment. Could you give us an estimation of what percentage of all the simulator sessions that the video cameras would be active?

CAPTAIN COX: Less than 25. It's -- it's specifically for -- the loft profiles is normally where we see it, or if we're in procedure development occasionally we'll use it. But on a day in, day out basis, it's not used.

CAPTAIN FENWICK: I understand you've had some experience with cockpit video cameras in the flight test environment. Could you give us an idea as to why the installation of quite complex and sophisticated video cameras might be justified in the flight test environment but would not perhaps be suitable for routine airline operation?

CAPTAIN COX: Sure. The -- in 1995, NTSB in conjunction with FAA, Boeing, ALPA, U.S. Air, conducted a flight test of a 737 to understand the effects of wake vortex that U.S. Air 427 had encountered on September the 8th of 1994. We had seven cameras on that airplane, including internal cockpit cameras. We had an extensive Boeing flight test package on board called PADS. We had flight test engineers on board.

The aircraft was recertified as an experimental airplane, and for a week, we flew up and down the East Coast doing specific tests to get data on the effect of the 727 -- that was the FAA's airplane -- but the wake of that 727 on our 737. There were four pilots, and I was one of the four that flew it.

We had specific needs because the flight -- the test requirements had requirements such as, please put the fin into the wake and nothing else. I can't see the fin. I have no clue where it is. We had a camera mounted on it, on the top of the fin, so that in use with that in conjunction with some help from the folks in the back, we were able to very precisely put the vertical fin into the wake so that the engineers then could extract the data they were looking for.

This is also true on the wing, that we would -- we would precisely walk the wake down the wing to a certain area and hold the airplane there, allowing them to take their readings of the force.

So in that case, we were using visual enhancements to do -- for the purposes of that. And it -- in flight tests, the unexpected -- the opportunity for unexpected events is such that you have enormously complex recording mediums on board. You have specially trained flight test engineers back there, all of this gathering data.

In that type of environment, image recording can be so carefully calibrated that it is of some value, but it was more for external -- what we found was more for the external use, where we could position the airplane for those needed tests, than the image recorders.

Once again, even in that case, in review of that data, I found the audio to be of more value than the video as far as the cockpit itself went.

CAPTAIN FENWICK: Referring to the Swissair 111 accident and the EgyptAir accident, or crash as it were, the -- the Board has suggested that the image recorder would have enabled the early detection -- it would have sensed optically the smoke or fumes within the cockpit.

From your experience as a pilot, what is the best available sensor for smoke and fumes in the cockpit?

CAPTAIN COX:  My nose, sir.
CAPTAIN FENWICK:  And typically, if a pilot smells something out of the ordinary, what are their initial reactions?
CAPTAIN COX:  There's a very quick determination of source:  is it air conditioning pressurization? is it electrical? is it increasing? can you determine the source? is it galley? what is the status of the galley?  Those determinations are made quite quickly so that you can rapidly begin to deal with the in-flight problem.
As I say, an in-flight fire is one of the scariest things that I can imagine, and the possibility of it growing rapidly out of control, as has occurred in some instances, it's very clear crew procedure that there is a diagnostic process underway:  did you -- do you smell that? call back there, find out if there's a problem in the galley; we're going on oxygen.  All of those are clearly defined points in the diagnostic process.
CAPTAIN FENWICK:  Could you remind us how an investigator of this airplane would -- subsequently to a crash, how the investigator might ascertain what the crew was doing?
CAPTAIN COX:  I think it would be very clear,

first, on the cockpit voice recorder, and secondarily, if the airplane started to divert or started to reduce pressure inside the cabin in an effort to evacuate smoke, those would all -- all be shown on the DFDR.

CAPTAIN FENWICK: Thank you. I have no further questions.

CHAIRMAN CARMODY: Thank you.

Mr. David of the Allied Pilots, any questions for the witness?

MR. DAVID: Yes, ma'am.

Captain Cox, sir, are you familiar with a product of the FAA Safer Skies Initiative, the Joint Industry Government Commercial Aviation Safety Team?

CAPTAIN COX: Yes, sir.

MR. DAVID: Were you involved in any of the Commercial Aviation Safety Team activities, and were other safety investigators involved?

CAPTAIN COX: Yes, sir. ALPA has a seat on CAST, and I have filled that seat on numerous occasions.

MR. DAVID: Yes, sir. Are there any CAST safety enhancements resulting from our exhaustive studies of U.S. and international accidents which call for cockpit image recording?

CAPTAIN COX: No, sir. In the review of the

CAST list of desired safety improvements, cockpit image recorders is not included.

MR. DAVID: Thank you, sir.

CHAIRMAN CARMODY: Thank you.

NATA, any questions?

MS. ROSSER: Yes, thank you.

I'll ask a follow-on question with the recommendations. NATA participated in a similar industry group targeted towards making recommendations for the air taxi and general aviation industry. The primary causes of accidents, one of the major issues was human factors, and increased training were some of our recommendations. Were those similar recommendations that came from the CAST?

CAPTAIN COX: Yes, ma'am.

MS. ROSSER: So, would you say, then, that if, as you stated, we have precious safety dollars to spend, and in the case of the small air taxi operator, typically one to two aircraft, 10 or fewer employees, $5 million or less in annual revenue, that there would be better ways for those precious resources to be spent than in the installation of these video recorders? As an example, perhaps sending a pilot to a simulator training environment where today they are not.

CAPTAIN COX: I'm of the opinion that the image recorders -- there are better ways to get the information for the same dollars than image recorders. Objective data, be it some of the new technology parametric data that I think could be installed on the smaller aircraft that you reference.

That -- I would prefer to see us go there on a proactive basis, which is where our focus needs to be, improve pilot training, enhance ground proximity warning systems, those sorts of things, so that we can prevent the accident of the future, is where I believe we should be spending the dollars.

MS. ROSSER: Thank you. No further questions.

CHAIRMAN CARMODY: Thank you.

Air Transport Association. Mr. Barimo.

MR. BARIMO: Yes, one question. Going back to Mr. Smart's statements, he -- he mentioned during his statement that FOQA is valuable in looking at normal, routine operations and not necessarily at abnormal situations.

Let me first say, I'm not an expert accident investigator, but the way I understand it is that there are little breakdowns along the way that eventually link up and get you into an abnormal situation.

So, from the FOQA standpoint, is FOQA

intended to identify those small breakdowns that happen routinely through normal operations and then -- and then drive those back into the safety -- the safety training -- flight training programs, or is it intended to capture the extreme abnormal events?

CAPTAIN COX: FOQA is going to capture it all. They -- the -- one of the benefits of FOQA is that it allows us to look at the smaller incidents earlier and to -- to tailor that information into the training programs.

What it will also do is, the larger, more serious incidents, it will also capture that data, so that we have the opportunity then to take that. And it's not just a major accident, it's anything just short of that. And a major accident is basically the most severe breakdown in the system, but the breakdown that is just one step short of that FOQA will catch. The accident investigation won't, for there was no accident. But this was still a very serious incident.

The FOQA data allows us to utilize the information, the objective data, and learn from it. So it's not only the day-to-day line operations but it's the irregular operations that went bad but didn't end up as a major accident that we get to draw -- to draw from.

So I think Mr. Smart, whom I respect and have known for a number of years, I think he missed the one aspect of the serious incident -- the minor to serious incident that the FOQA data will capture that the accident investigator will never see.

MR. BARIMO: Thank you.

CHAIRMAN CARMODY: And, Mr. Lotterer from the Regional Airline Association.

MR. LOTTERER: No questions. Thank you.

CHAIRMAN CARMODY: All right. Thank you.

Then, I'll move to the Board of Inquiry, and I'll start with Mr. Cash this time.

MR. CASH: No questions.

CHAIRMAN CARMODY: No questions.

Dr. Ellingstad.

DR. ELLINGSTAD: Just a few, Mr. Cox. Are you -- are you in ALPA satisfied with the privacy protections or that they have been resolved with respect to FOQA programs?

CAPTAIN COX: There are always improvements that can be made. We see successful FOQA programs today.

DR. ELLINGSTAD: But on balance, the privacy interests of pilots are well protected?

CAPTAIN COX: On balance, the success of the

FOQA programs indicates that we're not -- we're not seeing privacy issues that have come up so far.

DR. ELLINGSTAD: And the mechanism to -- to accomplish that is primarily through collective bargaining agreements, or -- or is there some other mechanism?

CAPTAIN COX: It -- it varies from carrier to carrier, sir. It can be through the collective bargaining process. It can be through regulation with the FAA. The FAA has taken some very, very positive steps to ensure the proper use of that data. It can be through the recommendations of the NTSB. So it's -- it's a multi-faceted approach.

DR. ELLINGSTAD: Okay. I just wanted to clarify that at least in that area of sharing data that reasonable steps have been taken.

You indicated that you have participated in a number of investigations. How many NTSB-led investigations have you personally participated in?

CAPTAIN COX: Well, I've worked at the Washington office and been a group member on six, and of the field offices, sir, I'm going to estimate something in excess of 25.

DR. ELLINGSTAD: Let me just restrict that to majors.

CAPTAIN COX: Okay.

DR. ELLINGSTAD: Okay. How -- how many CVR groups have you sat on?

CAPTAIN COX: I have not sat on a CVR group.

DR. ELLINGSTAD: Okay. And your exposure to the treatment of CVR data has been -- been through what? Through --

CAPTAIN COX: On --

DR. ELLINGSTAD: -- other contact with your membership?

CAPTAIN COX: No, sir.

DR. ELLINGSTAD: Or in relation to U.S. Air 427?

CAPTAIN COX: On U.S. Air 427, I was asked to review the voice recorder, along with some other people from Systems Group.

DR. ELLINGSTAD: Okay. What other groups have you participated on?

CAPTAIN COX: I've been on Systems, Structures, Air Traffic, Operations, that immediately come to mind.

DR. ELLINGSTAD: Okay. So you have participated -- I think that illustrates fairly -- fairly effectively that there are -- there are a lot of different disciplines that are brought to bear on major accident investigations.

In any of these six investigations that you've participated in, have you been struck that there's a rush to judgment?

CAPTAIN COX: The rush to judgment that we --

DR. ELLINGSTAD: With respect to -- with respect to the investigative activity of any particular group or any particular discipline.

CAPTAIN COX: I would say -- I'd characterize it this way, sir. The rush to judgment is oftentimes in the media for the cause du jour.

DR. ELLINGSTAD: I understand that, but --

CAPTAIN COX: The investigators --

DR. ELLINGSTAD: But as a participant in --

CAPTAIN COX: Yes, sir.

DR. ELLINGSTAD: -- NTSB-led investigations, have you been exposed to that kind of a pressure?

CAPTAIN COX: The -- the professionalism of the NTSB investigators and the other parties to which I have worked with have been very careful to avoid that.

DR. ELLINGSTAD: Thank you.

CHAIRMAN CARMODY: Mr. Battocchi, any questions?

MR. BATTOCCHI: Just a few. I understand you're a proponent of 1000-parameter type recorders.

And if you look at the date of manufacture, there are many in the fleet that don't come up to that standard, many of which have less than 100.

Do you have any sense or prediction or expectation of when the remainder will be at that level of 1000 parameters or more?

CAPTAIN COX: In the commercial fleet, all the aircraft that I'm aware of are going to fly by wire, or certainly data bus airplanes. So as the fleet modernizes, I believe you're going to see an increasing -- you'll certainly see an increasing percentage.

The cost of fuel today is going to make the older generation jets dinosaurs, if you will, and that's going to help, because the data bus airplanes are available -- even the hydromechanical airplanes in the middle '80s. So you're seeing the 737, 300, 400 series airplanes, certainly all the Airbus, and increasingly, the smaller jet type airplanes, using data bus. So I would estimate that over the next 10 years you're going to see certainly the majority, if not the vast majority, of the fleet capable of significant enhancements to the DFDR.

MR. BATTOCCHI: Thank you, Captain Cox.

And during these 10 years, if I understand correctly, you would prefer not to see, as an accident investigator, the additional data that would be provided by a video image recorder?

CAPTAIN COX: I would prefer, sir, to see the money that we would spend on image recorders put forward into enhancing the existing flight data recorders.

MR. BATTOCCHI: And have you or ALPA done any cost studies, formal cost studies, comparing the relative cost of the additional data for -- for data recorders versus image recorders?

CAPTAIN COX: I have not yet seen, sir, the -- an accurate assessment of what data recorders would cost, so we would have no means to do that. We don't have a place to store it.

MR. BATTOCCHI: Okay. So, your opinion that the money would be better spent on data recorders is not supported at this time by any objective data, over a video recorder?

CAPTAIN COX: The questions centers to me more on the objectivity versus subjectivity of the data. That -- that means, in my view, that we would be better served by gaining more objective data to whatever the cost would be, even if the video recorders were less. Then, fine, let's spend that money on gathering the objective data.

MR. BATTOCCHI: Thank you.

CAPTAIN COX: Yes, sir.

CHAIRMAN CARMODY: Mr. MacIntosh.

MR. MacINTOSH: Captain Cox, speaking of objective data and subjective data, you mentioned your doubts toward the image recorder and the nature of interpretation of the image, is that not true?

CAPTAIN COX: Yes, sir.

MR. MacINTOSH: Regarding the cockpit voice recorder, is there subjective data in the transcription of that recorder?

CAPTAIN COX: Yes, sir.

MR. MacINTOSH: How do we combat the -- the inaccuracies of that subjective data? From your experience, from your knowledge of the way our group system works, how do we do that?

CAPTAIN COX: We do that with realizing the limitations of the voice recorder and the ability to tie it to known events, such as timing marks. Also, we take the recognition that the voice recorder provides us one dimension into the cockpit and the flight data recorder provides us another piece of the overall understanding of what went on. The radar data provides another piece.

So you take the mosaic of all of these input

-- of all of this input and you develop a clear understanding of what went on from the time the airplane encountered its difficulty, or before, through the accident sequence.

MR. MacINTOSH: And we do that through the group system, right?

CAPTAIN COX: Yes, sir.

MR. MacINTOSH: What do you see the impediments are to using this same group system to strain the subjective data from an image recorder versus a cockpit voice recorder?

CAPTAIN COX: It has been my experience, sir, based on the training scenarios that I've seen that the audio data has more clarity and provides more significant information than the images do. The images somewhat fall away in their significance, where the audio, you can clearly see when a procedure was started or when it wasn't.

This -- the -- as you turn -- I could give you an example. I was given on a LOFT scenario in an Airbus check ride the case of an on-board fire. The Airbus is a very automated airplane. It's very intense crew work load to rapidly return the airplane in that kind of condition to minimize the time before landing.

As we reviewed the tape, all three of us, the instructor, the first officer, and myself, listened far more intently to the audio portion of it of, yes, I remember you saying that, and I remember thinking this. The video tended not to show what we were doing. It showed periods of inactivity when we weren't inactive at all. And the audio far better captured that.

As the first officer was typing the new information into the flight management system, the way that the cameras were located and -- it appeared that very little was going on, when we were quite, quite busy and the crew work load was quite high. That was captured very well in the audio portion of it. In the video portion, it was misleading.

My concern is there that I would rather, as I say, have the money we have to gain additional objective data, because I have not been -- I have not had a good -- a good feel based on my experiences with the image recorder portion of it.

MR. MacINTOSH: Well, I'd like to pursue just a little bit further this issue of the audio being more valuable. You described training instances where the DVD -- FDR would be a definitive record of a switch being activated. You suggested that a pilot's hand movement toward the switch was of less benefit for the investigation or toward your evaluation of a LOFT scenario.

Hand movements, nonverbal communications, checklist flow by the crew member. Are you saying that you and your organization do not see the benefit in understanding the human factors of the flight deck operation?

CAPTAIN COX: The human factors area, which we have worked so successfully in the recent number of years with some very complex accident investigations, we have always been able to successfully understand what went on based on using the existing technology of CVRs.

My concern centers on the subjectivity of the images and the ease with which an investigation could be misled by that when balanced by additional objective data. I would much rather know that that switch actually activated the system that the pilot asked for, than that his hand was in the general vicinity.

So of the two, I would rather have the objective data.

MR. MacINTOSH: Of the two.

Loss of control accidents. Flight data recorder records a cockpit display. Where do we get the information on the standby instruments?

CAPTAIN COX: The -- it could -- it could be, certainly, a recorded parameter. I'm not aware of it being at this time.

MR. MacINTOSH: They're analog instruments. We're back to the issue of data bus airplanes and non-data bus instruments. How can we interpret what went wrong with Birgen Air, for example, 757, when we only have information from the captain's display?

Are you saying we've got to get all displays put on the FDR? How are we going to evaluate these kinds of scenarios, because these are the accident scenarios. We don't need to look at the normal operation. We're talking about accident scenarios.

CAPTAIN COX: The determination of probable cause for Birgen Air was reached, as I remember. So that the existing technology and the existing data was sufficient to understand what happened to that airplane.

MR. MacINTOSH: There is a probable cause. I would -- I would question -- I would ask you to question the issue of the human factors that went into a three-man cockpit allowing that aircraft to go as far as it did. It's -- it's an issue of understanding what's going on in folks' displays, how that's transmitted into their minds, and the various movements that take place within the cockpit, and we're not able to see those.

Let's drop that subject and go on to flight test airplanes. Why do we put video recorders, image recorders, on flight test airplanes. You were on one. You know the -- you know the issue. Why do we even put them on the airplane?

CAPTAIN COX: In the case of the U.S. Air 427 test, we had specific need to -- to put a specific portion of the airplane in the wake. In other flight test applications, I think that they have found that they're taking data at such a rate to understand the performance of the airplane at the edges and beyond the edges of the envelope, so that it is not uncommon in the flight test environment to have video.

But in that case, the first place that everyone goes is to the objective data, and they have enough of it. They -- you're talking thousands of parameters recorded several times a second in the high telemetry airplanes.

So to compare that to a line operation where we're -- we don't have yet a sufficient number of parameters already being recorded, I'd rather see the dollars spent on the -- getting additional parameters recorded.

MR. MacINTOSH: Okay. Well, you've made your point. Thank you.

CAPTAIN COX: Yes, sir.

CHAIRMAN CARMODY: Thank you, Mr. MacIntosh.

I think that completes our questioning of this witness, but I just want to make an observation or, really, a comment, since I alluded to this in my statement.

You've made the point, Captain Cox, that we did reach probable cause in a number of accidents, and that's true. However, as I said, frequently we were hampered in our investigation. Frequently, investigations took a long time. That equates to investigative time spent and money spent.

And from my point of view, the longer the Board takes to get to probable cause, the less safe it is. I think it's a major frustration of many of us that some of our investigations take as long as they do. We're very thorough and I'm proud of that, but anything we can do to expedite those reasonably I view as a positive.

So I think the fact we've reached probable cause is terrific. I would have hoped that we could have reached some of them faster and with more certainty.

Let me suggest that we take a break now. We were going to have Ms. Gillan come up, but I think I'll ask her to come after lunch. And I would suggest the break be 45 minutes instead of an hour, so we come back at 1:15.

Captain Cox, thank you so much for your testimony and --

CAPTAIN COX: Yes, ma'am.

CHAIRMAN CARMODY: -- taking our questions. We appreciate it.

CAPTAIN COX: Thank you.

(Whereupon, the witness was excused.)

(Whereupon, at 12:30 p.m., on Tuesday, July 27, 2004, the proceedings were adjourned for lunch, to reconvene at 1:15 p.m., the same day.)

A F T E R N O O N   S E S S I O N

1:00 p.m.

CHAIRMAN CARMODY: I'd like to open the hearing again so we can resume.

Excuse me. Could we have --

(Pause)

CHAIRMAN CARMODY: Excuse me. Could the parties take their seats? We'd like to resume.

Mr. Cash, would you call the next witness, please?

MR. CASH: Yes, ma'am. Ms. Gillan from Navy, Sea Control Wing, U.S. Pacific Fleet.

Whereupon,

CONSTANCE GILLAN

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

Testimony of Constance Gillan

MR. CASH: Ms. Gillan, if you would, please state your name, title, place of employment, and a brief statement of your academic and employment qualifications that make you an expert witness today.

DR. GILLAN: My name is Constance Gillan. I work out at Sea Control Wing.

MR. CASH: Maybe if you move the mike closer.

DR. GILLAN: Sorry. Constance Gillan. I work out at Sea Control Wing with the Navy. I've been their education specialist leading in human factors initiatives for the last 15 years, working specifically with S-3 training, but I have worked with other community platforms during that time.

My role today is to introduce some of the initiatives that we've gained from the Naval Air Board's introduction to different initiatives to reduce the Class A mishap rate in naval aviation.

The initial demo of the fleet aircraft were in FOQA for the F-18 and the SH-60 have been instrumental, but what I've been working with for the last seven years is a computer-aided debriefing system in the training environment. So I'm going to talk more about that.

I've got a slide presentation.

MR. CASH: Right. Ms. Gillan has a presentation with -- Evan Byrne will be the main questioner.

CHAIRMAN CARMODY: All right.

(PowerPoint presentation)

DR. GILLAN: So this is just a general slide that shows that we've got a problem in naval aviation with human error. And again, it maintains a rate of about 80 to 85 percent human error. What we're trying to do is reduce that 50 percent by the year '06.

Those stats don't represent combat losses. So, again, a lot of these are done in -- in a training environment, so -- so that's the focus of our goal here.

And what we're trying to do is define better performance criteria and ways to measure it, revise and establish performance standards, and capture and archive best practices.

Next.

These initiatives started with the Sec Nav Office of Safety and Survivability and with the Commander, Air Forces, U.S. Pacific Fleet. Again, they took fleet initiative rather than waiting for the bureaucracy to start some of these initiatives, so we had a head start and, again, a ground swell of a grass roots effort in providing the fleet aviators what they needed and what they wanted to use.

So they've done demo projects with the aircraft, starting in 1997 with the C-130 as a proof of concept, and we've moved that into the simulator environment. So, initially, we had a six-month demo project to give Mr. Healing back here, who was the -- in the Office of Safety and Survivability at that time, but the fleet aviators didn't want to let it go. So we kept the computer-aided debriefing system that I'll show you in a little bit, and we've continued to advance on that concept.

So the use of technology to provide a means of training and operational proactive analysis versus formal task analysis or mishap analysis has been instrumental in moving training to a more scientific approach.

There is a need for advances to measure effectiveness of simulator syllabus and preparing for subsequent aircraft-based events. So we're trying to identify training issues that are not currently systematically evaluated, prioritize, establish, and refine training requirements, and better predict mission performance in the aircraft.

I'm not going to have time to go into a lot of the different initiatives, but we've got contractors that are supporting these research and development initiatives. Helmet Fire, Sim Author, Telden Controls, and Anakappa Sciences.

The use of advanced technology in concert with a more scientific approach to training has provided real-time, detailed feedback to instructors and air crews, so much so that some of this technology, if removed, the students and the instructors feel that they've had a degraded training experience.

The objective evaluation is possible through defined performance criteria that can be captured with a lot of the instrumentation you see in the upper right-hand corner with our CAD system that I'll describe a little bit later.

One of the things that we're trying to focus on is critical thinking skills, and this allows a replication of the event for crew self-assessment. So we're trying to teach them to -- to maintain the type of skills and to gain the type of skills that allows them to practice operational risk management in flight, rather than just as a planning practice.

We're trying to capture and better define underlying systemic problems that lead to mishaps through the routine use of data collection and feedback.

There are also capabilities to identify rates of skill degradation, but we have not routinely collected enough data to -- to make that part of the program to date.

This has -- the use of video recording in the simulator has been so successful that the Safety Center has recommended it for aircraft use in naval aviation.

Prototype computer-aided debriefing system, or as we call it, CADS, and associated performance measurement applications all work in concert to developing a better training program. So we're -- we're still doing a lot of simulator and aircraft R & D, and -- and these sorts of tools are assisting the aviators in becoming better performers.

Next.

Originally, we implemented a VHS image recording, similar to what the commercial airlines were using. We found this to be useful but a cumbersome method of providing feedback, as it did not provide precise marks for what -- what the crew was doing the instructor wanted to provide them during the debrief. So a lot of time-consuming, trying to find the exact point in time and ending time. Where he had to record it and synchronize the time with the simulator or the clock or his watch, made it difficult to use.

So it wasn't used a lot, so we were looking for a better way to do that, and technology allowed us to introduce a digital video recording capability that also provided the rest of the context of the aircraft environment.

Okay. Why digital recording is now used.

Okay. Both the fleet and the training commands have embraced this. There have been issues, but overall -- some of the quotes from the students and instructors:

"Best simulator improvement per dollar spent I've ever seen."

"I didn't realize what actually happened until I saw the CADS replay."

And the third one, "The most I've learned from a single debrief, and that was a good trainer." And this is a very experienced aviator, fleet aviator.

There have never been any requirements to use this device by instructors or students. They use it because it's beneficial.

What's very beneficial about this, as opposed to the VHS recording, is they can digitally mark -- and I'll go into that, but not as much detail as I would if I had more time -- but they can scroll back and identify precursors to events and results of specific actions and inactions in that file.

So they're not only seeing the video and hearing the audio, but they're also getting to see the aircraft aspect and the instrumentation at the same time. So it provides a complete picture of the environment.

So training system efficacy is my main goal here, so improved standardization with the files.

We're able to capture and provide instructor training, increase inter-rater reliability, SOP review. A lot of the files have been brought to the attention of the command for changes in SOPs. To capture the entire context of the incident is very, very important.

Instructor training, cockpit resource management materials. Have provided a bonus in terms of reduction in training dollars. We used to spend about $1000 a minute on videotape demonstrations of CRM, good, bad, indifferent performance. Now we just capture files, deidentify them, and use them in our training, in our computer-aided debriefing system as well as classroom.

They provide exceptional models of best practices and standards that we want our novice aviators to have as models.

This is a screen shot. It doesn't have everything up. There is some pop-up and some advancements that -- that you can't see just on one screen. But this is what I'm talking about, the total context that's available, and the air crew video provides a very strong component of providing that entire capture.

So you can put as many cameras in the simulator as you feel are required. In the S-3, we used to have four crew members, so we had four cameras, one on each crew member. We lost a crew member, but we left the other camera in the back seat. So this just reflects the front-seaters here in the upper right here.

So -- so this tool really enhances the debrief environment and -- and the training system overall. So high-fidelity digital file formats expanded on the crew coordination focus with the integration of additional multivariate data to provide an essence of the experience. A graphic recreation of flight instruments, tactical displays, animations using simulator data. So these are pulled directly from the simulator.

The crew video. Numbers of cameras vary, as I said. You get the 3-D aspect of the aircraft. And all -- again, all this data is being pulled from the simulator.

Flight displays. Varying degrees of resolution there. Performance file markers and moving map. There's nav charts available, and there's analysis displays on the second screen. So I will not go into the data analysis and displays. Again, that's an entirely different subject here. And we've got upgrades that aren't reflected here.

I'm going to show you a demonstration video, and the skipper of the FRS was kind enough to let us use this, because he felt strongly that this was an advantage to training and to capturing what goes on in flight. And again, this is in simulator. It's a pretty benign incident, to protect the aviators in question here. And we had a little trouble redacting it without losing the audio, so you're going to see a little bit of strangeness in the file here as the faces move a little bit.

So they're going to try and pull that up. But this is, again, an IFR departure from NASNI. And it's basically an altitude bust. And what this brings to the table is what -- what are the crew's inactions rather than what are they doing; what aren't they doing at a critical phase of flight and how are they being distracted.

(Video presentation)

DR. GILLAN: Not getting any video -- I mean audio.

(Video presentation)

DR. GILLAN: You can see from the video here that the -- we call them a COTAC -- a naval flight officer, the upper right-hand corner has his head pretty much buried in the PCL.

The pilot, we're not quite sure what he's doing, but we know he's not looking at the flight instruments because he -- he misses the altitude that he had prebriefed. And, is going into Lindbergh field flight path.

I guess the audio is not going to come through on that.

I do have more videos that are a little bit more dynamic and have gross motor movements that show the enhancement that video brings to the table, especially when safety is of concern. We've got some crew member out of position for ejection, which probably would have decapitated him, and we've got some gross motor movements of pilots reaching up for things, claiming that they've turned things on or off, and the instruments do not indicate that, and they land with gear -- gear up.

So there are some very dynamic things that video can bring to the table here, along with all the other data that's available, to provide a complete picture of what's going on.

Okay. These are some of the things -- we've done studies at North Island with the S-3 crews. They've been a great community to work with. And we've -- this came from one study with eight fleet crews, which is just the front-seaters, and eight novice crews. What I've tried to do is figure out some of the metacognitive processes that distinguished the more successful crews from the unsuccessful crews in -- in getting through a novel situation, something that -- that none of the crews had been prepared for in terms of SOPs or training.

So even though I was looking for something that isn't observable, there were lots of actions and lack of actions within the crews in terms of the range of performance that allowed you to assess that these are the factors that -- that provided the best crews with the most successful outcome. So there were either actions or lack of actions at certain points in the scenario, which was about 25 to 30 minutes, that allowed us to differentiate, you know, what made some crews successful or not successful. And they were debriefed for about an hour after the event to try and ferret out some of the critical thinking and cognitive processing that -- that they were doing during these periods of time.

So aircraft control safety. There's a list of things that the video brings to the table in concert with other information that is more useful than not having video.

Next.

These are some of the other areas. Crew positioning, again, for naval aviation, that's critical. Nonverbal communications. If you look at enough files, you see that aviators do a lot of hand talking and gesturing. They don't always respond verbally.

Some of the -- the gross reactions to noise and light. You can see jumping back and inadvertent flip -- flipping of controls. Again, we're working a lot with novice aviators, so you're -- you're getting, you know, the range of activities here that you might not get with more advanced flight crews.

Attitude, supporting behavior. A lot of that is very telling. Again, with audio, voice inflection, tone, stress can be -- can be heard in the voice. So although, you know, we don't scientifically analyze those things, the video alone, the instructors, the students gain a lot from just looking at that component in certain situations. Again, 100 percent of the time it may not be valuable, but it's there if we need it, so we have to collect it.

Again, these are some other issues that the video, again, aspect brings to the table.

So decision-making. A little bit hard to figure out what's going on in somebody's mind as they're making a decision, but you can tell the results of their action or inaction following that. So it provides opportunities to ask questions if the crew is available for that, and to try and figure out how they're thinking so you can change that thinking to make them better aviators.

Pay attention. These are some of the core competencies -- go ahead -- that -- that, again, some of the categorization that we've done in trying to go through the research and the active training that we do. These are some of the areas that -- that we find are critical to focus on, so we've designed a lot of our tools and our human factors training around these areas. And you can see a lot of them lend themselves to the computer-aided debriefing system data that's captured.

Next.

So video combined with other sources obviously is the best way to go, and with our systems, it's a part of the system. So there's no either/or sorts of decisions that need to be made. We want it all and we have it all. We just need to grow into more advanced uses of it.

Again, we have a capability to mark the

digital files, and I'll show you that in a second, record, and then retrieve them and in near real time. It takes them about two minutes to combine all this data and replicate it on a debrief screen in the debrief room.

Again, if you've got a dual engine failure, the data collected, the aircraft control prioritization skills, memory items, PCL usage, the video brings a lot to -- to that sort of incident.

Go ahead.

This is the marking device. You probably can't read it real carefully, but in the left-hand corner there you'll see a scroll down. Those are what instructors normally use as instructor guides. They just take the grade sheets, and there's categories down there in time sequence. So what we have them do is mark files with just a gross category of what the training issue is, and then we move over. And they can do one or all six of these, what's called marks.

And what those do is the digitally mark the file, so when you go back to the debrief you don't have to remember why you marked it. It's not just simply a time stamp. There's actually a category, either a skill or a behavior that -- that's available to the instructor to prompt him or her to remember what happened three hours ago in this particular event.

Again, where -- where the incident occurred in the flight profile; was it on deck, was it during takeoff, departure; and then we have -- you'll see there's eight categories, starting with aircraft control systems knowledge, and it moves across. And systems knowledge is broken down into system or equipment, operating limits, SOPs, weather, procedures, maneuvers.

So anything the instructor feels needs to be talked about as a learning point, either positively or negatively, during the debrief, he can mark digitally on that file and it remains with that file.

We're working on advances to collect this same sort of data during the brief and -- and the debrief so we have the entire evolution of the training event, not just the simulator portion. We found a lot of the learning goes on in the debrief and it's not captured.

So the crew member or crew members that are associated with this event mark -- can also be marked, and then that provides a snapshot of that one single point in time. And when you bring that up during the debrief, you can prescroll, you know, five minutes, three minutes, whatever the instructor feels is pertinent, and see what it -- what events led up to this incident or what events, you know, happened after this incident.

The -- the flight crews liked this so much and they're so engaged in it that even if there isn't time during the debrief, which is pretty short -- 20 to 30 minutes in a lot of cases -- they'll stay after the fact and watch the files.

So, next.

That's it.

So I've got a lot of backup slides, additional slides, and I'll show them if somebody's got interest. So, that's it.

CHAIRMAN CARMODY: Thank you, Ms. Gillan.

We'll go to the Technical Panel now. Dr. Byrne, I believe you're doing the questioning.

DR. BYRNE: Yes, thank you, Madam Chairman Carmody.

Good afternoon, Dr. Gillan.

DR. GILLAN: Good afternoon.

DR. BYRNE: I'd like to elaborate on or amplify some of the points that you brought up in your presentation, and if you could start with restating what the primary purpose was for collecting video in the training environment?

DR. GILLAN: It was to be part of a program to reduce the mishap rate in naval aviation.

DR. BYRNE: What was the -- was there a particular crew behavior or crew dynamic that was the goal that -- that video was the medium used to capture?

DR. GILLAN: They were just looking at crew coordination initially, but we found that the value of -- of the tool was such that everything was captured: mission performance tactics, skill-based errors, and eventually naval aviation caught up and saw that skill-based errors were just as much of a problem as crew coordination-type errors. And so the data's all there. It's just a matter of focus.

DR. BYRNE: And how effective is video in the simulator a tool to be able to identify these skill-based errors?

DR. GILLAN: You'd probably be better off asking the instructors, but in general, you know, they all say that it's a valuable component of the system.

DR. BYRNE: And I understand correctly, the video is used in a debrief -- primarily for debriefing purposes?

DR. GILLAN: Yes.

DR. BYRNE: Who's involved in those debriefs?

DR. GILLAN: The instructor and whatever crew is available for that event, either what we call FRS, the Fleet Replacement Squadron, where they're doing the initial training for an aircraft, or the fleet crews, after they've been in the fleet, come back for current training. And again, this is voluntary use. If they didn't think it was valuable, they wouldn't use it. It's the Navy, so things end up in the closet a lot. This has not.

Again, there's no dictate to use it by the commanding officer or anybody else in the Navy. It was done as a demo project. We were the initial site, but it has grown to, I think, about -- well, every platform on the -- on the Air Pac side, which is about 50 simulators. So it's not in every simulator, but it's going into every type model series on the -- on the West Coast, and all new simulators will have this sort of capability. They're not always called CADS, but the same capability is going in all new simulators.

DR. BYRNE: Is this technology used in -- for basic training as well as recurrent training?

DR. GILLAN: Yes. It's also used in the training command down in Pensacola.

DR. BYRNE: Okay. Captain Cox this morning testified that he had experienced problems using video in debriefings, that the audio was more valuable than the video was. Has the Navy experienced similar problems?

DR. GILLAN: Well, we don't have to say we want one or the other. The audio generally brings more to the table than the video, but you never know what the situation is going to be, so you have to capture everything.

DR. BYRNE: And as far as the number of cameras involved, is it standard, or how many cameras are you using? You said, I guess, originally there were four crew stations?

DR. GILLAN: Right.

DR. BYRNE: Now down to --

DR. GILLAN: We still maintain the same cameras that we use for the VHS recording, same cameras. We added some infrared lighting panels to help with the -- with the -- we used to have to leave the lights on, so that hurt us during the night events. So we've just become more sophisticated in the technology that's available.

DR. BYRNE: Are the images recorded or captured with the cameras only over the shoulder or wide-area views of the crew?

DR. GILLAN: Yeah. They -- they were set up for crew coordination and they were left that way. In some of the other platforms, they are focused on the instrument panel. You can see some of the instrument panel in the S-3. You can see the master caution light. But -- but the very discrete instruments, no.

DR. BYRNE: Why -- why was the decision made not to include the instrument panel in the S-3 platform as compared to the others?

DR. GILLAN: Our -- our CADS system provides that data for us, as you saw. We're limited to screen size and we're limited to the depth of the number of pop-ups available, distract the instructor and the crew. So what they do is they settle on the types of instruments that are normally valuable for debriefing. And again, it's -- it's a cost factor. You can get whatever you want if you're willing to pay for it.

But simple is better in this tool, we've found, so limiting the flight instrumentation. We are collecting data in the background in our analysis program, about 100 parameters. So we can go back and retrospectively look for other data and see -- see what we want with that.

DR. BYRNE: And I guess in terms -- you mentioned that there was some plan for using video in aircraft routine operational use. Would you elaborate on that?

DR. GILLAN: The -- the DOD is just getting off the ground with a new group. The Navy and the Air Force and the Army and the Coast Guard have been working separately towards initiatives like the commercial airlines. We call it -- we just put a "Military" in front of the FOQA, MFOQA. And so they're just getting off the ground in determining policies and equipment.

And knowing that I was coming here, I asked the group, which I'm a member of one of the working committees in the technology and safety, you know, what -- what was their stand on -- on use of videos. And they said that they hadn't purchased any cameras in the big picture but it was recommended by the Safety Center that that become part of the program. So that's the Navy's stand. DOD-wide, I'm not sure they're there yet.

DR. BYRNE: And how long have you personally been involved in using video in -- in training?

DR. GILLAN: Well, regular videotapes for -- for, you know, quite some time, but -- but the -- but the digital aspect, about seven years we've had the computer-aided debriefing system.

DR. BYRNE: And that's the -- the CADS system?

DR. GILLAN: Yes.

DR. BYRNE: What changes would you make or are you contemplating making to improve the effectiveness of that system in terms of number of cameras used so that you can accurately document both what activities are going on in that cockpit as well as what the crew is not doing?

DR. GILLAN: Well, in the S-3 community, it's -- you know, we're kind of being cut off at the knees because our platform is going away. So we have no more funding to even deliberate on -- on additions at this point.

But other platforms get, you know, groups together of the instructors and -- and the human factors specialists and determine for that platform, for the missions, for the issues that they have to deal with, how many cameras are viable and -- and how many they need. So we're working with a simulator. They usually can just screw them in in a few minutes.

DR. BYRNE: When you were talking about the list of events or behaviors that could be captured using video imagery, do you have any specific examples of any instances where a specific event was captured on an image recorder but it was not captured through audio or the performance characteristics of the airplane?

DR. GILLAN: So, you mean just the image itself was the outstanding feature of --

DR. BYRNE: Yes.

DR. GILLAN: -- an incident?

DR. BYRNE: That was the only way that the event became known to the instructors.

DR. GILLAN: Yeah, we have a lot of issues of nonverbal communications. There are nonstandard manners of going through checklists. In our community, we require verbal responses, so we've got examples of pilots just nodding their head or, you know, hands up signals or, you know. So if something were to occur, you would not necessarily know that a pilot was in concurrence with something.

There's -- again, in preparing for this, we just went to the file server and started going through files, and -- and my best guess is, you know, at least half of them have something that the video enhances in terms of a learning point or constructing an event and what led up to it or, you know, what it led to.

DR. BYRNE: My last question, Dr. Gillan. Could you summarize what the greatest value of image recording is in your particular application?

DR. GILLAN: I think it provides, again, the benefit of the experiences of those air crews to other air crews without having to live through it. It also provides models of excellence and standards, again, for novice air crews by, you know, senior air crews, normally, and saves a lot of rehashing of the same lessons learned.

The instructors that -- that are proponents of this, a lot of them are former commercial airline pilots that have come back to us as contract instructors, so they value all this additional information. Through their wisdom and experience they've figured out that, you know, they were afraid of this technology to begin with, but now they're our greatest proponents, because they're the ones that have to repeat the lessons learned over and over again to the students.

And now, with these models and with the realism of the -- of the experience put in front of the students, the "ahas" are there. There is no long discourses or arguments about who did what when. It's on the file.

So it's been very beneficial, and again, it's adding to our ability to predict performance in the long run, which is the key.

DR. BYRNE: Thank you, Dr. Gillan.

Chairman Carmody, I have no further

questions.

CHAIRMAN CARMODY: Thank you.

Moving now to the parties, let's start with the Air Transport Association.

Mr. Barimo, any questions for the witness?

MR. BARIMO: No, no questions from us. Thank you.

CHAIRMAN CARMODY: How about the Regional Airline Association?

MR. LOTTERER: No questions, thank you.

CHAIRMAN CARMODY: All right. Mr. Wallace of the FAA?

MR. WALLACE: Just a few questions, Madam Chairman.

Was that video we saw sort of a reasonable representation of what you usually see?

DR. GILLAN: Yes.

MR. WALLACE: I mean, I frankly found it a little difficult to follow, and --

DR. GILLAN: Well, it had been tried to be redacted, and that's why it wasn't -- got some -- some simple screen shots. And I can show you off the record some files I've got with me.

MR. WALLACE: Okay.

DR. GILLAN: But for public broadcast

purposes --

MR. WALLACE: I'm not sure that sort of the room conditions or whatever are --

DR. GILLAN: Yeah.

MR. WALLACE: And this is sort of a standard VHS recording?

DR. GILLAN: Well, it's digital recording.

MR. WALLACE: Uh-huh. And is that -- do you know --

DR. GILLAN: It looks similar to the -- to the --

MR. WALLACE: And so, is it about -- I mean, I understand VHS is on the order of maybe 20, 30 frames per second. Is that probably what that is?

DR. GILLAN: I'm not sure what the digital is.

MR. WALLACE: Because of the specifications for image recorders developed in Europe are for no more than four images per second, I think.

And this is through -- through four separate cameras that were -- you were filming there?

DR. GILLAN: Well, the one you saw was two cameras, one on the pilot, one on the NFO.

MR. WALLACE: Right. Okay.

DR. GILLAN: But you can have as many cameras focused on whatever. Some of the Hornet community people want the cameras, you know, focused on the hud and more of the instrumentation because it's very difficult to replicate. These were graphic images that are -- you know, you've got a digital picture of an instrument panel display, and then -- and then that's designed so that the data forces that to move the needle.

MR. WALLACE: In conjunction with this use in simulators for training, are you putting videos on training aircraft as well? Have you started to do that?

DR. GILLAN: There -- there -- again, that's the MFOQA effort, and that's a separate effort. It's not going on where I am right now. Not in -- in the S-3 community.

MR. WALLACE: Okay. Nothing further. Thank you.

CHAIRMAN CARMODY: Thank you, Mr. Wallace.

Captain Fenwick of ALPA, any questions for the witness?

CAPTAIN FENWICK: Dr. Gillan, with your background as an educator and a human performance expert, does observing behavior explain it or the reasons behind it?

DR. GILLAN: No.

CAPTAIN FENWICK: With regard to the -- the CADS system which is in operation now in your training environment, how crucial is the presence of a crew, in this case a live crew, in resolving with the instructor and amongst themselves the various coordination and communications issues that are observed during a session?

DR. GILLAN: I'm not sure I understand what --

CAPTAIN FENWICK: If -- if we were to show the video of a training session to, perhaps, just an independent observer, would it all become clear to that particular person, assuming they were an expert in that airplane and the operational environment, or is it -- is it necessary to actually have the crew participate along with the original instructor who observed the session to get a full understanding of what it was that exactly -- what was going on in the cockpit at that time?

DR. GILLAN: Well, not necessarily in the cockpit, maybe, but in the minds of the air crew. You'd need to ask them some questions, you know: what were you thinking now or, you know, what were you thinking of acting on, et cetera.

But again, we usually -- if we have an issue with a performance, more than one instructor will look at it.

CAPTAIN FENWICK: Okay. And in terms of the extension of the video capability to actual line airplanes, is it your understanding that this capability will be used for training flights or line operations, combat missions? What -- what realm would this tool be used for?

DR. GILLAN: Again, right now, for military use it's restricted to demonstration projects. Again, retrofitting a naval aircraft that has to land on carriers with additional equipment is a huge investment.

CHAIRMAN CARMODY: Excuse me, Ms. Gillan? Ms. Gillan, please speak into your microphone.

DR. GILLAN: I'm sorry.

CHAIRMAN CARMODY: I'm missing some of what you're saying. Thank you.

DR. GILLAN: I'm just aware of the demonstration nature of where they want to go with this, so any plans for outfitting for operational or just training is beyond what I know at this point.

CAPTAIN FENWICK: Thank you.

CHAIRMAN CARMODY: Mr. David with the Allied

Pilots.

MR. DAVID: Yes, ma'am. I have several questions.

The failure of the student to have the proper ejection preparation out of one of your videos, is that really a valid conclusion when the aviator knows he can eject from a simulator and he knows that he can't be hurt in any manner from the simulator?

DR. GILLAN: Well, people have been hurt ejecting, and -- and what we're trying to prevent is bad habit patterns. So we've got people in the right seat that are trained to -- to back up the pilot, and sometimes they lean over to look at -- I'm sorry, lean over to look at a couple of instruments when they should be trained to keep their position for ejection at all times during critical, you know -- especially.

So it's bad habit patterns that can be picked up in video. And sometimes you won't see anything in a single video, but over time, if you keep track of the same student or crews, you can pick up, you know, bad habit patterns. So that's what we're trying to capture before they become mishaps or incidents in the aircraft.

So I'm not sure if that -- that answers your question.

MR. DAVID: I believe so. So, you think that they're all -- the student is always going to be cognizant of ejecting from the simulator?

DR. GILLAN: If they want to stay alive, yes.

MR. DAVID: Okay. Interesting.

Do you have any experience with the current aircraft shoulder-mounted cameras which are in fleet aircraft at this stage right now?

DR. GILLAN: No.

MR. DAVID: You don't, okay.

Isn't this more of a tool applicable to rag students than a fleet operational aviator?

DR. GILLAN: Well, the fleet operational aviators come over and use it routinely for advanced training for their recurrent training, so they have found it very valuable. I think any level of training would find this valuable.

MR. DAVID: It hasn't been found valuable in the operational sense, only the training sense, is that --

DR. GILLAN: Right.

MR. DAVID: -- your statement?

Finally, in the video you showed up there, do you think the instructor really needs video to debrief that? He set up that student with a known failure in a known scenario to take off. He's given him the failure at a time when he knows that he should be concentrating on another task in the cockpit and he knows what the NFO's going to do and he knows what the pilot's going to do. What is he going to gain from the video that he doesn't already know is going to happen?

DR. GILLAN: What it shows, the crews -- and again, these are crews that are just coming together for the first time. The -- the flight officers are trained separately than the pilots, so this is the first time -- and again, that's where crew coordination is -- is so critical here, in that the trigger here was an abnormal situation. And the crews are trained to get the aircraft into a safe altitude before they start handling these.

So in jumping the gun and forcing his head into the PCL, the right-seater does not back up the pilot. The pilot is losing SA somehow, we're not quite sure how. But he's not watching his altitude, so he busts his altitude.

MR. DAVID: Yes, ma'am. I understand that, having done that scenario many times. What is he gaining from looking at it in the video that he's not going to gain --

DR. GILLAN: It's reinforcing generally,

especially the right-seater, to scan once in a while while he's reading off the PCL procedures, to take his head out of the book. They become very, very -- they prioritize that above everything else, including safety of flight.

CHAIRMAN CARMODY: Is that it, Mr. David?

MR. DAVID: That's it. Thank you.

CHAIRMAN CARMODY: Yes. All right. Thank you.

Ms. Rosser, any questions?

MS. ROSSER: No questions at this time, ma'am.

CHAIRMAN CARMODY: All right. Thank you.

We'll move, then, to the -- to the Board of Inquiry. Mr. MacIntosh will start.

MR. MacINTOSH: (Off mike) -- how about criticism of the system. Specifically, have you heard persons say, "I don't want to see this thing"? Have you heard instructors who say, "I don't need it. It's not working today, that's fine"? In other words, that kind of negative side of -- of this approach.

DR. GILLAN: Yes. And we expected a lot more when we initially introduced this. We were waiting for the cultural shock. Nobody, you know, likes to be videotaped at work.

But what we found was that that kind of was shoved to the side when they saw the advantages of using the system. So, obviously, we've had students go back in and try to erase their performance if they felt it was going to be kept on file, so we have issues that come up every once in a while like that.

Instructors -- again, it's additional work load for them to use this system, so there's some hesitance there. But when the students are demanding they use it, they learn how to use it and -- and are probably better instructors for it. So it's kind of self-reinforcing in using a system like this.

Originally, we put it in -- we've had socks over microphones, jackets over cameras, but you know, with a generation that has MTV and their whole life on the Web cam, it's becoming less and less of an issue in being recorded. So the senior aviators had, you know, more issues with it than the young kids coming in now.

We've had incidences of -- of them doing things in the simulator where they knew they were being videotaped and -- and you'd be horrified at some of the things that went on that they just don't care. I mean, it becomes secondary in the background.

But it is additional work load for the instructor initially.

MR. MacINTOSH: Speaking of instructors, would you -- could you opine at all about whether there are some instructors that have an overreliance on such a system to the deference of -- of good observation techniques, listening, and debriefing?

DR. GILLAN: Yes, there -- there are some issues, and especially in the S-3 community. Some communities get more support at the simulator console, so they'll have contractors sitting with them or more instructors, if they're from a larger-crew aircraft. So they become one-arm paper hangers. They're having to observe the crew, make marks on -- on the CADS device, as well as sometimes make -- make notes.

So it is a very difficult multitasking situation for the instructor, but again, they feel it's useful. They are not forced to use it. So as they gain experience in using it, it becomes second nature. The problem becomes if they're totally dependent on it and aren't taking any notes and something goes wrong with the electronics, you know, they're back to square one.

So -- but that happens very infrequently. It's got a pretty good reliability rate. It's over 95 percent, so that has --

MR. MacINTOSH: Very enlightening. Thank

you.

CHAIRMAN CARMODY: Mr. Battocchi?

MR. BATTOCCHI: Thank you. No questions.

MR. CASH: I just have one.

In response to one of the questions Evan asked you, you said half of the -- you queried your server for half of the -- and you stated that half of the -- these scenarios, I guess, had something to be gained by video. How many is that?

DR. GILLAN: Well, we looked just what was currently on the server, and that was about 30 or 40 files.

MR. CASH: I mean, how many training environments -- I mean, how many simulator sections?

DR. GILLAN: Those are 30 or 40 events, three hours in length, normally. And we -- what we do is we just -- we don't save every training evolution, only the ones that are -- are useful for either applying to what we call our goal standards, where we're able to reuse those in a classroom environment as models of performance, or there's issues there that are useful for learning points that are not models of performance but, you know, "Don't do this" sorts of issues.

Those are -- are captured and reduced to just the few minutes or seconds that that portion of the file is valuable for, and it's deidentified and put in a secure server room and used as the command sees fit, so that the files don't leave the command. There's not a lot of privacy issues that come up.

Again, we've got a captured audience in the Navy, so -- so those issues don't come up as much as they might in another organization.

MR. CASH: Can you make some assessment on how much -- how many times it's useful? I mean, in half of all simulator sessions is there something, or --

DR. GILLAN: We've never really done a study on that or tried to define that, because it's just become a common component of what is part of the debrief now and what is expected to be part of the debrief. So -- so in trying to force the issue and say, well, we -- we think audio is more valuable than video, or the instrumentations are more valuable, or the parameters are more valuable, we see it all in context. So we have never tried to devise what percentage is useful.

MR. CASH: Okay. No more questions.

CHAIRMAN CARMODY: All right. Thank you.

Ms. Gillan, thank you so much for your testimony and for answering our questions. The witness is excused.

(Whereupon, the witness was excused.)

CHAIRMAN CARMODY: And, Mr. Cash?

MR. CASH: The next witness is Ron Swanda from the General Aviation Manufacturers Association.

Whereupon,

RON SWANDA

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

Testimony of Ron Swanda

MR. CASH: Mr. Swanda, would you please state your name and title and affiliation for the record and any brief academic and -- and experience?

MR. SWANDA: Okay. I'm Ron Swanda, the senior vice president of operations with the General Aviation Manufacturers Association. I've worked there for approximately 22 years. I was an Air Force cargo transport pilot prior to that time. I flew C-130s for about 11 years.

I have an MBA in Aviation from Embry Riddle Aeronautical University and a bachelor's degree in Psychology from the University of Nebraska.

MR. CASH: Thank you.

And Dr. Bruce will be the main questioner.

DR. BRUCE: Ron, good afternoon. You and I have considered a list of accidents involving turbine-powered aircraft. These would be the fixed-wing and rotocraft aircraft that we would be recommending for Type C video recorders. That's defined in the EUROCAE video spec that's Exhibit 7.

That accident data for Part 135 and Part 91 operations is included as Exhibit 3. The list captures the aircraft that, for the most part, do not have any type of data recording devices.

Would you review for the record how we developed that list?

MR. SWANDA: Yes. That list excludes aircraft that are in commercial Part 121 operations and any of the large commercial aircraft that were operating under Part 91 when the accident occurred, such as repositioning operations. It also excludes any restricted and experimental category aircraft.

DR. BRUCE: So, from 1983 to 2003, how many turbine-powered aircraft were involved in accidents?

MR. SWANDA: That's about a little less than 3000, I guess, 2966.

DR. BRUCE: And how many of those involved fatalities? Well, not accidents. How many fatalities were in that group?

MR. SWANDA: In that entire period, 21 years, there were 754 fatalities, which averages about three dozen a year.

DR. BRUCE: And what would be the leading cause of those accidents?

MR. SWANDA: Person-related causes were cited in about 90 percent of those accidents. Environmental causes were cited in 47 percent, and aircraft-related causes were associated with 38 percent of the accidents. That totaled more than 100 -- these totaled more than 100 percent because one cause can be -- more than one cause can be cited for an accident.

DR. BRUCE: I just -- we're saying 90 percent of those have human factors-related causes. Earlier today, the Navy had used a number of 80 percent. So it's pretty clear that's the type of accident that we're trying to get to.

I want to switch a moment from discussing the accidents and talk about the fleet of aircraft. What's the fleet size of turbine-powered aircraft that are candidates for the video recorders?

MR. SWANDA: The latest data we have, 2002, estimates that turbine-powered aircraft in general aviation and air taxi operations was 18,639. That's an estimate, unfortunately, and the last census -- full census was completed in 1994.

DR. BRUCE: So that's an estimate. Where does it come from?

MR. SWANDA: It comes from the FAA's General Aviation Activity and Avionics Survey, which is performed on an annual basis.

DR. BRUCE: And that's a 2002 number. Is there a 2003 number?

MR. SWANDA: No, we do not have 2003 data. In fact, the 2003 data has not -- the survey has not even been mailed to the sample selected for the survey yet.

DR. BRUCE: And so, we would need that information in order to calculate the cost of equipping the fleet. What do you see as the limitations in that data when we try to do that?

MR. SWANDA: Any time you survey a population using sampling methodology, the subsets have a greater degree of variability in the -- the estimate than the overall. So I -- I have relative confidence in the overall fleet of all general aviation aircraft. Every time you take a cut at it, such as turbine aircraft or turbine-powered aircraft or airplanes, the average error of that estimate becomes much larger.

And in -- in fact, due to some problems with the sampling process used in prior years, we saw some of those estimates for the subcategories going as high as 50 percent.

DR. BRUCE: Thank you, Chairman Carmody.

Thank you, Ron.

CHAIRMAN CARMODY: Thank you, Dr. Bruce.

We'll start with the FAA. Mr. Wallace, any questions for the witness?

MR. WALLACE: Do your -- do companies that GAMA represents support the recommendations for small turbine aircraft?

MR. SWANDA: Well, that's a very good question. I'm glad you asked me that question. We did survey all of our companies prior to this hearing, and we are not aware of any company that makes a video recorder capable of withstanding the crash forces that are typically encountered by a small airplane.

Therefore, GAMA cannot provide an appropriate cost for such equipment, nor can we speak precisely to its potential effectiveness.

Additionally, in most cases, off-the-shelf video equipment could not be expected to reliably provide post-crash information useful to meet accident investigations. Under no circumstances do we foresee a video recorder substituting for an FDR or CVR.

For some accident investigations where a CVR and/or FDR is not installed, the information provided by a crash-survivable video recorder might be useful. GAMA does not believe, however, that the benefits of installing such recorders on small aircraft currently justify the cost.

Operator investments in aircraft safety equipment are much better justified in equipment that directly contributes to safety, not in equipment that only enhances post-accident investigations.

GAMA does not believe that government research into -- GAMA does believe, however, that research into the -- into ways of removing the technical barriers for these types of equipment does make sense. And that would include determining the appropriate standards that the FAA could use to certify such equipment. Once these road blocks are removed, the FAA could move quickly, I think. GAMA manufacturers would consider production as well.

However, GAMA does -- doubts that the benefits of such equipment when compared to even the lowest estimated cost will ever justify a mandate.

MR. WALLACE: I'd like to assure everyone in the room I wasn't asked to ask that question. I just asked it.

(Laughter)

MR. WALLACE: Do you distinguish between your customers who are Part 121, Part -- primarily Part 135, and Part 91 operators as -- as to issues regarding the acceptance? Recorders have typically been something we've seen in the commercial environment, yet this current set of recommendations takes us purely into the absolute private use environment as well.

MR. SWANDA: As I understand your question, yes, we do acknowledge that there is a difference among our -- ways our products are used in the fleet for commercial and noncommercial operations. However, the companies that we represent or the parts of the companies that we represent do not manufacture products for the Part 121 operations.

They do make the products, I should say, but we do not represent that part of that company. We strictly represent the general aviation side of those companies.

For example, avionics manufacturers may make avionics installed across the board. However, our interest is merely in the general aviation application of those products.

Did I answer your question?

MR. WALLACE: Well, yes, but just to clarify, I'll ask a slightly narrower question. Do you see different sort of use and privacy issues if -- if we find these recorders entering into the pure Part 91 private use, you know, Pilatus, taking the family to the Bahamas for the weekend type of operation?

MR. SWANDA: Yes, I'm sure there are differences in privacy issues, but the question that probably is more appropriate is, is there an appropriate -- who decides what degree of privacy. If it is the individual pilot flying for noncommercial purposes, they certainly have every right to make the decision. However, for commercial operations, the government has a role in determining what is appropriate.

MR. WALLACE: All right. Thank you.

CHAIRMAN CARMODY: All right. Thank you, Mr. Wallace.

Mr. Barimo of the Air Transport Association.

MR. BARIMO: No questions.

CHAIRMAN CARMODY: All right. Mr. Lotterer, Regional Airlines?

MR. LOTTERER: Thank you.

Mr. Swanda, the -- the written comments and testimony of this recommendation has estimated a cost of around $8000 per video. What is -- what is your estimation of the cost to retrofit an aircraft of the type that we're talking about?

MR. SWANDA: That was one of the questions we specifically asked of our 50 different members, including all the avionics and various component suppliers, and we could not get any estimates from those manufacturers. And I'm not aware of where -- who or where that $8000 estimate came from.

As I said before, GAMA cannot estimate the cost of this equipment, partly because the certification standards are not there. It's very difficult in that case.

MR. LOTTERER: One of the issues we had up on the cockpit door in terms of retrofit was the number -- various different models and the need to get STC's approval for that.

You mentioned something like 18,000 aircraft. Of that -- those aircraft, do you -- can you have an estimate in terms of the similar models within that population?

MR. SWANDA: I think that estimate could probably be done. However, I do not have that at my fingertips.

MR. LOTTERER: Okay. Thank you. No further questions.

CHAIRMAN CARMODY: Captain Fenwick with ALPA.

CAPTAIN FENWICK: Just one question, ma'am.

Mr. Swanda, this is really a hypothetical, but in terms of alternative or emerging technology, if perhaps a -- a new generation of new technology, low-cost, robust, excellent survivable flight data recorder, perhaps in combination with a CVR, were to become available, would -- would your association entertain that as a safety enhancement for the fleet?

MR. SWANDA: We would certainly encourage and support the development of such equipment. However, the mandate -- the government mandate of such equipment, I think, is a different issue, and that -- our feeling about that would vary depending on the segment of aviation that we're looking at. The commercial segment obviously has a different standard than the noncommercial segment.

If I may piggyback a little bit on those thoughts, I do believe that there are many technologies coming into our cockpits that will enhance our ability to understand what may have happened in the minutes preceding that accident. Those technologies include the current navigation equipment based on GPS that involves integrated cockpits.

We are looking at ways to be able to better retrieve that information and to safeguard that information. However, I don't think we will ever achieve a safeguard that will be equivalent of those found in the CVRs and FDRs. However, for general aviation, something is better than nothing, especially when it's after -- after a tragic accident.

I think other technologies that are quite promising that may lead to our understanding without a mandate are installed on aircraft for other purposes. These are, for instance, enhanced vision systems, which is a video recording technology or video transmitting technology that goes from the external of the aircraft. And I think even that is not -- those are not intended to be survivable equipment.

We often find in accidents that the forces do not meet the standards that we would design the equipment to. Therefore, the equipment, even though not designed to be crash-survivable, actually survives. We are aware, for instance, in some accidents of small aircraft where the aircraft -- one of the occupants of the four-seat aircraft was filming with a video cam during the trees as they passed by as the aircraft flew up a mountain pass. They were obviously doing some sightseeing on a VFR tour.

Tragically, in that videotape that was retrieved -- it had survived the crash -- we found evidence, both visual and oral, of what was going on in the cockpit, even though that video cam was aimed outside the cockpit. For instance, the stall warning alarm was heard and the occupants were heard to be making some light chatter prior to that incident, which may indicate they weren't paying attention.

The point here is that some technologies that are not installed on aircraft to specifically help us understand accidents may still provide our understanding. This is actually a practice, I think, that the Board especially has been good at for many years, in how to interpret various incidents in aircraft after the -- after the crash.

Another very interesting, I think, technology that is coming on board our aircraft is synthetic vision, which is based on a database of obstacles and terrain that is then displayed to the pilot. And if we could keep track of what is being on that display -- in some cases it may survive, although it's not required to survive -- that might be very interesting information in an accident.

CAPTAIN FENWICK: Thank you. Just one follow-up if I may, Mr. Swanda.

You mentioned safety equipment that may or may not be mandated currently, and I'll just restrict myself to the higher end of your fleet, the King Airs, the Caravans, the turbine -- the turbine equipment. Could you elaborate a little bit on, perhaps, some of the safety equipment that is not required to be installed? I have a few that I believe I know, but if you could lead off with -- with --

MR. SWANDA: I think this is a test of my knowledge of the FARs, and I'm not sure I'm prepared to do that today.

CAPTAIN FENWICK: Well, I was sort of getting at things like autopilots, weather radar, ground progs, enhanced ground progs.

MR. SWANDA: I can answer, I think, to this degree, that even though a piece of equipment is not mandated, as manufacturers, we don't know when we produce an aircraft if it's going to be in a Part 91 operation or a Part 135 operation. So what the manufacturers often do is meet the highest standard.

So even though a flight data recorder may not be required, it may still be installed. And the cost of doing so at the production of the aircraft is quite different, quite a lot lower, than trying to make a retrofit. So therefore, that cost is -- absorbed easier into the price of the aircraft.

CHAIRMAN CARMODY: All right. Mr. David.

MR. DAVID: Yes, ma'am.

Sir, in our ongoing studies of the Commercial Aviation Safety Team, we've identified numerous safety enhancements and risks that apply both to GA and the larger commercial aircraft and those that apply just to GA aircraft. We've passed those along to the GAJSC. Are you familiar with the work of the GAJSC?

MR. SWANDA: I am. I've been a member of that group since its inception.

MR. DAVID: Sir, has the GAJSC called for --

CHAIRMAN CARMODY: Could you explain what the group is? Give us the full name of it.

MR. DAVID: Would you care to do that?

MR. SWANDA: That's the General Aviation Joint Steering Committee, which is the general aviation equivalent of the CAST, which I think you're familiar with.

CHAIRMAN CARMODY: Okay. Thank you.

MR. DAVID: I'm a member of the CAST, also, sir.

Has the GAJSC called for cockpit image recorders in any of your studies?

MR. SWANDA: We did conclude -- in that work we have what a team -- they're called the General Aviation Data Improvement Team -- that is working on four tasks:  improving the activity data for general aviation to calculate an accident rate; improving the richness of the -- especially the human factors data and the availability of data that comes from an investigation; we're looking at ways to improve incident reporting systems; and we're -- then we'll take all those three and make some recommendations about how we might best use these indexes to measure general aviation safety.

The GADIT team, however, in its first recommendation on activity, did consider -- I'm sorry, the second recommendation on approving accident data -- did consider installation -- mandating it to some degree -- of a video recorder.

However, we are required under the processes of the CAST and the GAJSC to use a data-driven and cost beneficial analysis.  We concluded that at this time we could not justify any mandate of this equipment. However, we did think that continuing government-sponsored or -coordinated research into the technical barriers would be appropriate, and that did indeed survive our process.

MR. DAVID:  Thank you, sir.

CHAIRMAN CARMODY:  Thank you.

Ms. Rosser, any questions from NATA?

MS. ROSSER: Yes, thank you.

Mr. Swanda, what would you say of those 18,000-plus aircraft -- what would be the typical age of the fleet?

MR. SWANDA: I can't speak to the turbine aircraft. That's just not on the top of my head right now. I know that the average age of general aviation aircraft, including pistons and rotocraft, et cetera, is about 34 years. I would suspect that the turbine fleet would be much less than that.

MS. ROSSER: In considering the installation of recording equipment in aircraft that do not currently have it, what kind of special considerations -- and I'm thinking specifically about the space available in the aircraft for both the installation of the recording unit that would need to be crash-protectable in the aft of the aircraft, and also for the location of -- of cameras in the cockpit area. What would be the limitations faced by a typical Caravan, Lear jet, King Air?

MR. SWANDA: These are significantly smaller cockpits than you encounter in the Part 121 arena, and often installing video recorders requires line of sight to what you want to see. And in fact, it has to also remain out of the line of sight of the pilot that needs to look out the window. And that's a delicate balance, and it's often very difficult to meet that for any equipment you install in these smaller cockpits.

MS. ROSSER: In speaking with some of our members about the availability for installation, there are numerous FAA-mandated equipment requirements that are out there, and it is increasingly a problem finding space to fit the equipment. In most cases, there is a lack of head room. You're looking at approximately, I think, six -- six inches, maybe, of head clearance.

Are those areas not already typically occupied by circuit breakers and other pieces of equipment?

MR. SWANDA: The range of designs is extreme and there probably are some that do.

MS. ROSSER: And just one other question here. We -- someone had mentioned in one of the previous questions percentage of aircraft that would require an STC for the installation of this equipment. And although you can't necessarily estimate the cost of a video recording system, what would you say the typical cost for an STC is in the general aviation/air taxi industry?

MR. SWANDA: You know, I don't think I can say that off the top of my head. I'd be happy to provide something for the record, if that's possible.

MS. ROSSER: And that's all I had. Thank you, Ron.

CHAIRMAN CARMODY: All right. Thank you.

We'll move to the Board of Inquiry.

Mr. Cash?

MR. CASH: Just one question. Out of the 700-plus accidents, you stated 95 percent of them were pilot error?

MR. SWANDA: Human factors.

MR. CASH: Human factors. Without any additional information, without a recorder, without a cockpit voice recorder, flight recorder, video recorder, is there any -- is that an acceptable rate?

MR. SWANDA: Certainly not.

MR. CASH: How do you propose cutting that rate down without finding out what happens, you know, getting any more information?

MR. SWANDA: We often are able to infer -- and the Board does a pretty good job of this with their field investigators -- what was in the mind of the pilots. Unfortunately, in too many cases, that may be a very reckless attitude.

And I tell pilots that I know are learning to fly that a safe operation of the aircraft is to presume they have control. If they have the right attitude is the number one approach.

So I think that's, frankly, the conundrum of general aviation safety programs, is almost all of them have to be on a voluntary basis, and it requires a positive attitude as a recipient. As you know, somebody that doesn't agree that safety is important and sits through a safety briefing will probably not walk away with much improvement.

MR. CASH: Okay. One other thing, too, just to clarify. I mean, the recommendations that we have are not generally targeted at general aviation, and to muddy that, you know, with the recips -- I mean, we're pretty much targeting turbine commercial operations.

MR. SWANDA: One of the difficulties in dealing with Part 135 is that the aircraft today, in fact this hour, could be operating under Part 135, and the next hour it could be operating under Part 91, and yet it's the same aircraft.

So it is indeed very difficult to discern and determine accurate data on operational use of those aircraft, primary use of those aircraft. It's done right now primarily through the General Aviation Activity and Avionics Survey, which I spoke of earlier, which has the built-in problems that I think we talked about. The accuracy has been questioned many times, and it's a -- it's an issue that we are struggling with in the GADIT, which is part of the GAJSC.

MR. CASH: Okay. The -- the Board was very firm in their -- very resolved in their -- when they made the recommendation that for-hire commercial services, and certainly the 90 -- 90 percent accident rate is probably not acceptable to them, either.

No further questions.

CHAIRMAN CARMODY: Dr. Ellingstad.

DR. ELLINGSTAD: Yeah, I'd just like to follow up just very briefly on a question Mr. Cash asked and clarification that -- of some things that Mr. Wallace had asked relative to the applicability of these recommendations.

Now, the -- the 3000 accidents in the last 10 years that you introduced here were under what operating part?

MR. SWANDA: That is a combination of Part 91 -- larger aircraft involved in Part 91 and 135.

DR. ELLINGSTAD: Okay.

MR. SWANDA: Turbine-powered aircraft.

DR. ELLINGSTAD: The -- just to remind you of the language, the recommendation talked about these turbine aircraft operated under Parts 135 or 121 or commercial or -- operated under Part 91 for commercial purposes. So we're not talking about the -- the private use, recreational kinds of things that Mr. Wallace seemed to be implying, is that correct?

MR. SWANDA: That's my understanding.

DR. ELLINGSTAD: Okay. You also mentioned that with respect to this -- this group, and I'm sorry that I've forgotten the acronym.

MR. SWANDA: GAJSC.

DR. ELLINGSTAD: Okay, yes.

MR. SWANDA: Easily pronounceable.

DR. ELLINGSTAD: That you had done a -- something -- some kind of a cost benefit analysis. Was that in fact a formal sort of a cost benefit analysis that considered the -- the cost of the 3000 accidents or the 750 fatalities?

MR. SWANDA: Not a formal analysis by any means. However, we were required to, in the best way we could through a large number of suggestions. The process required that the team studying the history of accidents of a certain type would never take anything off the table in the first process, and only in the second part of the process would we look at feasibility.

So the first part was basically

effectiveness, and if it was effective, it was on the table. And then -- then we would ask feasibility, and feasibility included the cost, the complexity, and if something was a mandate versus a program that could be a voluntary, obviously that increased the -- decreased the feasibility.

DR. ELLINGSTAD: I'm just trying to get at -- we'll hear a good bit more about the -- the conduct of cost benefit analysis related to the regulations that the FAA promulgates tomorrow.

MR. SWANDA: Well, this was not anything near that.

DR. ELLINGSTAD: Was it -- I'm just trying to get a sense of whether you're talking about the same process that we'll hear about from the FAA tomorrow.

MR. SWANDA: I would liken this to a photographer taking a picture who first holds up his thumb to look at, well, it looks like this might work. That's the kind of process we use to evaluate these suggestions for feasibility.

DR. ELLINGSTAD: Okay.

MR. SWANDA: The type of process used by the FAA would be the actual -- determine setting the shutter speed and doing the full process.

DR. ELLINGSTAD: That's fine. We'll get to that tomorrow. I just wanted to clarify that.

CHAIRMAN CARMODY: Mr. Battocchi, any questions?

MR. BATTOCCHI: No questions.

CHAIRMAN CARMODY: Mr. MacIntosh?

MR. MacINTOSH: If we could just talk a little bit more about that cost benefit issue, and I realize there'll be more -- stop me if I'm -- if it's improper -- regarding the investigative uses.

But our industry has the -- has the history of the Kassebaum-Dole Initiatives and so on for the manufacturers and the frivolous lawsuit accusations that certainly surround our general aviation community. I was shocked to hear that a cost benefit analysis wasn't going to benefit anybody except the NTSB and the investigators. I somehow didn't hear that right, I believe. Could you kind of straighten me out on that?

MR. SWANDA: You think I said that?

MR. MacINTOSH: Well, I certainly put down some notes which may be extremely inaccurate, but can we talk a little bit more about the benefits to the manufacturers regarding the more definitive causes, cause factors, and -- and elimination of mechanical things that might be available through any and all sources that we can get to our field investigators.

MR. SWANDA: If I said something along that lines, that certainly was not my intent. I may have spoken out of line.

But nonetheless, let me reiterate that it is not our intent to speak for the Board, nor to speak for the FAA. We speak for the manufacturers, and the manufacturers need to sell products, and they know that the customers who buy the products respond to government mandates or to a perception that the -- that the benefits exceed the costs.

And so we are reluctant to produce products that don't have either one of those. We prefer that the benefits exceed the costs because then everybody's happy. Without a government mandate, people buy our products. That was the way I was going in the analysis, not at all a criticism that the -- or stating the policy of the Board to not consider costs and benefits. I frankly think that's not my position.

MR. MacINTOSH: And I think -- I appreciate that clarification very much.

If we're talking about a 206 airplane, about how much money does that cost?

MR. SWANDA: Of course, that -- there'd be a big difference between new and used aircraft.

MR. MacINTOSH: Let's just take a new one today.

MR. SWANDA: That would probably be about a $3 million aircraft.

MR. MacINTOSH: About a $3 million airplane. How about a King Air 300?

MR. SWANDA: I'd have to look that one up.

MR. MacINTOSH: Uh-huh.

MR. SWANDA: But that's probably not too far away.

MR. MacINTOSH: Right. And are we talking about flight recorders and video recorders and other objects that are in the -- about how much?

MR. SWANDA: The cost of the --

MR. MacINTOSH: Yes.

MR. SWANDA: I'm not sure I could quote exact cost.

MR. MacINTOSH: We'll see if we can't draw that out during the hearing, then. That's good. Thank you very much. No more questions.

CHAIRMAN CARMODY: Thank you.

I believe that completes the questioning --

MR. WALLACE: Madam Chairman?

CHAIRMAN CARMODY: I'm sorry?

MR. WALLACE: Just a point of clarification --

CHAIRMAN CARMODY: Mr. Wallace.

MR. WALLACE: -- if I may. I'm a little confused. As I read 0364 -- this is for Dr. Ellingstad perhaps, and if we want to discuss this at the break, that's fine -- but I see that 0364, as I read it, applies to all turbine-powered, non-experimental -- category aircraft manufactured prior to January 2007 that are not equipped with a voice recorder, and it does not contain any language about full-time or part-time for commercial or corporate purposes, as 0365 does.

So -- so that's what I was referring to, and if I don't understand that, please correct me.

CHAIRMAN CARMODY: Hold on. We're looking.

(Pause)

MR. CASH: I believe in the text we make reference to commercial operations and fractions.

CHAIRMAN CARMODY: You're saying the language of the specific recommendation does not include that, or do we have the recommendation in front of us so we can look at it?

MR. CASH: Yeah, the recommendation is -- he's correct, it does not.

CHAIRMAN CARMODY: Okay. We reference it in what sense, then? In the text?

MR. CASH: In the text I think it does -- the intent was for commercial operations, I believe.

CHAIRMAN CARMODY: Well, this is the text of the recommendation letter or the text --

MR. CASH: He's just reading the recommendation.

MR. WALLACE: Well, we're held to respond to the recommendation. The recommendation is clear. And as I cited the example to Mr. Swanda of someone flying their family in their Pilatus single-engine turbine airplane, this recommendation applies to that airplane. It appears to me it would apply to that airplane in that situation, entirely a private operation, unlike the other -- the other recommendations have some different language.

CHAIRMAN CARMODY: Well, we'll have to take a look at it, but I would assume that the text is trying to explain the recommendation.

Is that what -- Ron, do you want to respond to this? No, you don't want to respond.

So where are we left? Are we -- does Mr. Wallace have a point, or do we need to --

MR. CASH: Yes, he has a point. That's correct.

CHAIRMAN CARMODY: All right. Okay. Taken under advisement. Thank you, Mr. Wallace.

Is there anything else? Okay.

Thank you, Mr. Swanda, for your testimony and for answering our questions, and you're excused.

(Whereupon, the witness was excused.)

CHAIRMAN CARMODY: And, Mr. Cash, would you call the next panel, please?

TECHNICAL FEASIBILITY

MR. CASH: The next panel is Mr. Frank Doran from L3 Communications and Jim Elliott from Smiths Aerospace.

Whereupon,

FRANK DORAN

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

Whereupon,

JIM ELLIOTT

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

MR. CASH: If you would, Mr. Doran, would you state your name and -- and title for the record, and any educational and work experience that leads you to be an expert?

MR. DORAN: Certainly. My name is Frank Doran. I'm the vice president of engineering for L3

Communications, Aviation Recorders Division, in Sarasota, Florida. I've been with the company for about 20 years now. I've been a licensed private pilot for about 22 years.

In my tenure with the company, I've been responsible for the software, hardware, and systems engineering related to the development of embedded processing-based products for the high speed data acquisition signal processing, and more specifically, for the last eight years, for aviation and marine crash-protected recorder research and development.

MR. CASH: Thank you.

Mr. Elliott?

MR. ELLIOTT: Yes. I'm Jim Elliott with Smiths Aerospace. I've been with the company for 24 years, 18 of which has been in the design, development, and test -- flight test and working group related to data recorder products.

MR. CASH: Okay. Thank you.

Both Mr. Elliott and Mr. Doran have presentations.

Testimony of Mr. Frank Doran

(PowerPoint presentation)

MR. DORAN: Madam Chairman, Board Members, invited guests, ladies and gentlemen, it's a pleasure to be here and participate in these proceedings targeted toward the advancement of aviation safety.

Next slide.

During this brief presentation, I would like to provide some background on our aviation recorder product legacy and review the salient points that are the subject of this afternoon's session. These will include a quick historical review of the general technologies related to aviation recording, the enabling technologies for aviation image recording, the current standards and specifications, and cost issues.

Next.

Our recorder products legacy extends back over 47 years and includes some of the first flight data recorders and cockpit voice recorders that were available in commercial production. Over that time period, the company has been actively involved in many of the industry working groups, such as EUROCAE RTCA, and AEEC, helping to generate and evolve the specifications and standards for aviation recorder equipment.

In that 47 years, we have produced thousands of recorders, and as the picture indicates, about two weeks ago, we celebrated the production of our 60,000th aviation recorder. The recorders have been and continue to be utilized across the full spectrum of airframes, including large transports, regional transports, and general aviation aircraft.

Our commercial products are also widely used on military transports and helicopters. Our sister division, L3 Electric Dynamics, provides crash-protected recorders for many military tactical aircraft.

Since the year 2000, we have also been providing crash-protected recorders to the maritime industry, specifically large passenger and cargo ships. These recorders meet specifications very similar to the aviation requirements; that is, with the exception of the 3400-G impact requirement.

Starting with a 1.5 gigabyte product, our current product offering can be configured with up to 12 gigabytes of crash-protected, solid state memory. This will soon be extended to 48 gigabytes.

In 1999, we worked with another L3 sister division to produce our first crash-protected video recorder. This used an external video compressor combined with our third generation solid state aviation recorder platform to store about 20 minutes of low-frame rate NTSC video, utilizing about 60 megabytes of crash-protected memory.

Most recently, our imaging experience has been extended with the introduction of cabin surveillance systems.

Next.

We trace our origin back to the original Fairchild Aviation Recorder product line, and although progressing through several corporate identities in our 47-year history, the company now known as L3 Communication Aviation Recorders has benefitted from a great deal of continuity from long-time employees.

Next.

Recorder availability has generally followed specific enabling technologies. As we heard earlier today, the first commercial flight recorders were based on metal foil, stylus-engraved graphs, representing about five flight data parameters. Recorders came into their own, though, with the widespread availability of quarter-inch magnetic tape and the thermoprotective packs, resulting in commercially viable cockpit voice recorders and associated improvements in extended parameter digital flight data recorders.

For our tape-based products in particular, we exploited the back-lubricated, endless loop 8-track cassette design popular in the '70s, to produce a compact tape mechanism for both CVRs and FDRs. These tape-based aviation recorders represented the best available technology for over 25 years.

Next.

Our current generation of aviation recorder products are the direct result of several commercial technologies. A key technology was the availability of nonvolatile, solid state memory devices, in the first form of electrically erasable, programmable, read-only memory.

However, the real density advantage came with flash memory devices. The initial one megabit densities rapidly increased to 32 megabits in a few short years. Combined with advanced thermal protection techniques and small, high-strength stainless stain or titanium castings, modern recorders meeting the improved crash protection requirements of ED 55 and ED 56A and the associated TSOs became a reality.

These improvements have enabled two-hour cockpit voice recorders and extended higher data rate flight recorders that today offer over 100 hours of 512-word-per-second parameter data streams.

Further, these technologies have made combined voice and data recorders possible. The aviation industry also benefits from smaller, lighter, lower-power designs, not to mention lower overall initial and operational costs.

Now we arrive at the need for image recording systems. The desire for cockpit image recordings to assist in post-accident investigations has been well known within our industry for many years. Now, with the convergence of several enabling technologies, cost effective commercial image recorders are possible.

Compared to voice and data recorders, image recording requires significant increases in crash-protected memory, acquisition, and processing bandwidths. Obviously, it also requires the image sensors and the associated technology.

With four gigabit flash memory devices currently providing 512 megabytes per surface mount chip, crash-protected memory units no bigger than existing modules can be configured to handle the required image data rates and recording durations. Available compression algorithms, such as Motion JPEG, both proprietary as well as open standard, offer configurable efficiencies while maintaining the required frame-to-frame integrity.

We have benchmarked a nominal compressed frame size of somewhere between 30 and 50 kilobytes, usually opting to use 50 kilobytes on the high end for nominal calculations of memory requirements. And we've provided margin available for significantly larger frames if needed.

As with the computer industry in general, the availability of embedded processing bandwidth continues to increase significantly, allowing complex image data handling with low-cost CPUs.

With digital cameras showing up now in many consumer devices, the proliferation of image sensors is well known and understood. With both direct digital sampling or NTSC video digitization, image data is available in many resolutions and chip set implementations. Processing and conversion latencies are minimized with real-time hardware integrated with the sensors themselves in many cases.

Finally, data privacy issues can be readily addressed with a variety of existing and emerging encryption technologies. We often hear of the concerns for wireless data transfer, Internet security, and the like. There are many compatible algorithms available for programmable logic or real-time software implementations that can provide the needed security.

Like the tape-based recorders of old, image recording directly benefits from the widespread commercial demand and availability of the enabling technologies.

Next.

The image recording specifications are in place. After several years of effort, Working Group 50 produced ED-112, a comprehensive update of existing recorder requirements and introduction to image recording specifications. It incorporates a bulk erase capability directly borrowed from the longstanding CVR requirement.

Unlike the recent evolution to CVR and FDR specifications, however, the image recorder specs break new ground. As a result, the work towards ED-112 needed to anticipate multiple image recording requirements, including the general cockpit area, instrumentation, heads-up displays, digital message, and other aircraft camera data available to the crew.

While limited proof of concept work was performed during this process, the specifications are based on the sound engineering and technical collaboration of industry experts.

Now, the most important cost subject. The variety of cockpit configurations to be addressed may mean that a one size -- most certainly means that a "one size fits all" does not apply like it does for CVRs and FDRs. As a result, installed costs will vary, and it will be based on the number of cameras, image resolution, sensor types, as well as the total configured memory required.

We have estimated a single-camera, general cockpit area field of view, two-hour duration recording system meeting ED-112 survival requirements, frame rate, and duration, at about $10,000 or less. That's a general ball park number for that specific configuration. It can scale up or scale down based on changes to the configuration required.

We expect that further work will be needed to establish the minimum configurations acceptable for the various intended installed applications, the area where STC work would apply. In any case, as with CVRs and FDRs, image recorders will evolve from initial simple configurations.

In summary, the technologies needed to enable cost effective image recording systems are here today and rapidly evolving with improved capability. ED-112 provides us with an excellent initial specification that addresses the fundamental image recording needs as stated by accident investigators and others.

As we progress with image recording equipment development, further real-world testing of intended applications will need to be done in parallel. This should include flight testing to assess the minimum compliance and acceptable configurations and the extension of the technologies to smaller aircraft.

And, as with our current CVR and FDR equipment, image recorder cost performance will improve as the technologies continue to evolve. This will allow greater resolutions, pixel depth, and frame rates for future image recorder implementations.

Thank you.

CHAIRMAN CARMODY: Mr. Elliott, please go ahead with your presentation.

Testimony of Jim Elliott

(PowerPoint presentation)

MR. ELLIOTT: It's going to start soon.

Can you hear me? Okay.

Madam Chairman, panel members, and members of the audience, I appreciate this opportunity to present aviation image recording, a little overview on the technical feasibility. It -- you may find a lot of parallels with what Frank has just presented, being a manufacturer.

I want to briefly talk about some of the recording standards, the current technology, where we are today, the requirements as set forth in ED-112, associated image costs for recording, feasibility of encryption, and some of the technical issues.

First, a little bit about Smiths Aerospace. Smiths has been producing the solid-state recorders for two decades now. Developing and producing solid-state recorders started back with the F-16, when there was a need for solid-state recorders because the recorder heads kept coming away from the magnetic tape during high-G maneuvers.

We've progressed from there into commercial transports and helicopters, all branches of the military, and the U.S. Coast Guard. Similar to L3, we have some of the same engineers that started working this product line two decades ago that help incorporate improvements along the line. We also participate actively in industry working groups, EUROCAE working group, the AEEC, and Digital Flight Data Recorder working groups.

Fundamental need for image recording. This comes right out of ED-112. And I don't really like to read slides verbatim, but this needs to be put forth.

"To augment the existing flight and audio data by capturing images of the cockpit to better understand the cockpit environment, flight crew interactions, and the overall human-machine interface."

That was verbatim.

Now, what we're looking for is what's not available in the cockpit voice recorders and flight data recorders:  what is the ambient cockpit environment; what's going on in the cockpit; what is the nonverbal crew communications.  And more than once in the previous presentations, I've heard that come up quite often, nonverbal crew communications.

What's the crew work load; what are the crew activities; what's going on in the flight deck; what are the instrument display selections and the status; what are those all showing.  These are all information pieces that cannot be recorded on existing cockpit voice recorder or flight data recorder.

This is to supplement it.  The recording standards that we have today are ED-112.  EUROCAE Working Group 50 put this together.  It took quite a few years.  A lot of smart people worked on it, did a very good job, and it's for crash-protected airborne recorder systems.  Part III addresses specifically the image recorder and airborne image recording system.

Additionally, Voyage Data Recorder has an IEC requirement out there.  That's also a minimum operational performance type of standard, and they do image recording of the radar display snapshots every 15 seconds. So it's not a far -- far fetch of the imagination to go from that type of recording into image recording.

So current, recorder technology today. Solid-state memory. That's our forte. That's all we've really done for the last two decades. ED-112 requires solid state.

Dual redundant integrated recorders are -- we're looking at doing combi recorders. We've done those for 10 years now, voice and data recorders throughout the military. We have them in commercial transports, and we're looking at recording voice -- cockpit voice, flight data, parametric flight data, image, CNS/ATM, and FRED. Flight Recorder Electronic Documentation will also be put inside this recorder. It kind of documents what the flight data parameters are, the engineering units, how the flight data is packaged and stored inside the recorder. It's in the crash-protected portion of the recorder. That's the best place it could be.

We have high-speed data buses, very broadband data buses of 100 megabits per second. Larger capacity crash-protected memories. Density of memory devices has increasingly gone up. The cost of memory devices has gone down. We've gotten smaller, lighter packaging, smaller amounts of power are required to record.

And historically -- I'll touch on the cost a little bit ahead of time -- we have seen more go into these recorders in the last five years as the price has gone down: more capability, more -- more storage capacity, more data buses for acquiring data. We've got information coming in over the ethernet, over Mil Standard 1553, the ARINC 429 data buses, RS-422, and there's various recorders out there that all the companies make that have analog -- capture of analog parameters.

The ARINC 767 form factor, the big, clunky, half ATR short, half ATR long recorders. There's a new spec being developed that addresses a different packaging of these, so we'll get smaller yet.

Hosted function data acquisition inside a common core system, going out there instead of all the different -- specifically for a flight data recorder, capturing and gathering the information from the different devices out there. It's already being gathered by different flight management or autopilot systems. A hosted function just gathers it up and provides it to the flight data recorder. It's kind of getting away from a separate box of a flight data acquisition unit.

Another current technology, the RIPS, Recorder Independent Power Supply. There's several manufacturers working on that. The main thrust was to have a -- the -- a forward recorder, a combi type recorder, that could not be interrupted by power loss on the airplane. And it would hold up the area microphone so we know what's going on in the flight deck. And if there's any type of an area camera, it's the tie-in to the image recording part then you need to hold that up, also. Also if there were something that --a camera control unit that's supporting that camera and the camera itself looking at the area inside the flight deck.

ED-112, the EUROCAE document, covers a lot of -- lot of design performance specifications, the minimum specification, and the -- the general design and overview. It talks about coverage areas and what we expect the image recorder to be looking at when it's used asa general cockpit area, or an overall view of the instruments and control panels, overhead panels, the pedestal, the control areas of the airplane. It talks about -- discusses the recorder specifications and the camera specifications. It goes into great detail about what the field of view is; would it require color; the frame rates that we need to capture; the resolution.

Synchronizing it with other recording information out there. If you have all these types of flight data recorder or voice recorder or an image recorder either as a separate box or all in one box, we still want to be able to tie this information back to a central point so we can synchronize all the different data types.

It addresses image compression. Also, the usual environmental test, standard test conditions, installation suggestions. It's a very detailed document.

Along with that, ED-112 talks about the different classes of image recorders. We've got five main classes. Class A is the one of prime interest for the area camera. It supplements -- and that's the key word there, "supplements" -- conventional recorders. Not just trying to take the place of a CVR or an FDR, but to fill in some gaps there. We have another type of class recorder that looks at the CNS/ATM displays.

If we look at the Class A recorder, what they're looking at is four frames per second to capture this image. It's not video. It's not 29.97 NTSC video streams. It's four frames per second. For the other classes of recorder, we're looking at capturing images of one frame per second.

The Class C image recorder is where it's not practical to put in a flight data recorder with the installation of all the different sensors and the wiring and all the support for a flight data recorder. It's a lot cheaper to put in a camera that can capture that, that can do an adequate job and have the resolution to present what's necessary for a good investigation.

Heads-up display. That's another -- Class D, and this third class is the other camera images. And this would happen to be if we have a display inside the flight deck with cameras monitoring the cargo or the cabin. And if it's being monitored by the flight crew and that's desired to be captured also, you directly couple to that video source or use another camera to take an image and capture that for the -- what's being displayed.

Associated image recording costs. I like the number Frank gave out. That's about as far as I can go as an engineer. However, there are some factors that do push the cost one way or the other.

The number of cameras is going to vary, most likely, for what we're trying to do-- the coverage area for each unique aircraft type. A lot of the aircraft we're seeing nowadays, and we're not seeing a lot of new ones being built, but they're typically two crew-type airplanes. You don't have that third navigator in a 727.

But the number of cameras will drive the cost. That's pretty simple math. Whether it's one camera or three, you're going to obviously drive the cost.

The type of interface that these cameras plug into. If you want to take and digitize this information, you either do it at the camera or you have a control -- or a control unit that puts it on the proper data bus to get it into the recorder. It's also a factor of the cost.

The certification cost. There is some -- some cost associated with that, along with additional checklists that the crew -- the flight crew may have to perform. They may have to make sure that the camera optics are unobstructed and the camera's looking where it's supposed to be looking.

Maintenance. Annual maintenance, periodic maintenance with every type of system.

The two-hour storage. What we looked at is the image recorder needs to record the same amount of duration as the voice recorder. So if you have a two-hour voice recorder, you must have a two-hour image recorder. And two hours of storage, that's a minor cost driver, if we have a well-defined coverage area and we know what it is.

The big factor on the manufacturers for the -- the recorders is to certify these to the survivability tests. That's a lot of fun to do survivability testing, where you shoot them out of an air cannon and we drop penetration pins on them. We try and crush them. We burn them. We try and make sure that the data remains protected through the rigors of a crash, but that's not a simple task.

So we needed to have a good idea of, you know, how -- how big of a recording capacity is needed for the two hours.

Next slide.

As an example, the bottom line on the math, it's about 2.8 gigabytes to do two hours without doing any type of a reduced update frame rate. The ED-112 allows you to record the last 30 minutes at four frames per second for that Class A camera, and then for the subsequent 90 minutes, you can reduce that to one frame per second.

We at Smiths have never done the combined audio, which was similar to this. We think that if you just look at the two hours and try not to do a reduced rate, do it at four frames per second, it's easier to implement. And that's going to take about 2.9, almost three gigabytes to do two hours.

This is based on a 30 kilobyte average frame compression, which is right in line with what Frank had mentioned, I believe, 30 to 50 k-bytes average. So it gives you an idea what the storage is.

So that's providing, we know, four frames per second times three cameras. If you change it to 12 cameras, then -- my math's off.

Next slide.

Feasibility of image security encryption. The bulk erase function is there, similar to the cockpit voice recorder, to be able to erase the imagery. That's required by ED-112. ED-112 also says we need to provide this at the playback system, and they suggest either a dual password or encryption key protection. Earlier, the three password or three encryption keys was being bantered about. ED-112 says dual password encryption.

Commercial encryption algorithms are available. The installation of this encryption key, the control of it, and the distribution, does bring with it some issues. As the technical guy, those are issues that are beyond my scope of this. I can tell you how to build the recorder; I can't tell you -- I could tell you how to build a car. I can't tell you where to put the key.

Physical security issues, also. The equipment itself. Once you have that image recorded in there, you're only allowed to download it by taking the recorder off the airplane. So the recorder itself and then the playback equipment, you have to look at and address the security issues of that, and also the image itself.

Technical issues. There's a few of those. The video image standards. They're bound to evolve. What we have today -- this is not going to be what we have in 10 years. There's going to be some standard that needs to be adaptable.

The lighting and vibration. There's actually sections in ED-112 that specifically address this because, you know, we've got a fairly high vibration environment. The cameras may shake or not, and the lighting is very dynamic in the flight deck, whether it's day or night.

Camera recorder configurability. Suppose we have three cameras and you have them set up for different frame rates. You've got one frame looking at the monitor that the pilots have for their cockpit door surveillance system, and you have another two or three cameras looking at the flight deck itself. Supposing you need to swap a camera; how do you tell the cameras, okay, you're now the four-frame-rate-per-second camera and you're the one-second. It needs to be adaptable.

The recorder needs to talk to the camera somehow, and there will be a dispatch issue for the airlines to be able to do a quick turnaround on an airplane.

The camera installation themselves, is addressed in ED-112. You need to exclude the crew heads and shoulders, yet provide adequate coverage. This is going to take some working. Right now, we're looking at a big airplane vendor and the layout for the cameras inside the flight deck. It needs coordination with both the airplane manufacturer, the camera manufacturer, the investigators, to make sure it's adequate, and the certifying authorities.

Are we really doing what ED-112 is asking us to do. That's a tough one, it really is. The coverages. Keep the pilots' heads and shoulders out of the view, but still do an adequate coverage of the flight deck instrumentations, panels, and pedestal.

So in summary, ED-112 does adequately address the image recording. The technology has been there. An airborne image recorder is what it's called in the ED-112. It's currently available. It's been available for some time.

We discussed cost a little bit. Some of the drivers on that will be the number of cameras, and the definition. We're back to this proper definition between the manufacturers of the airplane, the certification authorities, the investigators, and the vendors themselves, because, as I mentioned earlier, the cost when it comes to certify these, it's not like going to Radio Shack and saying, okay, eight gigabyte was not big enough, I need a 12 gigabyte or a 48 gigabyte.

So that's my presentation. Thank you.

CHAIRMAN CARMODY: Thank you, Mr. Elliott.

Mr. Grossi, are you going to have some questions from the panel?

MR. GROSSI: Yes. Thank you. You've both done a very thorough job of -- of stating the state of art in image recording.

You've mentioned quite often, both of you, in your presentation EUROCAE and the EUROCAE document ED-112, and you've given quite a bit of background information on there. For the benefit of the audience, could you give a general background on what EUROCAE is and -- and the background of the Working Group 50, the actual group of people that drafted the document ED-112, either -- either of you, or both.

MR. ELLIOTT: Frank pointed to me. EUROCAE -- I don't know the exact time frame as -- probably as well as Dennis Grossi does. I think he was one of the original members. It goes back, I believe, six or seven years for ED-112. It started out with different names.

What it includes, it's a European organization, and Working Group 50 specifically was -- consisted of the investigators, the BEA, AAIB, TSB Canada, NTSB. We have the certifying authorities throughout the world, CAA, the FAA. We have the airplane manufacturers throughout the world: the Air Buses, the Eurocopter, the Boeings. We -- the pilots unions were represented by several people that are in this meeting. The airlines themselves have representation, and then, lastly, the recorder vendors were also present.

And we met four times a year, different places throughout the world, and addressed a lot of volatile and not so volatile issues to come together with a -- the one spec does all.

Part of ED-112 was driven by the fact that we had ED-55 and ED-56-A for separate recorder systems, for cockpit voice recorder and flight data recorder. And there were changes to those and they didn't happen at the same time.

The FAA changed the TSOs and said we need a 60-minute high-temperature flame test, and the EUROCAE was slow in incorporating that and they still couldn't do it at the same time. So we came up with an idea that we need to put all these recorder-type systems into one document so the survivability requirements are all the same for a cockpit voice recorder as a flight data recorder, as a CNS/ATM recorder, as an image recorder. So it's all on the same playing field. It can be in one box, it can be in separate boxes.

That's the long version.

MR. GROSSI: Thank you. That was very thorough.

We heard earlier testimony that there -- there was -- there wasn't a technical spec for an image recorder. Would you classify ED-112 as a technical spec for an image recorder?

MR. DORAN: I would certainly consider it a technical spec, very good starting point. I'm sure it'll evolve as years go by and technologies evolve, but for right now it's a very solid technical spec.

MR. GROSSI: Okay. Have either of you developed a image recorder prototype either based on ED-112 or any other technical specification?

MR. DORAN: Other than the work that we did several years ago with a video recorder -- crash-protected video recorder, we have just done experimental work as part of ongoing research and development, anticipating the need sometime in the future for cockpit or other image recording system, but no product ready for the market as of today.

MR. ELLIOTT: And as of today, we are working on a recorder that addresses -- that was proposed as an ED-112 recorder. It's -- the requirements are kind of evolving, and the interpretation of those requirements, but it does address image recording and it does address the capability of having image recording.

MR. GROSSI: Okay. As a recorder manufacturer, could you give us a brief rundown of what it would take to get an image recorder, or any recorder for that matter, installed on an aircraft, for -- for existing aircraft, newly manufactured aircraft, and newly type certified aircraft? What would be the steps that you would have to go through? What documents or standards would you need to -- to move forward in that process?

MR. DORAN: Well, certainly, for a crash-protected recorder, the first thing we would look for would be a TSO. We would build a recorder to meet the requirements of a given TSO. Then we would look to airframe manufacturers to define the environmental characteristics that need to be met for planned installation locations on the airplane, what the interconnects would be. We'd have to know quite a bit about the planned installation itself, and we would rely on airframe manufacturers to provide that guidance for both new aircraft as well as retrofit opportunities.

For retrofits, we'd have to address STC requirements and the documentation package associated with type certifying equipment in a retrofit type of application. We would work with the original aircraft airframe manufacturers and cooperate with them for the original type certification that would be associated for a new install.

MR. GROSSI: Okay. Jim, anything you want to add to that?

MR. ELLIOTT: I don't think there's anything I could add -- that Frank didn't already address.

MR. GROSSI: I would agree.

Are the existing flight recorder TSOs adequate to move forward, or will we need new TSOs?

MR. DORAN: Well, obviously, the existing TSOs don't mention image recording at all. They don't mention ED-112 at all. So I would anticipate a definite need for revision or new TSO to address this requirement.

MR. GROSSI: And, Jim, you -- you touched on this earlier in your -- in your -- your statement. In ED-112, there are some provisions to address the privacy concerns of -- of the flight crew. Do you foresee any -- any limitations in the technology that would prevent that -- those privacy concerns from being addressed and implemented?

MR. ELLIOTT: Not in current technology. The privacy issues, if you're looking at how the camera is recording what's on the flight deck --

MR. GROSSI: Right.

MR. ELLIOTT: -- no. No, but it does become a cost driver, as I mentioned, and you're probably getting tired of hearing that, because you may end up using quite a few more cameras than you initially thought in order to preserve those privacy issues.

MR. GROSSI: Keep that in mind. My next line of questioning follows on with some cost considerations.

Frank, you mentioned that L3 is now looking at -- has accomplished some cabin security recordings, working in that area.

MR. DORAN:  Not specifically recording, Mr. Grossi.  Cabin surveillance systems which are intended to give the flight crew, the cockpit crew, an awareness, now that we have closed, secured doors, what's going on right outside the cockpit door, as well as the general cabin area.

MR. GROSSI:  Is there any camera technology developed for that program that could be applied to a cockpit image recorder system?  Are there any lessons learned from that?

MR. DORAN:  There are certainly lessons learned in terms of camera placement considerations, field of view, focal length, those sort of things related to image sensors in general.  And certainly, it helps define minimum capabilities for low-end applications that would require an image sensor.

MR. GROSSI:  Thank you.

More specifically, going back to the TSO issue, is ED-112 adequate to develop a technical standard order, a TSO, for the recording portion of a

TSO or an image recorder?

MR. DORAN: I certainly believe so. The precedent is that our current TSOs 123-A, 124-A, for CVRs and FDRs, directly refer to the existing EUROCAE standards, minimum operational performance specifications, ED-56-A and 55, for the technical requirements. And further, the TSO has the flexibility to amend those requirements in any way that is appropriate to ensure a proper system.

MR. GROSSI: Can the same be said for the camera portion of an image recorder system? Is the ED-112 adequate to develop a TSO in that regard?

MR. ELLIOTT: I think we might want to wait until Mr. Horne comes up and discusses that. That's -- that's outside of my expertise -- the cameras and image sensors.

MR. GROSSI: That's a very appropriate answer. Thank you.

Turning away from the ED-112 issues and -- and getting into some of the more specific cost issues associated with implementing an image recorder, what are some of the more significant cost drivers in the installation of an image recorder? Either of you want to take that and give us an overview?

MR. DORAN: Yeah, I'll give you my brief view of that.

Number one, the number of cameras certainly, for two reasons: one, the physical number of sensors that would have to be deployed on the aircraft, and secondly, the more image sensors you have, and especially relative to the placement of the recorder itself, it may be smarter to aggregate all of that image data in one place.

For example, if the recorder ends up in the rear of the airplane, we would not want to run individual sets of wires from each sensor all the way back to the recorder. Rather, we would want to aggregate that data up front.

Jim alluded to an image controller unit, video capture controller unit type of device. That would add cost up front and then save costs in the overall installation because we eliminate a number of wires going back. So that's an up front system cost.

Secondly, the amount of memory that has to be configured. The more cameras, the more image data streams, the more memory's going to be required to support the two-hour duration. At least today that has some direct bearing on what the overall cost would be.

MR. GROSSI: Jim, do you want to comment?

MR. ELLIOTT: He is so good. That's a really good answer.

MR. GROSSI: You guys are doing a great job.

Now, the NTSB has a number of recommendations on the books requiring different levels of image recording, some for cockpit area, the general cockpit area, others specific to recording instrument panel.

If we could -- if you could give me an estimate or some sense of the costs associated with installing a general cockpit area camera system and recorder system, both on a newly manufactured aircraft and also on a -- on a retrofit basis? I understand it's difficult to do, not knowing a specific type aircraft, but if you could give us some general sense of the costs associated with that.

MR. DORAN: Believe it or not, I'm not familiar with what the installation costs are in particular. We can certainly talk about the equipment costs, the up front costs for all the bits and pieces that would have to be procured that would be supplied from a manufacturer such as us, but in terms of the actual installation, that's usually left up to the airframe manufacturer or other third parties that do retrofit type of work. I wouldn't feel qualified to comment, unless Jim has an idea.

MR. ELLIOTT: I'm not qualified to comment.

Same -- same as Frank said. If you do the retrofit, though, you do have a cost that you will incur for an STC. You'd need to have DERs out there to -- to check it and submit it. There's -- there's a lot of paperwork involved with that.

Again, the cost of the cameras. The cost of the recorder is really not an issue.

MR. GROSSI: Okay. All right. So right now, neither of you really have a good handle on -- on the full cost associated with installing the recorder, either on a newly manufactured or a retrofit case?

MR. DORAN: My gut feeling right now, Dennis, is that the cost of the equipment itself is probably the smaller part of the overall installation cost for -- for an airplane, especially for a retrofit.

MR. GROSSI: For -- you mentioned earlier a baseline recorder unit that would -- single-camera unit that would go for around $10,000. The -- would that unit fit the Class C type recorder as defined in ED-112, which is the camera that would record the cockpit instrumentation panel with sufficient resolution to -- to recover parametric data from the instruments?

MR. DORAN: Assuming that a single-camera installation would satisfy the minimum requirements in light of the privacy issues of excluding pilot head and shoulders and still have the proper field of view, yes, it would.

MR. GROSSI: Would -- would that type of recorder system be the least intrusive into the systems on the aircraft, as opposed to, say, a full-out flight data recorder which would try to capture the same type of parametric information?

MR. DORAN: Certainly, in terms of interfaces with other on-aircraft systems, it would be much less intrusive.

MR. GROSSI: Jim, do you have anything to add to that?

MR. ELLIOTT: I agree with that. The -- the cost of installing a camera and the amount and the recorder versus the different sensors and wiring those all up, you're going to have cost savings both in the amount of hardware, the labor, and the weight.

MR. GROSSI: We heard considerable testimony earlier today in -- in putting emphasis on recording additional parametric data, as that being more beneficial than recording image data. There are, as you know, a large number of parametric requirements for different types of aircraft out there -- air carriers, particularly.

Could you give me a cost estimate of the difference of fitting a -- of upgrading a 34-parameter flight data recorder system -- say that we fit it on a 767 that was manufactured before 2000. Of course, it's just fitted with a data bus system -- as to -- opposed to trying to capture that same level of information with a -- an image recorder?

That's a long question. I don't know if you got the grasp of it.

MR. DORAN: Again, my gut feeling would be, it'd be quite expensive to retrofit all of the sensor data acquisition capability onto an older aircraft to capture that same amount of data. And again, assuming -- making assumptions about the number of cameras required to provide that level of coverage on the airplane, it may be a more cost effective solution.

MR. GROSSI: Jim, do you have anything to add?

MR. ELLIOTT: It really is more like a flight data acquisition -- question.

MR. GROSSI: Okay. We talked about crashworthiness earlier. As you are aware, there are a number -- different levels of crashworthiness that have been required over the years. One is TSO C-84, which is a reduced crash fire survivability. For the application of a general aviation level type recorder

-- image recorder that would be fitted on the turbine-powered aircraft that we've talked about earlier, would there be any cost savings if we were to reduce, say, the crash fire survivability to a TSO C-84 standard?

MR. DORAN: From my perspective, I believe there would be. When you reduce the crash survivability requirements, it inherently allows you to make the module smaller, use less material, and there's always cost savings associated with those types of actions.

MR. ELLIOTT: I agree with that, too, Dennis. The -- by -- if you looked at specifically C-84, just fire survivability, you're carrying a lot less fuel on the smaller airplanes. It's not going to burn as long. You may have to look at and specifically address what the impact levels are. You may be able to look at that and find a reduction there. Every change that you can make to survivability will have a little impact on the recurring cost of the materials.

MR. GROSSI: Okay. Could you estimate the -- the annual recurring maintenance costs for an image recorder as opposed to -- to an FDR or a CVR of the same level of technology as a solid-state recorder?

MR. ELLIOTT: The maintenance on the

recorders themselves, there should be no -- there should be very little difference, if any, between whether it's image recording or flight data or the cockpit voice to the recorder itself. They're solid state. They're very reliable. We keep increasing the mean time between failures. They get better numbers for the airlines.

Now, the optics is a different -- when it comes to the image sensors, there's a little different issue.

MR. GROSSI: Okay. Are either of you manufacturing a combined voice data recorder at this time, and could that particular design, if you are designing one, accommodate an image recorder?

MR. DORAN: We currently do offer a combined voice and data recorder that supports two hours, 25 hours voice and data recording duration respectively. We're looking to evolve to our next generation of recorder architecture to allow both voice data and image recording, as well as CNS/ATM recording as well.

MR. ELLIOTT: Pretty similar answer. We've had for several years now a combined voice solid-state recorder that does cockpit voice recording, 512 words of data per second for well over 25 hours. It does two hours of uncombined audio in the same box. It has provisions for CNS/ATM via ARINC 529 input, clock input, and the maintenance type input. We've had solid-state recorders in the military for well over 10 years that do combined voice and flight data.

MR. GROSSI: Getting back -- getting back to the cost issues, what would be the incremental cost of adding image recording to your existing combined recorder designs?

MR. ELLIOTT: We've got a design in development right now that's looking at doing an image recorder, but just to take it and replace it, that's more of a design -- you look at the system from the beginning. What does it have to do. Instead of trying to jam it into the same box, you try and develop it from the -- from the onset. You'd have to change the memory size, you'd have to recertify it. The memory devices may not be compatible with what your original design is. They change over the -- over the months. I'd say years, but there's rapid changes in memory devices as we use them, so.

MR. DORAN: And just to add to that, the required data acquisition bandwidths for image recording are so far in excess of what our bandwidths are for audio and flight data recording right now that there's really no comparison between the two and it really does require new architectural thinking to accommodate it.

MR. GROSSI: Okay. All right. Turning from the -- the cost issues, we'll quickly go over some of the general questions I have.

Do you know of any operator or airframe manufacturer that is currently making provisions for the installation of an image recorder, either of you?

MR. DORAN: I'm not familiar with anybody that is currently making provisions for cockpit image recording systems.

MR. GROSSI: Jim?

MR. ELLIOTT: I really can't talk about that.

MR. GROSSI: Okay. All right. I understand.

Are you aware of any STCs -- existing STCS, supplemental type certificates, for image recorder installation?

MR. DORAN: I'm not.

MR. ELLIOTT: Not for STCs. There's nothing to put -- again, there's no TSO for an STC.

MR. GROSSI: I understand. Okay. Just crossing that check box off.

In a related question to some questions that were raised earlier in reference to the placement of the circuit breaker for the cockpit voice recorder, are either of you aware of any cockpit voice recorder installations where the -- or image recorder installations where the -- the circuit breaker is not located on the flight deck?

MR. ELLIOTT: 777.

MR. DORAN: I don't know.

MR. ELLIOTT: I believe Boeing does have one that's located outside the flight deck on the 777.

MR. GROSSI: Thank you. That -- that concludes my questions at this time.

CHAIRMAN CARMODY: Good. Thank you, Mr. Grossi.

Is there anything else from the Technical Panel?

Okay. Mr. Brazy, I have my eye on the clock, so I urge you to be succinct, and also the panel. Thank you.

We have another panel after this one, and I --

MR. BRAZY: I'd be happy to. I only have one question.

CHAIRMAN CARMODY: Good. Thank you.

MR. BRAZY: And that question is, as -- as Dennis alluded to, there's a bunch of things that would be required to install video recorders on airplanes.

My question is, is if you were provided with a TSO largely based on -- on ED-112, the appropriate supplemental type certification information, as well as appropriate federal regulations, how long after you had those pieces of information, how long could we expect a video recorder to be available for the Cessna 208 Type C type application?

MR. DORAN: Speaking for us, probably a 12- to 16-month time frame.

MR. BRAZY: You can answer, too, if you'd like, Jim, but that's -- that's fine.

MR. ELLIOTT: It'd be somewhere -- the first thing that comes to mind is, how soon do you need it.

MR. BRAZY: Eleven to 14 months.

MR. ELLIOTT: We do have a recorder that's in development right now that addresses image recording along with the other cockpit voice, flight data, and CNS/ATM.

MR. BRAZY: That's all I have.

CHAIRMAN CARMODY: Thank you.

Moving on to the parties, Mr. Wallace from the FAA.

MR. WALLACE: All my questions are for whoever wants to answer them.

The -- Mr. Swanda from GAMA stated earlier that GAMA's not aware of any company that makes a video recorder capable of withstanding crash forces typically encountered by a small airplane. Could you respond to that?

MR. DORAN: Well, I'll just say we -- we don't have a video recorder today built that survives the crash forces of a small airplane, but we build voice and data recorders and combined recorders that survive those crashes. So I think we're in a good position to -- to be able to produce such a recorder if need be.

MR. WALLACE: Right, because obviously only the recording device in the back of the plane needs to survive, not the cameras.

But is there a concern that, you know, with so much less mass with a smaller airplane and -- smaller airplanes may sometimes travel at smaller speeds, although airplanes don't generally crash at their cruising speeds. And so assuming crash speeds are comparable, is there an issue -- a technical hurdle there in the fact that you've got so much less airplane between -- you know, sort of crushable structure between your impact point and where your black box is, or orange box is?

MR. ELLIOTT: I don't think that's an issue.

We just need a good definition of what it has to survive. Military aspects, they do crash -- unscheduled landings at very rapid speeds into very hard, fixed objects.

MR. WALLACE: And as far as the basic Class C ED-112 camera, which seems to be what's targeted by the recommendations for -- for smaller aircraft, do you believe that you can do this with one camera? Because you've talked about privacy concerns and, although we haven't really sorted out exactly what those might be in small aircraft.

But you had a list of things you put up there. I think it was you, Mr. Elliott, who put up about the things you would want to film in a confined cockpit with -- with one or two pilots in it. Do you think it's feasible we could do that with one camera? It seems to me it would be, you know, a cost driver.

MR. ELLIOTT: The -- I think you're going to have to look at it case by case; what are you trying to capture in the image and your overall view. The things that were on my slide were not things that I wanted to capture. Those were things that were identified in ED-112. Those need to be addressed from that standpoint, and it may take several visits out to that actual airplane to install some cameras on a trial basis to --

to actually -- get the coverage area that's defined.

MR. WALLACE: Do you have plans to -- to do some sort of trial basis installations on aircraft or do a beta test or try to seek some volunteer operators or something like that to -- to determine the viability of these products?

MR. ELLIOTT: We've done flight tests already with the U.S. Coast Guard to address the feasibility several years ago. I think that, you know, that any good manufacturer would make sure, you know, that the certification, the installation, that everybody's happy with what they see on the images.

MR. WALLACE: No further questions.

CHAIRMAN CARMODY: Mr. Barimo from the ATA.

MR. BARIMO: No, we have no questions. Thank you.

CHAIRMAN CARMODY: All right. Mr. Lotterer from the Regional Airlines?

MR. LOTTERER: Thank you.

We heard earlier testimony from the Navy on their training program whereas for -- to respond to the lighting situation with image sensors that they needed to go to infrared. Is the infrared problem or the ability to see things at night and day and broad sunlight coming into the cockpit, are they addressed by this specification right now?

MR. ELLIOTT: Actually, during some of the discussions of Working Group 50, that -- that exact point came up, and image -- infrared was in and infrared was out, the case in point being that they wanted to see what the ambient conditions in the flight deck truly are. They didn't want infrared sensors blasting through the smoke, so to say, to actually see what's going on. The sensitivity of the -- the devices out there in image sensors today with infrared can get you down to, you know, almost zero lux light level conditions.

So it was discussed and it was decided they really want to truly see what the ambient conditions are, so no infrared.

MR. LOTTERER: Okay. And you said in response to the question on how fast can you move on this, and your response, as I assume is typical for most manufactures, how soon can you -- how soon do you want it.

In response to 18 -- like 18,000 airplanes, you -- I take it this 18-month production is -- is based upon making one unit. What -- what is -- for the both of you, what is your current production schedules? In other words, how long -- if -- if in fact this was mandated for that size of population of aircraft, how long are you looking at to manufacture these things?

MR. DORAN: Well, I'd probably really want to defer to our VP of operations, who schedules all of our factory activity and the resources dedicated to that production line. But we regularly produce 3000 recorders a year, and that's just nominal production. It's peaked at levels much higher than that, and could certainly be ramped up to accommodate even higher production levels if need be.

MR. ELLIOTT: Excuse me. That's providing we have a TSO that says it has to be done and everyone wants to do it.

The FAA is pretty generous in their schedules that they allow typically for something like this. They won't phase it in overnight. So that would give everybody time to address it and look at their needs. They're not going to demand that you have to have it within 12 months, most likely. I may be going out. I may be overstepping my bounds here, but I have not seen anything come up where they said, you absolutely have to have this within a 12-month period.

MR. LOTTERER: I wasn't suggesting to trap you into what the FAA might do on this, just your opinion in terms of manufacturing capability.

MR. ELLIOTT: I think 18,000 recorders, we'd like that challenge.

(Laughter)

CHAIRMAN CARMODY: It sounds like you're not going to get a definitive answer on this one, so let's move on.

MR. LOTTERER: The other issue in terms of -- we've got two issues here. We've got the so-called supplemental to the existing information from the CVRs and DVRs, and we have the smaller aircraft in terms of the unit itself as a stand-alone unit.

Has there been any studies -- the issue with respect to the smaller one was that the -- that the cost would be much less for the video type unit as opposed to a cutdown type CVR, FDR type unit.

What's your take on that in terms of relative cost and comparing the two units?

MR. DORAN: Well, in just the equipment itself, the recorder equipment itself, there's probably not a whole lot of difference between a flight data recorder -- a combined flight data recorder, cockpit voice recorder, and an image recorder system, assuming a single or maybe two image sensor inputs.

It's data acquisition, as Jim said earlier. That's where the cost begins to become more important in equipping -- positioning the sensors, wiring them all up to a data acquisition type capability, and then routing that information to the flight data recorder.

MR. LOTTERER: Thank you. That's it.

CHAIRMAN CARMODY: Moving on to the Allied Pilots Association. Mr. David, do you have any questions for the witnesses?

MR. DAVID: Yes, I do, ma'am. Thank you.

You said your cameras are effective down to zero lux?

MR. ELLIOTT: I said the technology is available for -- we don't manufacture cameras -- that -- that they are down to zero lux with infrared assistance.

MR. DAVID: Are these same cameras affected in a rapidly changing environment, such as in an oscillatory environment, where the aircraft is moving in and out of bright sunlight?

MR. ELLIOTT: Again, I -- my expertise is the recorders. If you can hold that question until our camera guy -- panel is seated up here, he could answer that better than I could.

MR. DAVID: I shall.

We've heard that it would monitor many things in the cockpit. A typical large transport category cockpit, we'll say a Boeing 767, how many cameras are going to be needed to effectively monitor everything that everyone wants to monitor in the cockpit and include the privacy issues of ED-112?

MR. ELLIOTT: We've done some preliminary looks at that, and it looks to be three cameras to get the overall view, which is a Class A camera, to make sure that you're getting left side, right side, and the center pedestal.

Additionally, if you have some type of a cockpit door surveillance system monitor, or it's monitoring the cabin, you need another camera, a Class E type camera, one frame per second, or an input to record that, whether it's a camera looking at the monitor picture or a direct video tap into the recorder. So you're looking at four chunks of memory -- I'm looking at it from a memory standpoint -- whether it's three cameras in a direct tap or four cameras.

MR. DAVID: And that will include video of the pedestal and exclude the pilot's head and shoulders?

MR. ELLIOTT: Yes. That was a very key issue, was to look at -- I don't want to use the words "look at" -- to address the privacy issues of capturing the flight deck as defined in ED-112.

MR. DAVID: Thank you. You also talked about bulk erase. If bulk erase is used, can the image still be extracted using special means?

MR. ELLIOTT: I think the provision for bulk erase is the same as the cockpit voice recorder portion.

MR. DORAN: It does allow that it can be extracted using other -- other means usually specified by the recorder manufacturer.

MR. DAVID: How easy are those means to use?

MR. DORAN: They're not very easy in the way we implement them ourselves in terms of being able to easily retrieve the data from the memory.

MR. DAVID: So they would only be able to be done by the recorder manufacturer and not any other we'll say agency or country?

MR. DORAN: I wouldn't go that far, given the resources that could be available to somebody to go in and pull data out.

By the way, there's a very good reason why we can't just definitively say that bulk erase gets rid of all the data, and that is, the erase process on flash memory devices takes quite a bit of time. Especially when we talk about the volume of memory required in an image recorder, it would be very impractical to sit and wait the -- the lengthy duration to make sure that everything was erased.

So basically what we do is disable playback with special marking and manipulation of the data structure within the memory.

MR. DAVID: I see. Thank you both very much.

CHAIRMAN CARMODY: Thank you.

Captain Fenwick with ALPA, any questions?

CAPTAIN FENWICK: No questions.

CHAIRMAN CARMODY: All right.

MS. ROSSER: Thank you, Chairman.

I apologize if I skip around a little bit. Several of my questions have already been asked.

But, Mr. Doran, your original presentation, early in your slides you represented the marked place you serve, and you had large transports, regional airlines, and general aviation. Can you just clarify where the 135 air taxi operations are? I'm guessing that's included in the general aviation market --

MR. DORAN: Yes, it is.

MS. ROSSER: -- as traditionally 135 is included in GA, but I just wanted to clarify that's where you counted us.

MR. DORAN: Yes.

MS. ROSSER: Okay. In your research, what -- can you give some idea of what size aircraft you've looked at, either or both of you? We just heard in the one example for the airline, larger transport aircraft would require four cameras. Is that the typical environment you've looked at, or have you really gone into the smaller aircraft that today are not currently equipped with any recording devices, the often-mentioned Caravan, Lear jet-sized aircraft, and what type of recording equipment would be necessary for those?

MR. DORAN: In our preliminary look at it, just knowing the general size of the cockpit and the general layout, they all tend to be fairly similar for that generic size of airframe. Probably one to two cameras would be sufficient to capture the required information.

MS. ROSSER: And this may have already been answered, but in the estimate you gave of a two-hour recording with one camera in the $10,000 ball park, what class of recorder would that have been? Would that be an A, a C, or would they be the same?

MR. DORAN: A single image A or a single Image C, typically.

MS. ROSSER: What difficulties would you

envision in the older aircraft, you know, a 20- to 30-year-old turbo prop? Do they present any additional difficulties in installation versus a newer aircraft on a retrofit?

MR. DORAN: I'm not an airframe person myself, so I couldn't comment. I -- I would not think there'd be much of a difference between the two from a retrofit standpoint.

MS. ROSSER: Also mentioned here recently was testing with the Coast Guard, and again, what size aircraft was that looking at?

MR. ELLIOTT: HU-25 -- HU-25.

MS. ROSSER: Can you give some idea of what -- what dimensions that is compared to a smaller 135 aircraft?

MR. ELLIOTT: Two crew.

MS. ROSSER: I guess I'm just thinking more dimension, size. You know, how much clearance do you have if you're trying to meet that goal of not capturing the head and the shoulders. In many of our aircraft, you are literally shoulder to shoulder in the aircraft, and I'm wondering what additional -- if that's ever been really directly looked at?

MR. ELLIOTT: I think it's fairly close to like a Falcon -- Falcon 900, Falcon -- it's a tight, two-crew flight deck.

MS. ROSSER: And how many cameras would that have?

MR. ELLIOTT: We'd just use one as a feasibility study.

MS. ROSSER: Thank you.

Thank you, Madam Chairman. That's all my questions.

CHAIRMAN CARMODY: Thank you.

Moving to the Board of Inquiry, Mr. Cash, any questions?

MR. CASH: No.

CHAIRMAN CARMODY: Dr. Ellingstad?

DR. ELLINGSTAD: No questions.

CHAIRMAN CARMODY: Mr. Battocchi?

MR. BATTOCCHI: No questions.

CHAIRMAN CARMODY: Mr. MacIntosh?

MR. MacINTOSH: I do have two questions, one for you gentlemen together. Obviously, each one of you has got about 20 years or over of experience in accident investigation, working with us, and we -- we're concerned about the -- the statement we heard this morning in the U.K. study that the stand-alone device is not likely to be of much use to the investigator.

You're making the equipment. Is it useless equipment, not of much use to us?

MR. DORAN: It is definitely not useless equipment. We're in the business of providing tools, and any tool that would aid in an investigation is a useful element.

MR. MacINTOSH: Mr. Elliott, what do you say about this? When somebody says, "Oh, it's a stand-alone piece, we can't -- we can't depend on it"?

MR. ELLIOTT: I suppose it was difficult to retain my professionalism. However, it's a safety piece of equipment and it is very useful. They've seen a lot of -- we've seen a lot of use in voice -- voice recording, flight data recording, and I -- I'm very certain we'll see usefulness come from an image recording.

MR. MacINTOSH: Well, I don't think I'm allowed to testify, but we have investigated a lot of accidents where one or the other of our pieces of equipment has been lost to fire or damage, et cetera, and found the other to certainly be most helpful.

The other issue is about the EUROCAE group. This EUROCAE Working Group 50 ED-112, are we victims of inbreeding a bunch of accident investigators that just go off to a room somewhere and dream up things like ambient condition -- purpose, ambient conditions of smoke, general crew activities, use of checklist charts, health and well being of the crew, nonverbal communications, hand signals, pointing, cockpit selections within crew reach.

Were we just dreaming that up or was that an industry group that came to some conclusions? Who was on that group?

MR. ELLIOTT: Let's back up again. That group was a very broad group of people which included the investigators, the certifying authorities, the airplane manufacturers themselves, the airline owners and operators, the -- the vendors of the equipment, ARINC -- they're the specification writers, EUROCAE specification writers.

MR. MacINTOSH: Could I interrupt you?

MR. ELLIOTT: Sure.

MR. MacINTOSH: Did they bring pilots?

MR. ELLIOTT: There was pilot representation from the pilots unions.

MR. MacINTOSH: Pilot unions. How about test pilots, company pilots from manufacturers?

MR. ELLIOTT: Some of the manufacturers' representatives were pilots. In fact, a large majority of those professional people had some type of a certificate.

MR. MacINTOSH: And operators had pilots there?

MR. ELLIOTT: I would have to look at the list. Perhaps Mr. Grossi could help with some of the -- knowing some of the people. There was -- there were pilots there. I couldn't identify them all.

MR. MacINTOSH: The point is, it's a cross section, and that's what we want -- what I'd prefer to understand, was that some of the things I've heard about the -- the issue of cockpit image just not being the answer apparently to the group that was assembled for EUROCAE, it wasn't answered, and we have this purpose.

Thank you very much.

CHAIRMAN CARMODY: Thank you, Mr. MacIntosh.

I think that completes our -- the questions of this panel. Thank you both very much for your testimony and your answering our questions. I -- and you are excused.

(Whereupon, the witnesses were excused.)

CHAIRMAN CARMODY: I propose we come back at five after 4:00. We'll take a short break and then we'll start with the last panel today. Thank you.

(Brief recess)

CHAIRMAN CARMODY: Thank you.

Mr. Cash, would you swear in the next panel, please?

Whereupon,

MIKE HORNE

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

Whereupon,

RICK SHIE

having been first duly sworn, was called as a witness herein and was examined and testified as follows:

MR. CASH: Mr. Shie, could you please state your name for the record and title and place of employment and any significant educational and work experiences?

MR. SHIE: Yes. My name is Rick Shie, and I'm with Physical Optics Corporation, where I'm the senior vice president there. And I've worked at Physical Optics for over 11 years, and we're a small, high-tech company in southern California. And I do hold a master's degree.

MR. CASH: Okay. And, Mr. Horne, could you state your name, too?

MR. HORNE: My name is Mike Horne. I'm (off mike).

MR. CASH: I don't think your mike's on, Mike.

CHAIRMAN CARMODY: Yeah.

MR. HORNE: Oh.

CHAIRMAN CARMODY: Start over.

MR. HORNE: -- secretary of the subgroup writing the image recording section of the ED-112, and -- and I'm now chairman of the -- another EUROCAE group working on flight deck -- flight deck door monitoring systems.

MR. CASH: Thank you.

And both Mr. Shie and Mr. Horne have presentations.

CHAIRMAN CARMODY: All right. Why don't you proceed. Whoever wants to go first, please begin, and then the other will follow.

MR. SHIE: I'll go first.

CHAIRMAN CARMODY: All right.

Testimony of Rick Shie

(PowerPoint presentation)

MR. SHIE: My name is Rick Shie, and we're here to talk about FAERITO, which is a data-centric flight recorder which provides over four hours of recorded video, audio, and data all into one box.

Our problem statement begins with NAVAIR, who was a witness earlier today. And we're an SBIR company, and this technology was developed under SBIR Phase I and SBIR Phase II for PMA 209 at Pax River.

The issue there was the Hawkeye, the E2-C, required a crash-survivable flight recorder, and currently is not using a recorder of any kind. The idea was to develop an advanced or a future box which could combine all the features of video, audio, and data into one box. This box would have two memories, one being crash memory and the other one as a post-flight downloadable memory, all into one box, which is small, actually, measuring four by five by seven inches and weighs less than nine pounds.

Primarily, our customers are military and not in the commercial world. Our focus is there, pleasing them, but a lot of this technology can fit into the commercial arena. So PMA-209 -- the Hawkeye is our primary focus, but there are other military aircraft that could benefit, including helicopter applications and the Air Force, Army, and now we're beginning to do more in the UAV and the UGY arena in terms of video and voice.

Of course, the commercial aircraft is what we're here today to talk about, but this also can be utilized in marine, ground transportation, and also in homeland security applications.

The baseline technology, you're familiar with the voice-only, the data-only, and after listening to people today, I'd have to say there are some people doing video. But there are none doing all three: video, audio, and data. The solution is the FAERITO box, which combines all these functions into one.

The features. We provide over four hours of recorded video-audio data, and that's per channel. The idea is that we combine five recorders into one small footprint, such as the crash box, video box, audio box, data box, engine recorder box, all can be combined into one box.

And as you can see there, it has two digital memories. The picture shown there is a one-gig memory, which is crash-survivable and also has removable flash memory which is -- operates off the USB bus. The -- it's a stainless steel housing, and again, can withstand 4000 Gs.

Here I'm showing you a two-gig memory, all in the titanium casing, which protects the memory from crash, and it's with an aerogel environmental protectant.

The second photo, I'm showing you the video, audio, and databoards. The advantage here is you can swap in, if your needs -- you have different videos, different audios, different videos. The architecture of the system, you can swap in and out the boards that meet your specific criteria.

Same is true with the universal connector. One of the big issues with current boxes is that they cannot be easily adapted. The connectors are issues. Again, the architecture of FAERITO was designed in the manner that if you have a different pin need, we just put your connector in and you're good to go.

The area that separates us from many people is in the video compression. In fact, we're so good at video and video compression, people refer to us as the video box. But we're equally good at voice and data.

We have some very unique features in the way we handle the video compression, and we utilize our intelligent hypercompression system which is object-oriented wavelength base. So we can take in the entire scene or, in this case, we've identified a car and we can manipulate that image, boosting the image quality, in contrast to the trees in the background, which we don't care about. So this is a very significant feature in being able to record high-quality video.

Our compression system is very unique and proprietary to Physical Optics, and we can -- we're achieving now variable compression ratios from 10-to-1 to 4000-to-1. We can also do variable frame rates, from 60 frames per second to zero. The data rates are also variable, from 56K to 2 meg.

And a very important feature is, we address each individual frame. We do frame-by-frame management so you don't lose your data. So if there's a problem with one frame, you immediately move to the second frame, maintaining your image quality.

We also have synchronous playback with time stamps, and also FAERITO can be featured. Not everybody will need all those features. In this case, we're just talking about a video box. So this can be adapted. We can add other, you know, 429, ethernets, synchro. Other things can be adapted into the box.

This is our system architecture. As you can see, I'm showing two cameras -- two videos, four audios, and our various buses that we support. And you can see we have a crash memory built into the box, as well as a USB downloadable memory. So at the end of the flight, just grab your memory and walk out.

Our specifications are also listed there in terms of the -- the number of channels we support. And again, we can do four hours per channel.

FAERITO was built to the Pax River specification. We're not limited to these specifications. These were just for our customer and what they required in terms of image quality that meet their needs.

The state of development. Again, we're completing the Phase II. We're -- finishing the environmental testing now. Our Phase II final report will be done in August. We'll begin our removal downloading memory in September. Our crash memory will be completed in the October time frame, and then we'll put everything together in the FAERITO system as of January of '05. We'll go through certification, which will be completed in April. Prototype delivery to the Navy will be in June '05, and in July '05, we'll be commercially available.

Now, I might add that we -- we've already been approached for UAV applications with video only, and we do have orders in place for that and some other related technologies.

Here is a little bit about our company. We are a private company. We're a small business. We're employee-owned. We've heavily patented our technology. POC has over 40 technologies. FAERITO is just one of them. We have full production capabilities, and our company has six spinoffs.

Other emerging products. We have five shown here. The one I'd like to point out specifically is our Omniview, and that addresses a question that came up in the earlier session. And we've developed a system for DARPA where we had one lens and one camera, and this can be expanded to see 360 degrees in the cockpit. In this case, it was an outdoor application and they required seeing at night, and we implemented a -- an IR camera with an auto-iris system, so it could easily go from day to night.

Again, we're using one lens, one camera, into the Omniview system, which also could be a camera that fits within the FAERITO package.

That's my presentation.

CHAIRMAN CARMODY: Thank you, Mr. Shie.

Mr. Horne, would you give us your presentation?

Testimony of Mr. Mike Horne

(PowerPoint presentation)

MR. HORNE: Okay. A little about me, first. AD Holdings have been in business since 1982, developing state-of-the-art security video recorders really since the technology became available. Right from the CAMPLEX video recorder in 1984 to the first aircraft-mounted ethernet capable video server that we produced in 1998, and we've been flying ever since.

My own background is in the development of harsh environment TV, putting cameras on guided missiles, submarines. I've dealt in thermal imaging and low-light surveillance.

Been a member -- well, I was a member of EUROCAE Working Group 50 for seven years, since I think it was meeting two I joined, ending up as the secretary of the subgroup writing the image recording section of ED-112.

I'm now the chairman of the EUROCAE working group dealing with flight deck door security video. I've spoken at NTSB and ISASI conferences and various security symposia.

Today I'll be talking about the technical feasibility of camera systems, hurdles to be overcome, costs involved, with the sensor under the proposal for the system. I think we've already heard a lot about the recorder system.

So just to recap, really, on what accident recorders -- accident investigators are really using at the moment. We've traditionally used a variety of techniques, including data and voice recorders, conversations with air traffic control, comments from the flight deck crew and between the flight deck crew, and instruments stuck at the time of the accident.

With the introduction of glass cockpits, we've lost the data from the stuck instruments. At the same time, CNS/ATM replacing air traffic control conversations with data has made the traditional cockpit voice recorder much less effective.

Also, we've heard already of a wide variety of additional information which will be useful to air accident investigators by the use of voice -- video recording. Specifically, a few are picked out there: use of checklists and operating procedures, whether the pilot was distracted, whether there was something else going on in the cockpit, something -- somebody climbing into the cockpit, smoke filling the cockpit, whether there were work load issues, and the wealth of additional descriptive and nonverbal communication which goes on makes up a huge proportion of the command control links within the flight deck.

NTSB and AAIB in the U.K. -- I think we've heard that -- have been pushing for video recording as an accident investigation tool for many years now.

I'll just go on to answer one of the questions that came up earlier, who is EUROCAE. It's European Organization for Civil Aviation Equipment.

And we were asked to write a MOPS for the recording requirements of the ATM.

It was a truly international group. There are -- I didn't count them off, actually, but there were some 150 participants listed in the ED document. It comes from air accident investigators, both in the U.S., the U.K., Canada, France, Germany -- I can't think of any others at the moment -- pilots' unions, Air Bus -- airlines, manufacturers, both the aircraft airframe manufacturers and kit manufacturers, recorder manufacturers. All of the major people who are involved in this industry sat on that panel.

The conclusions of EUROCAE Work Group 50 were encapsulated in EUROCAE ED-112, which we've already heard. I do apologize for repeating some of the stuff that's gone before.

This laid down two major targets for Image recorders. We should probably look at them separately. It also looked at other sources to be recorded -- such as head-up displays and external cameras and so on.

The first target is the possible replacement of flight data recorders where it might prove to be prohibitively expensive to fit them or extra requirements on instrumentation that may be particularly applicable to smaller Part 135 type aircraft.

This leads to a requirement for extremely high resolution, moderately low update rate cameras, which is quite a harsh or a difficult specification to meet.

The second target is for a high update rate camera to get additional information from the cockpit environment, such as the use of checklists, positions, status, and work loads of the flight deck crew.

We ought to draw a careful line here that ED-112 does not permit identifiable images of pilots to be recorded, but to be of use, hands on the controls need to be in a field of view. It's our contention that with good design both of these aims can be met with a single camera, although it will be a very specialized item. And if it's a single camera, it will be an expensive single camera.

We estimate that this camera system would be $5- to $7000 to an airline. That would be -- that would be reduced as the numbers go up, the numbers of systems, and as technology goes on, prices will inevitably come down.

But that's really looking at the high-resolution end camera. For low-resolution, maybe an area view camera for a private or small aircraft, the estimate would be $1000, $1500, something like that, for the camera. And that would give you certainly an awful lot more information than is available now: information on what the flight deck crew were doing, what instrumentation was alive, probably to the extent of seeing what graphics were available on the instrumentation.

So any system fitted to a commercial aircraft, particularly in the area of the flight deck, has many environmental and operational considerations to be taken into account in the design. These are covered by RTCA, SAE, EUROCAE standards, FAR regulations, and so on.

They lead to components, as has been mentioned before, which need to be designed specifically for the task. You can't buy standard, off-the-shelf, commercial equipment and expect it to stand up in the cockpit.

To be of use as a flight deck recorder replacement camera, the camera recorder system must be of sufficient resolution to capture at least the graphical information from flight deck instruments, preferably the full textual data. The difference between those is very significant. It has a great cost implication and a great technology implication.

Moving from being able to identify that an instrument is working and being able to see the marker, as you see here, to being able to read the text going around the -- the instrument, that's a big step.

These high-resolution digital images can be compressed using JPEG compression techniques to a file size of perhaps 100 to 200 kilobytes for the high-resolution images. Standard -- a standard NTSC sort of image will be compressed at around 20 to 30 kilobytes, as we heard earlier.

But these high-resolution images to give you the data from the flight deck instruments will be bigger in size. That can be transmitted by Ethernet, much as was laid out earlier.

These technologies are well understood, stable, and based on a huge number of systems in commercial use every day throughout the world.

So, in conclusion, I believe that the case for the benefits to be derived from the recording of the flight deck are unanswerable. The technology is available and in use daily. While there are undoubted technological difficulties to be overcome in adopting these technologies to airborne systems, these are by no means insurmountable. A fully qualified technical solution could be available within months and at a reasonable cost.

Thank you.

CHAIRMAN CARMODY: Thank you, Mr. Horne.

Questions from the Technical Panel. I believe Mr. Brazy is going to be asking those.

MR. BRAZY: Yes, ma'am. Thank you.

Mr. Shie, you indicated in your presentation a figure of four hours of recorded video per video channel. Could you expand upon that a little bit and -- and tell us what types of frame rates and image sizes we would be talking about to achieve those rates in the context of the specifications in ED-112?

MR. SHIE: To actually get that answer, it's a combination of things in terms of your compression ratio, the frame rates, the size of your memory --

CHAIRMAN CARMODY: Mr. Shie, would you speak into your microphone? I'm sorry. Some of us are having --

MR. SHIE: My kids say I'm loud enough.

(Laughter)

MR. SHIE: Yes. So in the context of what we're doing at NAVAIR, we're getting -- seven frames per second, and compression ratios of 250-to-1 and we're able to come up with some very good image quality with four hours per channel -- and that's times two video channels in that context.

Now, if you change your frame rate, you change your compression ratios, you change your memory size, those can -- again, if we're just talking video only, you could probably get more recording time.

So it's a variable parameter and not fixed.

MR. BRAZY: Thank you.

That -- the frame rate that you mentioned exceeds the minimum frame rate as specified in -- in ED-112.

MR. SHIE: We're finishing a -- we'll be delivering a video with two audios for a UAV application that will achieve 30 frames.

MR. BRAZY: You said 30?

MR. SHIE: Thirty frames.

MR. BRAZY: In terms of what can be captured from each individual still picture, one-seventh of a second, in your experience, using the compression algorithms that you -- that you are testing at this time, do you believe that they will meet the -- the resolution specifications in terms of not the size or the number of pixels but the resolution, and can you resolve the distance between the lines on this test pattern, such as the pattern that's in ED-112? Do you think -- or, do you know if that's achievable?

MR. SHIE: Yeah, it's definitely achievable. In fact, I invite all of you here to come and see me in southern California and we can demonstrate -- we can show this to you. I mean, it's -- this is one of these things that you have to see with your own eyes and not just take my word for it.

But the power of being able to address each frame is enormous. Being able control the compression ratio, these types of variables that you've haven't been able to do before, is -- is incredible. And then, you have the idea of being able to track objects and not the entire scene.

So if you're looking at the instrumentation panel, you're looking at specific dials, you can look at specific zones on those dials and that's the information that you're interested in. But the things out the window, things you're not interested in, those go over at a much lower rate.

MR. BRAZY: It's my understanding that you're in the middle of trying to meet ED -- the full set of -- of specifications in ED-112, and my question is, thus far, have you encountered any significant hurdles that were extremely difficult or even impossible to achieve to your -- in your testing it to date?

MR. SHIE: As a new guy on the block, I'm happy to have standards. But our customer is -- PMA 209, and they give us our statement of work and we do our bill to that.

Now, the things I've talked about today I can demonstrate already to you on the ground, everything I've talked about. We're in the process now of getting additional funding to complete the work that we need to do in terms of finishing the crash memory, which I think will be a non-trivial issue but an addressable one. That's something we still have to prove.

MR. BRAZY: Great. Thank you. That's all I have for you for now. I'm going to ask a couple of questions of Mr. Horne. But after -- when I'm through, Mr. Grossi has some additional questions for you. Thank you very much.

Mr. Horne, my first question to you is, have you determined yourself or do you know what image size in terms of pixels will satisfy the -- the specifications in ED-112 for both the Type A and the Type C recorder? And if you could give us some context, how does that size relate to an NTSC television image size?

MR. HORNE: The Type A, which is the general area, could be done with a standard NTSC type camera. The Type C, where you're trying to pick up -- trying to read instrumentation, is a much harder task. We reckon something like 3000 pixels spread across the width of the instrument panel.

Now, if you think of a standard -- standard camera, NTSC type camera, maybe 600 pixels, something like that. That would be five of those, or it would be one mega pixel camera, which could be clocked. So you could do it in a variety of ways. Obviously, if there are more cameras, there's more real estate needed in the flight deck, so getting it down to one camera would be ideal.

The technology is there now. There's -- it was only marginally there when we were writing ED-112, but it's actually there and proven and you can go out and buy mega pixel cameras now quite easily. So we're looking at something like a six mega pixel camera, which is readily available, not expensive. There needs to be some -- have a back end on it, but the technology is certainly not novel.

MR. BRAZY: Thank you.

Can -- can the intent of the Safety Board's recommendations for -- for small turbine-powered airplanes, along with the specifications in ED-112, effectively be met with just one camera stream -- one camera or video stream? If not, or if so, would it also be beneficial to have more than one camera in -- for some other purposes? I know you've -- you've already answered a portion of that question already, but do you see any benefit to or need to use two cameras to achieve a different goal, a lower cost?

MR. HORNE: It depends. I mean, as a camera manufacturer, I'll design anything that you want me to do. If you want me to pick up a piece of data out of an instrument panel, I'll do that. I'll come up with a camera that will do that. If you want me to -- to show you where there's smoke in the cockpit, I can do that. The two may be achievable with the same camera, or they may not.

At the moment, as I see it, instrumentation cameras are certainly achievable with one camera, one high-resolution camera. To what extent the general area or general cockpit view under Type A is achievable with the same camera, it depends on the extent of the privacy issues we have to handle.

There is -- if you can see the flight deck controls, you can see the pilot holding onto them and you can -- you see the air between the camera and the instrument panel, the flight deck controls, then you get a pretty good idea of what's going on on the flight deck as well, at the same time. And that can almost be seen to come as a freebie.

MR. BRAZY: In my experience in talking with -- with potential manufacturers or manufacturers of video recorders that are intended for the smaller turbine airplanes, virtually every one of them has mentioned the ability or the desire or testing that should be done in -- in regards of capturing audio as well in the smaller airplanes.

I know that your expertise lies mainly with cameras and optics, but are you aware of -- have you done or are you aware of any testing that's been done in capturing audio in small airplanes along the lines of a cockpit area microphone?

MR. HORNE: Yeah. It's not really much of an issue. The data required by a video recorder or a video tape just swamps the data rate required for audio. So you can -- you can actually do quite good quality audio without even a noticeable difference.

MR. BRAZY: As memory chip density and storage technology has increased since ED-112 has been issued, is it possible to achieve higher frame rates than those minimums that have been specified in the 112 easily?

MR. HORNE: It is. It's the same game that we were just playing a minute ago. You have a finite amount of volume. The recorder manufacturers are working very hard to move that up.

When we started writing ED-112, the standard crash-proofed memory block was 89 megabytes. When we finished writing it, it was four gigabytes. So that's the measure of how that moved in that time.

Once you have established what your bucket of memory is, you can then divide that up how you'd like. If you want to do it over a shorter time frame with faster updated images or a longer time frame with slower update or lower resolution, you can play all of those games, and it needs just a mathematical exercise then to work out what your update rate is at what resolution.

MR. BRAZY: Do you foresee any -- any difficulty in determining the location of or the mounting of cameras in these smaller turbine airplanes or helicopters in terms of capturing the data that's desired? Any vibration or blurring issues that may be imparted to the camera or other installation considerations to meet what's specified in ED-112, which I believe says to capture flight data.

MR. HORNE: We've done quite a few tests, quite a bit of testing. There are two bits to that question which I'd like to address separately, if I may.

The installation space is always a problem on small aircraft. It's always a problem on aircraft. It's always -- an increasing problem on older aircraft. Finding areas that you can mount anything in an older flight deck is a problem. It's not an insurmountable problem. There's always some way you can find to fit it. We've never yet found an area which is impossible or an aircraft that's impossible to fit to.

If I could relate it to the flight deck door monitoring system, when we started work on that, we were told that there was no way you could put an extra monitor on the flight deck to do video -- to show the pilot video from outside the flight deck door. We have not yet found an aircraft we couldn't fit a monitor to. And that's not doing anything extraordinary, pulling things out or pockets or anything like that. Standard mounting.

It can always be done. It's just you have to look at the aircraft.

To answer a question that was asked earlier, the difference with older airframes and the difference in the STC work as opposed to new build work is that you don't actually know when you approach the aircraft what installations they've got in already. That is a problem. You find that over 30 years of life of an aircraft, various people have been in, put various kits in, taken other kits out. It doesn't necessarily look anything like the identical aircraft next to it, which is a problem from the STC point of view as well.

With a well-written STC that gives you some flexibility in mounting position, there really shouldn't be a problem.

MR. BRAZY: And one last --

MR. HORNE: Sorry. There was a second part of the question.

MR. BRAZY: The second part of the question dealt with vibration and blurring or --

MR. HORNE: Vibration, okay. Mostly, we're dealing with wide angle sensors. If we're looking across a flight deck and also across an instrument panel, we're dealing with quite a wide angle. That sort of wide angle characteristic means that the vibration -- any vibration component is lessened.

You're actually not talking about the camera vibrating. You are talking about the instrument panel vibrating in relation to the camera. So with some aircraft, it is going to be a problem. It will never be a problem so much that you can't, for instance, read the graphics.

You know, one of the ongoing queries we had in Work Group 50 was in reading the graphics or reading the data. With digital instruments, obviously, you have to be able to read the data. The analog instruments or graphical representations of analog instruments. You can almost always get away with reading the graphics, and it'll almost certainly not be an issue to work out what is going on. We've done a number of trials and it's never been an issue to date.

MR. BRAZY: Do you feel or have any knowledge of -- that helicopters would have the same -- you would have the same type of success in combating vibrations in rotocraft?

MR. HORNE: We done quite a bit of work on helicopters as well, and it's the same issue, that if you -- the problem is if you try and look in directly on a small area at one instrument, then for certain periods of time and certain flight phases, that instrument will be vibrating wildly in comparison to the very steady camera. That is a transient phenomenon. It's not going to be doing that all the time, and it will come back in and you'll be able to read it as it goes through.

The other way of doing it, of course, the more sensitive camera is, the faster you can shutter it, and then the -- the less vibration you get.

MR. BRAZY: Thank you, sir. One last question and then I'll let Mr. Grossi finish off the Technical Panel questions.

Are you aware of any technology that exists to detect adverse conditions, such as inadequate lighting, overexposure, contaminated or intentionally blocked lenses, and along those same lines, are there any robust, built-in test equipment for testing the functionality of an entire video recording system?

MR. HORNE: Very easy to test if there's no video, if it's broken. If it's a whiteout or blackout, they're easy to check. Blocking the picture is quite hard. If someone were to 100 percent block it, you'd be able to detect that very easily. Partially blocking it, you have to look at it from the sensor’s point of view and see whether that could possibly look like an ordinary picture.

So some of those things are difficult, but mainly, if the camera's operating, then it will see what's coming out. They're very -- they really are very robust these days. Solid state have had a lot of hammer over the years. When I started in video, cameras were not in any way the same as they are now.

MR. BRAZY: I think that's -- I think that's

-- Dennis?

MR. GROSSI: Just a couple quick questions, I hope.

To follow up on -- on Doug's earlier question on the test capabilities, does ED-112 call for a self-test or a test capability similar to the cockpit voice recorder?

MR. HORNE: I don't know whether it does, actually.

MR. GROSSI: All right.

MR. HORNE: I think -- I think it -- I think it calls for a test to see that the link works, but I don't think it calls for a -- a loop test in the same way as a cockpit voice recorder.

MR. GROSSI: I think we can adjust the record later.

MR. HORNE: Thank you.

MR. GROSSI: You also stated that you were the secretary of Working Group -- the subgroup in Working Group 50 that handled the image recorders. Were there -- and you also stated that there were pilots group participation in that group.

Could you describe the level of participation? Were they casual observers or active participants?

MR. HORNE: I would say that all participants in the group were active. There were very few people who came along to listen. It wasn't that sort of forum. The forum was very voluble and everybody made their point and made their presence known.

MR. GROSSI: I think you also stated that you have some security systems currently flying on -- on commercial aircraft. Could you describe those systems and -- and also touch on any lessons learned from those systems that could be applied to cockpit image recording?

MR. HORNE: I think you're specifically alluding to the work since 9/11 which we've done on securing the flight deck door. We have some 3- or 400 aircraft fitted now with cameras around the flight deck door. These are not recorded. These are shown to the pilot in real time for the pilot to decide on the security outside his door and decide whether he can open it and so on.

There is -- we have some things there that can read across, certainly on the low resolution side. These are not particularly high-resolution cameras. They're standard NTSC type cameras. But for a flight deck area view, that would be sufficient.

MR. GROSSI: How about for the -- the

different lighting situations you'd find in the cockpit versus the cabin?

MR. HORNE: What we -- again, it's a question of what the requirement is. For the flight deck door monitoring systems, because they're a security system, they -- we decided -- in fact, in the absence of any specification or standard, we decided that they had to work under all lighting conditions, i.e. down to zero lux. If a terrorist or hijacker or whatever broke all the lights, then you still needed to see what was going on outside. So we put infrared lighting in at that point.

The specific requirement in ED-112 which meant that we couldn't do infrared lighting in ED-112 was the requirement for color. There was a consensus in the group that color cameras, color sensing, was required to be able to see the instruments properly and to be able to see the pilots properly. And that was a driver, and that means that you can't have infrared.

So we deal with that, and we deal with it in other ways. We expose for longer or we -- you know, there are a number of ways we can get more sensitive instruments.

MR. GROSSI: Okay. I've got a cross-related question to Rick. You're more or less producing an end-to-end system with a recorder and camera. I want to give you an example type installation, and hopefully you'll be able to give me an estimate of cost.

For a single-camera system capable of recording the cockpit instrumentation with sufficient resolution to -- to extract parametric data from the instrument panel, could you give me an estimate of the cost for a system similar to that?

MR. SHIE: Yeah, sure. Again, it depends on the bells and whistles, but we just finished a quote. I think we were somewhere between $3- and $5000 for a crash memory single video-only box. If you want audio, things like that, that drives cost. But we're trying to keep these things inexpensive, and that's the way we designed our architecture, is that you could add to, take away, minimize features. If you wanted to put them on a taxicab, of course they wouldn't need to be crash, and that was our thought in designing the system.

MR. GROSSI: I asked the recorder manufacturers, the other panel members, earlier about reducing the crash survivability standards and what effect that would have on the cost of the recorder. Do you have any --

MR. SHIE: A lot -- a lot. It would have a lot. The crash survival standards, it would help a lot to reduce the cost. In, again, the UAV that I talked about earlier, I'm just surviving a drop and not a crash. So we're adequate -- I guess that's the thing, is what can you -- what can you survive.

MR. GROSSI: Okay.

MR. HORNE: Can I just add something to that?

MR. GROSSI: Yes. I was going to ask you next if you had some cost numbers that you would like to share with us.

MR. HORNE: Okay. I'd just like to add something to that last comment. The question was asked at Working Group 50 about whether we could define a lower range of environmental conditions or crash conditions for smaller aircraft types, and after much head scratching, it was decided that we couldn't. So I don't know whether -- I'd throw that one back to the NTSB.

MR. GROSSI: Thank you.

Do you have any additional cost information that you could share with -- with the hearing?

MR. HORNE: What are you thinking of?

MR. GROSSI: Again, the single-box system, single-camera system?

MR. HORNE: Well, I don't -- I don't do the recorder.

MR. GROSSI: Okay. All right.

MR. HORNE: But I would guess, for instance, standard NTSC cameras come in about $1500, something like that.

MR. GROSSI: It was voiced by the earlier panel members that -- that one of the big cost drivers would be the installation cost. Is that your understanding, both of you, also?

MR. HORNE: I take it from the flight deck monitoring -- flight deck door monitoring systems. To give you a ball park of where we are now of of a -- the LRUs for such a system being around $10,000. The installation kit, I think, all the wiring and bracketry and so on, as being around $5000. STC costs to certify a kit like that on an aircraft type being around $30,000.

MR. GROSSI: That STC, would that be a one-time cost?

MR. HORNE: That would be a one-time cost.

MR. SHIE: In our case, the cost -- you know, we're just doing the box, but where you locate it is a cost parameter. If you can get it close to the cockpit, that would reduce the cost of installation, certainly.

MR. GROSSI: And I take it that the installation cost would vary as to how much intrusion you have to make into the aircraft systems?

MR. HORNE: Of course.

MR. GROSSI: The more intrusion, the higher the cost.

MR. HORNE: Yeah. I think what we can talk about now is ball park figures.

MR. GROSSI: Right.

MR. HORNE: We'll find out more when we start doing it.

MR. GROSSI: Okay. Mr. Horne, just a general question. Why in ED-112 do we refer to the image recorder rather than video recorder?

MR. HORNE: We didn't want to specify video as a technology. We wanted to look at -- leave it open to any imaging technology that there might be in the future.

MR. GROSSI: Okay. A quick follow-on question to the TSO requirements for the camera system on -- as you understand it.

Is ED-112 adequate to define -- to write a TSO?

MR. HORNE: I would have thought it was. Perhaps I'd defer to the regulators to see whether they think that, but I would have thought there was sufficient in there. Certainly, there was regulator input into the document. I would hope there is.

MR. GROSSI: Okay. A quick question. There was some testimony earlier in reference to a CAA flight deck image recorder trial. Are you familiar with that?

MR. HORNE: Yes. We took part in that.

MR. GROSSI: Did you -- you participated. Would you describe your involvement in that test?

MR. HORNE: It took place in October 2002 in a simulator in south England. It was funded by the CAA. We provided the kit -- the cameras, and they're just standard cameras, and the digital recorder. Also, a CVR and a flight data recorder were linked up.

The different sets of data were obtained from four scenarios which are set, I believe, by the AAIB. And those recordings were then sent off to different sets of accident investigators to see whether they came to the same conclusions based on the video data and on the traditional CVR and FDR data, and mostly they did.

There were several interesting things that came out of it. There were several issues of work load that were not shown on the CVR or the FDR.

Strangely enough, we had two instances where the either partial panel or full panel failure was initiated, and in neither case did the pilot actually say to the other pilot that he had a panel failure. He just pointed. So of course, on the CVR and the -- the accident investigators who were looking in just the FDR and the CVR data, had no idea that the copilot had no panel.

We had another one -- I'm picking out -- I'm being quite selective here, but another instance where the smoke was introduced into the flight deck and the pilots went on oxygen. And during the course of putting on his oxygen mask, the captain knocked his glasses off and spent something like 30 seconds trying to find his glasses. That again was not recorded in the CVR or the FDR, strangely enough, his glasses not being wired up.

MR. GROSSI: Thanks. That was very appropriate testimony for the previous session on investigative themes. Thank you very much.

But your involvement was specifically to install the cameras, is that correct?

MR. HORNE: Correct, yes.

MR. GROSSI: Okay.

MR. HORNE: Yes, yes. We installed the cameras that look across the instrument panel and to look at the general cabin -- cockpit view, and then we retired and awaited the results.

MR. GROSSI: What are the lessons learned from this strictly on a technical level as far as the --

MR. HORNE: There were quite a lot of interesting results, actually. First of all, there were some positive things. We found that we could actually pick up the instruments and read the instruments in all light levels. There were some times that the general lights in the -- in the cockpit were switched on, and that was fine. And there were other times that it was flying full night simulation, which is the normal status for a simulator, and in those cases, there was good definition out to the instruments because they were all illuminated.

So there was -- there was quite a lot of good stuff that came out of it. We were marginal on the resolution, I'd say. We had four cameras across the width of the flight deck, which I thought was sufficient when we started the trial, and I probably should have made it five.

CHAIRMAN CARMODY: Excuse me. Mr. Grossi, you said you had a few quick questions.

MR. GROSSI: I'm sorry.

CHAIRMAN CARMODY: Do you have many more, because it's 5:00.

MR. GROSSI: We're just about -- that's just about it. I have like two more to go.

CHAIRMAN CARMODY: Let's try to move forward, because we have parties to ask questions, too.

MR. GROSSI: Okay. Pretty much, that's -- that's it, Mike and Rick. Thank you.

CHAIRMAN CARMODY: Okay. Thank you.

Is that it for the Technical Panel, then, at this point? All right.

Moving to the FAA. Mr. Wallace, any questions?

MR. WALLACE: Just quickly. I've heard some numbers here, and just to follow up. I know we had some discussion on cost with Mr. Shie, but you -- you threw a number out, $3- to $5000. That's -- people who put things in airplanes know that that's the price of an ash tray. So, is that including --

MR. SHIE: I guess I come from the car industry, so that's --

MR. WALLACE: The -- the -- so this FAERITO box that can -- can record so many channels between -- between, say, these -- if there are a few cameras on the flight deck, is there some other devices in there, or processors or something in between?

MR. SHIE: Yeah. It's actually a fairly sophisticated system, but again, we -- our company is very OEM-driven. I mean, our product lines go into products that other people make, so we're very sensitive to the cost of things and the practical use and how to implement them. So --

MR. WALLACE: Well, okay. I don't want you to redescribe the system or anything, but bearing in mind here that we're looking at a -- a recommendation for a retrofit --

MR. SHIE: Right.

MR. WALLACE: -- I'm just looking for, if there is a realistic number that you might come up with that's not the price of, you put your box on the table and how much money does someone have to put there to take the box away, but rather the bottom line for -- for an operator who has to meet whatever rule might -- might evolve here.

MR. SHIE: Is the FAA telling me the price was too low? (Laughter)

MR. WALLACE: Well, you have a number on the record here of $3- to $5000, which then gets tossed out in the public debate about what's -- what's feasible and what isn't.

MR. SHIE: A lot depends upon the bells and whistles that you want. If you started adding things, we'll talk about a single channel video box with crash memory, that's a doable number. As I said, we've got an RFQ that we just completed of a similar nature.

Now, if you start adding other things to it, removable memories, on and on and on, the price tag goes up, but I would say fairly in line with what was said earlier -- the session earlier.

MR. WALLACE: Nothing further. Thank you.

CHAIRMAN CARMODY: Thank you.

Mr. Barimo with the ATA?

MR. BARIMO: No, we don't have any further questions. Thank you.

CHAIRMAN CARMODY: Mr. Lotterer with RAA?

MR. LOTTERER: Just a few quick ones.

CHAIRMAN CARMODY: All right.

MR. LOTTERER: A follow-up to Mr. Wallace's comment.

Mr. Shie, do you have a PMA?

MR. SHIE: You mean with the government?

MR. LOTTERER: With the FAA. Have you ever done business with the FAA?

MR. SHIE: No, we have not, and our -- well, I guess we did do a flashlight project at the recommendation of the FAA where they were doing aircraft inspection and we worked with Sandy at National Labs in the evaluation for inspection of the aircraft, because we had a diffusing capability. So in that regard we have, but not directly. Our -- our business has been primarily commercial, and now, with this flight recorder, our -- our main customer is Pax River 209. That's our main customer.

MR. LOTTERER: I think what Mr. Wallace was alluding to is, it's tougher to do business with the FAA than the military.

A question for Mr. Horne. In terms of -- you described the retrofit of five -- five lenses or five sensors. What type of aircraft was that in?

MR. HORNE: The CAA trial. Is that what you mean?

MR. LOTTERER: The what? Yeah.

MR. HORNE: The CAA trial. That was in -- that was a simulator.

MR. LOTTERER: A simulator for what type aircraft?

MR. HORNE: A 737.

MR. LOTTERER: Have you ever worked on smaller aircraft, commuter category type aircraft?

MR. HORNE: Yes, I have. I've worked on Jet Star.

MR. LOTTERER: The Jet Star.

MR. HORNE: Citation. Citation 1 and Citation 2.

MR. LOTTERER: I guess I envision these lenses to be behind the captains in order to be able to see the instrumentation.

MR. HORNE: Yeah. Ideally, almost directly overhead, actually.

MR. LOTTERER: Yeah. And if -- if you can't get there on a particular aircraft, would you envision some type of bracket, or how far away do you have to be from the instrumentation panel in order to have a good acuity?

MR. HORNE: You said the right thing. It doesn't matter -- it doesn't actually matter how far away you are. What matters is that you have a clear line of sight. So if you're the wrong side of the pilot, that's a problem. But you can be as close as you want. I've done systems where, for instance, the cameras fitted under the glare shield. I've done systems where the camera is fitted in the overhead instrument panel.

The -- certainly, a proper installation -- not a trial installation, a proper installation -- would be flush mounted with the other instruments.

This is the sort of thing that we're doing outside the flight deck door.

MR. LOTTERER: Thank you.

CHAIRMAN CARMODY: Mr. David with the Allied Pilots.

MR. DAVID: Thank you, ma'am.

As a follow-on to Mr. Brazy's question, is any work being done to ensure the cameras are not easily defeated?

MR. HORNE: Hard question to answer, really. You can always defeat a camera. You can always -- you can always put a piece of chewing gum over it. You can always hang your hat over it. We've certainly had that in the past, and an earlier speaker alluded to the same.

The real question is a question of trust. You don't -- if that camera is there for a reason and the data is not going to be used for anything other than that reason, then there's no reason to distrust it.

MR. DAVID: We had the same issue with the circuit breaker.

ED-112 calls for the pilot's head and shoulders to be excluded. I noticed in your picture of the single-camera installation, it showed the pilot's shoulders. How does that comply with the privacy restrictions of ED-112?

MR. HORNE: Those pictures I showed there and various other ones were done during the development of ED-112 or were done as trial installations where you really get what you're given. You have half an hour to find out the ideal place.

So some of them are marginal, pushing it. I don't know what you want to say, but some of them are not where we'd locate a camera for an actual installation.

MR. DAVID: With the privacy sensitivities obviously, marginally is not acceptable to us.

MR. HORNE: I agree.

MR. DAVID: Will that one camera -- sir?

MR. SHIE: May I address that issue, also?

MR. DAVID: Please.

MR. SHIE: Because, with our compression, I don't think this is fully understood, is because not only is it motion based but it's object-oriented. So you can select objects that you want to see and manipulate the image quality, but you can also do the inverse of it. So let's say that I wanted to block your -- your head and your shoulder area. We could actually draw a box and fix that area where it's completely blurred. But the other data points in the background, things that you want to see, could come over with a very high resolution. That's very -- very doable.

MR. DAVID: I did pick that out of what you talked about.

Again, back to Mr. Horne, your single-camera installation, will that camera pick up small items, like we talked about CPDLC messages and the overhead panel. Will that single camera pick up every include?

MR. HORNE: You certainly couldn't get the overhead panel from a single-camera installation, especially if that single camera is in the overhead panel.

On the other hand, we look to the CAA trial, one of the slightly unexpected results was that we ended up with some cameras that were looking along the plane of the overhead panel at the top of their screen, and that was not really -- we didn't really expect to be doing that. We were focusing down onto the instrument panel, but the top of the field of view just happened to be along the top of the -- of the cockpit.

And what that meant was that we picked -- we did pick up lights and switching that -- when the pilot reached up to switch something, we could actually tell with the layout of the cockpit what he'd switched.

MR. DAVID: We have a great many switches which are as far as I can physically reach up above me, so there is a lot to be picked up up there.

Lastly, we talked about auto-iris cameras. I'm not familiar -- I don't know what an iris is, obviously, but are the cameras effective in a rapidly changing oscillatory environment, where you happen to be going out of direct sunlight to dark, direct sunlight to dark, in a rapid manner?

MR. SHIE: Well, in the application that we did for -- as I said, for DARPA -- I can't say what that was about -- but it was a fairly sophisticated imaging system that had to be deployed and utilized Omniview, where you had one lens and one camera in an environment. And you can imagine they put it out somewhere, dropped it somewhere, and the antenna goes up and then it just looks. So it's got to be able to withstand the daylight and then transition to starlight. It's got to work in starlight.

And so having the IR camera -- a single lens, a single camera, with an auto iris, was a good solution -- was very good in terms of making that transition (day/night) and also providing the image quality that was acceptable.

MR. DAVID: What about a rapid transition? You're in an aircraft that's now in an upset, it's oscillating very fast back and forth from direct sunlight to dark. Will it transition that fast to give you a usable image inside the cockpit?

MR. SHIE: Ours wasn't intended to do that, but my colleague probably has a better answer.

MR. HORNE: You can -- you could certainly make a camera that is capable of doing that. Normally, to smooth out changes, you would slow things down so that it had maybe a quarter second transient from dark to light, something like that. But you could certainly speed that up.

I just want to pick up on one point. "Iris" is a bad word. You don't want to have any mechanical moving parts. Vibration of the flight deck doesn't agree with mechanically moving parts.

MR. DAVID: Thank you. Thank you both.

CHAIRMAN CARMODY: Captain Fenwick of ALPA.

CAPTAIN FENWICK: Thank you, ma'am. Just three questions for Mr. Horne.

I'm wondering if you could help me clarify some impressions that perhaps are being created by Mr. MacIntosh and Mr. Grossi from the Board. With regard to the activities of EUROCAE Working Group 50, would it be a fair characterization to say that the going-in position, the going -- the mandate for this group was basically that image recorders were coming and that they were going to be developed?

MR. HORNE: The reason for the group was to work out how CNS/ATM recording could happen. In meeting one, one of the possibilities of recording CNS/ATM information was tabled as being to put a camera on it rather than trying to get -- stream the data out in the back of it. It was that point I joined the group. I wouldn't say that there was any preconception at all.

CAPTAIN FENWICK: Okay. And in terms of Working Group 50 being an industry effort, would it be also fair to say that although there was certainly interest and participation by airframers, regulators, pilot associations, and operators, that the two drivers in defining the needs and defining the technical specs that ultimately became ED-112 were two groups in particular: on the one hand, the black box and camera manufacturers, and on the other hand, a few investigative agencies?

MR. HORNE: The way that the group operated was that a fundamental needs paper was drawn up which was -- the group drawing up the fundamental needs paper was almost entirely made up of accident investigators of various nationalities. Only when they had finished their work and come up with a completed fundamental needs document was the technical side came into it to write the technical side to the fundamental need.

CAPTAIN FENWICK: Thank you.

And just one final question. With regard to smoke -- and I know we refer to that a lot here -- but I'm looking back at Swissair 111 and ValuJet and some of the other accidents in which there's been smoke in the cockpit. Has your company done any testing of your hardware, your cameras, in terms of the minimum threshold at which your devices can detect smoke and, on the other end of the spectrum, the density levels of smoke at which the utility of your devices becomes degraded?

MR. HORNE: It's -- that's an easier question to answer than it is for you to ask, actually. If you can see it, the camera can see it. If you can't see through it, the camera can't see through it. Simple as that.

What that means, we've done extensive FAA trials, actually, on another program to see at what stage smoke becomes detectable. And it becomes detectable at the same time as you can see it with your human eye, and that is a not-unexpected result, I think.

CAPTAIN FENWICK: And would it be fair to say that perhaps you could smell it before you could see it?

MR. HORNE: You would -- there are certainly types of smoke that do not present visibly and there are fumes which do not present visibly, and the camera -- at the end of the day, the visual sensor will see what is visibly in front of it.

There is another aspect to this that -- which hardly needs stating, but the camera will not see things that it's not pointed at. So one of the conclusions from the CAA trial was that the camera system did not notice somebody coming into the flight deck because there was no camera pointed to look at somebody coming in from the flight deck.

CAPTAIN FENWICK: Thank you very much.

CHAIRMAN CARMODY: Thank you.

Ms. Rosser, any questions?

MS. ROSSER: I just have one clarifying question. It was stated that you as a manufacturer would make whatever people wanted. If you want to see the smoke, we can get a camera for the smoke. If you want colors, we can show you that.

I guess my question is, you sort of presented it as separate cameras can do separate things. Can you get one camera that does all of those things?

MR. HORNE: Yeah.

MS. ROSSER: And is that a substantially more expensive camera than one that just is going to have a single purpose?

MR. HORNE: I'm afraid the answer is it depends. With a lot of these parameters, they run together, and some of them run in the opposite direction and sometimes you have to make compromises on the parameters. But mostly, if you're making a good sense of it sees what is in front of it, then that's what we need.

MS. ROSSER: I don't have any other questions.

CHAIRMAN CARMODY: Thank you, Ms. Rosser.

Starting with the Board of Inquiry, Mr. MacIntosh, any questions?

MR. MacINTOSH: Well, I think it's been very enlightening for both -- from both of you.

Mr. Shie, I think you've invited us all to California.

(Laughter)

MR. SHIE: With the weather here, now is a good time.

MR. MacINTOSH: And, Mr. Horne, you've told us the technology is here now. We've heard about this Pippa Moore study, pluses, minuses. Interesting.

Gentlemen, where do we go from here? We've got -- we've got a local -- we've got a local newscaster that's a good guy, Bill O'Reilly. No spin zone. He always gives his guests the last word. Summarize in a minute or two where should we be going? Where should we be going right now?

We've got GPS, GPWS, EGPWs, all these things that we've seen come down the line historically, and now we're looking at another tool. Tell us where should we be taking that tool.

Mr. Shie, do you want to start?

MR. SHIE: The technologies we have today are incredible. You've got a comdexing of a lot of technologies converging to solve a lot of different needs. I've never seen technology come together like this before -- technologies we never thought would even relate to one another are now beginning to solve real problems.

I think the technology is here. I certainly know from an optic standpoint and also from a recorder standpoint, the technology is here.

MR. MacINTOSH: Is the airframe here? Is the airframe ready for the technology? Put it on, give it a try, see what it looks like.

MR. SHIE: We'll be doing that with our military customer here very soon.

MR. MacINTOSH: Are we allowed to look over your shoulder?

MR. SHIE: You have to ask the boss.

MR. MacINTOSH: Okay. Good. That's a question. Thank you. I appreciate that one.

How about Mr. Horne?

Did I cut you off? I'm sorry, Mr. Shie. Do you -- okay. Thank you.

How about Mr. Horne?

MR. HORNE: I think the problem is that --

MR. MacINTOSH: You're okay, et cetera. Big groups talking about it, talking it I won't say to death, because each one of these things develops more issues. And certainly, the professional pilots associations' points of view are very, very valuable.

MR. HORNE: Absolutely.

MR. MacINTOSH: But where are we going to go from here?

MR. HORNE: I think the problem is that any accident investigation tool is a cost to the airlines.

And it's not something they're going to put -- they're going to put money into without a mandate, without being required to do it.

With my other hat on, the cockpit door monitoring systems, we have various airlines who just think it's a good thing to do and the way to go. We aren't going to get any airlines volunteering to put video recording in their -- in their flight deck, I don't think. Certainly, we've been around a number of them and at the moment money is tight.

But -- so I think we do need to push, and I think the specific is -- is the new aircraft that are coming online, new aircraft that are in design now. And I think if we -- if we miss the chance to get on new aircraft right now, then we put the project back for a number of years and we'll never find out what the true potential as an accident investigation tool is.

MR. MacINTOSH: Thank you very much.

CHAIRMAN CARMODY: Mr. Battocchi?

MR. BATTOCCHI: No, thank you.

CHAIRMAN CARMODY: Okay. Dr. Ellingstad?

DR. ELLINGSTAD: Just a couple of questions, particularly focused on the -- the Class C or Type C recorder.

Mr. Shie, you talked about the -- the image processing capabilities where you would have certain areas of an image at a higher resolution than others. Does -- does the sort of recorder that you had projected at $3- to $5000 include that kind of technology?

MR. SHIE: Yeah. We were talking about a single video channel, video compression, and a crash box. And it would have that.

DR. ELLINGSTAD: And that particular processing, that's happening between the camera and the box?

MR. SHIE: Yeah. It's -- it's -- yeah. It goes -- you take your full video, you compress it. It's then recorded and stored, and then you -- at the other end, when you're ready, you decompress it and then you have a full capability playback.

DR. ELLINGSTAD: Yeah. It sounded to me as though there's a number of things possible. Is it possible, for example, in the small aircraft environment to essentially configure a template that would allow you to defeat your particular instruments and only use your higher resolutions for those --

MR. SHIE: Yes. It could take in the full scene or it can take in portions of the scene. You can -- we can set the box to record a certain way, or we can have the box where the user can define what things they want to look at, like in a security application, for example. Maybe you want to see a bad guy in the parking lot, and then they just go over and take a look.

DR. ELLINGSTAD: Are there any appreciable delays due to that kind of a process?

MR. SHIE: In terms of setting up the box, no, it's just a matter of punching a couple of keys.

DR. ELLINGSTAD: Okay. And this would be -- this could be accomplished with a single camera installation in those kind of aircraft?

MR. SHIE: Yes.

DR. ELLINGSTAD: Mr. Horne, in terms of your response to that same -- that same kind of a small aircraft situation, you're also anticipating a single camera operation but essentially capturing a relatively higher resolution image?

MR. HORNE: Yeah, I think that's right. I think that's the way to do it. I'm very interested to see -- to see Mr. Shie's technology.

MR. SHIE: You're welcome.

MR. HORNE: I'll be over.

DR. ELLINGSTAD: Thank you.

CHAIRMAN CARMODY: Mr. Cash?

MR. CASH: Just one question.

Mike, what -- what -- if you drop the pilot constraint, you know, as far as the -- the ED spec does say to the maximum extent possible. But say you just drop that. I mean, how much -- how much of the camera views and stuff is being driven by the -- the pilot requirement, basically?

MR. HORNE: Quite a lot, quite a lot. We did a lot of work early on before ED-112 and around the start of ED-112, and we certainly developed locations of cameras over the course of ED-112 to satisfy the pilots.

But, you know, I believe the pilots are fully competent professionals and any, you know, video capability should show they're carrying out the correct procedures. I don't really see what the problem is.

MR. CASH: How does that affect -- how much would that affect the cost or the --

MR. HORNE: It's not a cost driver. It's just -- it's just an awkwardness driver.

MR. CASH: Well, it's cost if you have to have five cameras to do the job that you could probably do in one if you didn't have that constraint.

MR. HORNE: Yeah, yeah. It could be, it could be a cost driver. I mean, it's certainly makes it a lot more difficult to do an installation and define a suitable installation. You know, it could be that it ends up having to -- having to split the cameras merely to get the views that you need.

MR. CASH: How about in the smaller aircraft? Is that --

MR. HORNE: It would be hard.

MR. CASH: It would be hard to --

MR. HORNE: Probably -- probably harder than in a larger aircraft to find a location.

MR. CASH: That's it. Thank you.

CHAIRMAN CARMODY: Thank you. Thank you, Mr. Shie and Mr. Horne, for your testimony and for answering our questions, and you're now excused.

(Whereupon, the witnesses were excused.)

CHAIRMAN CARMODY: At this point, I will adjourn the hearing for the day, and we will reconvene tomorrow at 11:15 and start with the Legal Panel.

Thank you for your attention.

(Whereupon, at 5:25 p.m., on Tuesday, July 27, 2004, the proceedings were adjourned, to reconvene at 11:15 a.m., on Wednesday, July 28, 2004.)