NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

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In the matter of: :
:
THE INVESTIGATION OF THE USAIR, INC. :
FLIGHT 427, A BOEING 737-300, N513AU : Case No. SA-510
ALIQUIPPA, PENNSYLVANIA :
SEPTEMBER 8, 1994 :

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Springfield Hilton Hotel
Caribbean Ballroom
6550 Loisdale Road
Springfield, VA 22150

Thursday, November 16, 1995

The above-entitled matter came on for hearing pursuant to notice, at 9:05 a.m.

Board of Inquiry:

Jim Hall, Member NTSB
Chairman

William G. Laynor, Technical Advisor
Office of Managing Director

Ronald L. Schleede, Deputy Director
Office of Aviation Safety

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Materials Laboratory Division
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John Clark, Chief
Vehicle Performance Division
Office of Research and Engineering

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P R O C E E D I N G S

(Time Noted: 9:05 a.m.)

CHAIRMAN JIM HALL: We will reconvene this Board of Inquiry and call as our next witness, Mr. Walter Walz, the Customer Service Representative for Parker Hannifin in Irvine, California. I appreciate your presence here this morning, sir.

(Witness testimony continues on the next page.)

WALTER WALZ, CUSTOMER SERVICE REPRESENTATIVE, PARKER
HANNIFIN, IRVINE, CALIFORNIA

Whereupon,

WALTER WALZ,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows:

MR. SCHLEEDE: Mr. Walz, could you please give us your full name and business address for the record?

THE WITNESS: Walter James Walz, Parker Bertea Aerospace, Irvine, California.

MR. SCHLEEDE: What is your position at Parker?

THE WITNESS: Presently, I am retired, but I was manager of technical integrity.

MR. SCHLEEDE: Would you give us a brief description of your background and experience that qualified you for your position at Parker?

THE WITNESS: Forty-three years in the industry, 35 years at Parker.

MR. SCHLEEDE: And in the industry, referring to what type?

THE WITNESS: The aerospace industry.

MR. SCHLEEDE: Thank you. Mr. Phillips.

MR. PHILLIPS: Good morning.

THE WITNESS: Good morning.

MR. PHILLIPS: We've got Walter up there. I guess we've always called you Wally. Is Wally okay?

THE WITNESS: Wally is fine. Walter is my dad.

(Laughter)

MR. PHILLIPS: Well, I was told, we needed to be formal. We would like to talk a little bit with you today about Parker-Hannifin's support of its products and some other areas related to the main power control unit. I would like to start off with, in your position prior to your retirement at Parker, what were your responsibilities?

THE WITNESS: Manage and direct the engineering department, all the engineers and the jobs going through the plant.

MR. PHILLIPS: Okay. And that was in the

customer --

THE WITNESS: Service.

MR. PHILLIPS: Customer services division.

THE WITNESS: Yes, customer support.

MR. PHILLIPS: One of the products of that division is the main rudder PCU for the 737?

THE WITNESS: Yes.

MR. PHILLIPS: Did you -- what kind of activities did you manage in the engineering group? Was it tests?

THE WITNESS: Mainly, I would arrange and schedule the units coming in, make sure the engineers were available, any accommodations that were necessary, the test stands, the equipment.

MR. PHILLIPS: Coordinate the test activities then?

THE WITNESS: Absolutely.

MR. PHILLIPS: Have you been involved in any accident investigation test activities?

THE WITNESS: Yes, I have.

MR. PHILLIPS: Could you give us a brief summary of the ones that you remember?

THE WITNESS: Well, 585. I was up at United Airlines on that one. In Pittsburgh, I went back there for 427.

MR. PHILLIPS: In that role, you were acting as a Parker representative?

THE WITNESS: Yes, I was.

MR. PHILLIPS: Does the main rudder power control unit, does it have a warranty?

THE WITNESS: A new warranty, yes.

MR. PHILLIPS: What is that warranty?

THE WITNESS: Three years, I believe. I'm not really certain. I don't work on that end of that business, but I believe it's a three-year warranty.

MR. PHILLIPS: So when units are returned from operators in-service, they can -- like an automobile, they can have things fixed in a certain time period.

THE WITNESS: That's correct.

MR. PHILLIPS: And you think that there's three years on this. What would the warranty cover? Would it cover replacement of broken parts, worn parts?

THE WITNESS: Oh, yes. When you say "broken parts," it depends on how they were broken, but, yes.

MR. PHILLIPS: So if it was a result of some kind of manufacturing defect, you would --

THE WITNESS: We would warranty them; that's correct.

MR. PHILLIPS: Do you have any kind of system at Parker that tracks manufacturing defects?

THE WITNESS: Absolutely. We have a reliability -- yes, we have a reliability program. Every unit that goes through the plant, there's a history folder that follows it and everything that's done to the unit is recorded in that history folder. And when it gets to the end of the trail, the back door, ready to be shipped again, that history folder then goes to a reliability group where the data in there is extracted and put into a database.

MR. PHILLIPS: What kind of information is in this history folder?

THE WITNESS: Normally, we record part number, customer, date, reason for return, what else we found wrong with it beside the reason for return, what repairs were done to it, and the major components that were replaced.

MR. PHILLIPS: And then the reliability group studies the information in this folder every time a new folder comes to them?

THE WITNESS: When you say studies it, they look at it. They know what it is and they put it in the database.

MR. PHILLIPS: So then every power control unit that's been worked on by Parker, there's some record of everything that's been done?

THE WITNESS: Yes, that's correct today.

MR. PHILLIPS: Do you also keep records of tests that were done in that folder?

THE WITNESS: Absolutely. Yes, we do. I believe it's in the same folder. There's a time when it goes into the quality control file system, but -- and that's usually off on another site.

MR. PHILLIPS: So then if I would take a 737 that's operating on the flight line for most any operator, if that power control unit has been worked on or serviced by Parker, there would be records as to what was done --

THE WITNESS: That's correct.

MR. PHILLIPS: -- and the test results. How long are those records kept?

THE WITNESS: Ten years, to my knowledge. It might be longer.

MR. PHILLIPS: Is there any requirement for you to keep those records?

THE WITNESS: We've been trying to find out what the official requirement is and we get many answers. Ten years we feel is safe and so we keep them ten, and I think that they're kept longer than that.

MR. PHILLIPS: Would that be an FAA requirement?

THE WITNESS: According to the QC manager, ten years is the number.

MR. PHILLIPS: In your experience at Parker, the years that you've been there, have you observed broken units come in to be serviced? Have you seen broken units come in?

THE WITNESS: Yes, I've seen some units that were broken. Broken is a pretty broad term, but yes.

MR. PHILLIPS: I was just going to ask, can you briefly tell us what would be a common return on the main rudder power control unit? What would you -- what would be the reason for returning to Parker? The most common that comes to your mind?

THE WITNESS: Well, the most common one is repair. That's all they tell us is repair.

MR. PHILLIPS: So the mechanic sends it back and says "repair this?"

THE WITNESS: That's exactly right. We put it on a test stand and we test it and find out what's wrong.

MR. PHILLIPS: The tests that you do, with no more direction other than repair, how extensive of a test do you do?

THE WITNESS: We do a complete receiving test, which is a complete ATP.

MR. PHILLIPS: Does that receiving test require you to test the hydraulic fluid that's contained in the unit?

THE WITNESS: If it's under warranty, we do. If it's not, we do not test the fluid in the unit. We flush it out before it goes on the stand.

MR. PHILLIPS: And why do you do that?

THE WITNESS: So the reservoir in our system won't get contaminated.

MR. PHILLIPS: So you don't want to move the dirt from that part into your test equipment.

THE WITNESS: That's correct.

MR. PHILLIPS: Do you have any test equipment that uses dirty fluid to test the components?

THE WITNESS: No, we don't.

MR. PHILLIPS: Has that ever been a requirement at Parker that you're aware of?

THE WITNESS: I think maybe over the years, we've made a few setups where we've done that, but it's been years ago.

MR. PHILLIPS: When you receive units for repair with just the statement "repair" on the tag, do you -- are you required to notify Boeing that a unit has come in for repair?

THE WITNESS: No. No, we are not.

MR. PHILLIPS: What kind of system do you have to let them know that you may be seeing a unit for frequent repair for the same calls?

THE WITNESS: I don't know that we have a requirement to notify Boeing if a unit comes back for the same thing. If we see something that's very unusual, we will normally notify Boeing. We will notify ROEM first and talk with them. Then they normally would contact Boeing.

MR. PHILLIPS: Is the FAA in this dialogue loop?

THE WITNESS: Not yet, it isn't.

MR. PHILLIPS: Not yet. Do you mean that it's not got to the level where it's important enough --

THE WITNESS: That's correct.

MR. PHILLIPS: -- to the FAA?

THE WITNESS: It may or it may not, depending on our conversation.

MR. PHILLIPS: Does Parker work on all the PCUs? Is there a requirement that Parker is the only approved repair station?

THE WITNESS: We would like to think that, but it's not true. We work on 25 to 30 percent of the units that are built by Parker. We repair and overhaul.

MR. PHILLIPS: Okay. So if you work on 25 to 30 percent, then the rest are being modified or repaired? I won't say modified. They're being repaired by people other than Parker?

THE WITNESS: That's correct.

MR. PHILLIPS: And who are those people?

THE WITNESS: I would say the biggest ones are the airlines themselves. Then there are some third-party shops.

MR. PHILLIPS: Who gave them the approval to modify or to work on -- repair those parts?

THE WITNESS: I would assume the FAA.

MR. PHILLIPS: In repairing those parts, are they required to use Parker documents to test documents and equipment?

THE WITNESS: By "they," who are you talking about?

MR. PHILLIPS: The operators.

THE WITNESS: The operators, yes, they usually do. The third-party shops, I don't know what they use.

MR. PHILLIPS: Do you provide to them the documentation and the test equipment they need to do the tests?

THE WITNESS: Are you talking about the third-party shops?

MR. PHILLIPS: The operators.

THE WITNESS: The operators, we do.

MR. PHILLIPS: The third-party shops, let's talk about them. How are they different than the operators?

THE WITNESS: They're a separate entity. They're in business on their own, and they have no connection with us whatsoever.

MR. PHILLIPS: In the critical design review report, a portion of that report addresses third-party or after-market repair. Are you familiar with that report? Have you read it?

THE WITNESS: Yes, I've seen parts of it.

MR. PHILLIPS: Do you have any comment about the recommendations that the FAA has made in that report or the CDR team has made to the FAA?

THE WITNESS: Can you be more specific on the recommendations?

MR. PHILLIPS: Okay. We'll dig one up here. Specifically, I believe the -- well, we'll get the recommendation here. I believe we're talking about recommendation 20, 21, and 22, on page 46 of Exhibit 9X-A.

THE WITNESS: Well, first of all, you're talking about PMA and you're talking about qualified people out there in those shops. The FAA is going in and they're going to approve them. How they do that, I'm not aware of how they do it. The data that they use in those shops, I don't know where it comes from. It doesn't come from us.

We build the units. We write the procedures. We have the process paperwork, and we don't supply that to the third-party shops. So how they arrive at a conclusion, I'm really not sure.

MR. PHILLIPS: To make a point clear here, were the -- was the main rudder PCU that was involved in the USAir 427 accident, to the best of your knowledge, was that ever worked on or repaired by anyone other than Parker?

THE WITNESS: Not to my knowledge, it was not.

MR. PHILLIPS: In your years at Parker, have you observed testing of the servo valve, the dual spool concentric servo valve?

THE WITNESS: Yes, I've observed it. You can't be there 35 years and not see it.

MR. PHILLIPS: In that testing, do you use a special test fixture for that test?

THE WITNESS: Yes, we do.

MR. PHILLIPS: And why is that?

THE WITNESS: The parameters that are required to be met take a fixture that's machined, very fine dimensions on it, and it's designed to handle that piece of equipment.

MR. PHILLIPS: And then the functional test procedure, the top assembly procedure, could you tell us --

THE WITNESS: Same thing.

MR. PHILLIPS: Could you tell us a little bit about the differences between the servo valve level test and the full assembly test?

THE WITNESS: Well, the servo valve test concentrates on the servo valve itself, what it can do, what it's supposed to do, and what it actually does. And at the top, it has the servo in it. You perform the tests at the top assembly and see how it's going to operate.

MR. PHILLIPS: So if the servo valve can't pass the servo valve level test, it can't make it to the top assembly?

THE WITNESS: That's correct.

MR. PHILLIPS: Would it be possible for a servo valve to malfunction and still pass the top assembly test?

THE WITNESS: Not to my knowledge.

MR. PHILLIPS: Do you -- as a matter of repairing the power control units, are you ever required to take detailed dimensions of the parts that come back in?

THE WITNESS: Oh, yes. There are times when we do that.

MR. PHILLIPS: Are you looking for wear?

THE WITNESS: Looking for wear, yeah, that's one of the things we look for.

MR. PHILLIPS: Are there a group of

components that are defined by Parker to be replaceable on a regular interval or at the time-based interval?

THE WITNESS: Not on a regular interval. With the exception of seals, software and stuff like that.

MR. PHILLIPS: Does this power control unit have a fixed service life?

THE WITNESS: No, it does not.

MR. PHILLIPS: Who made that decision? Is that a Parker decision or was that required --

THE WITNESS: No, I think that's probably a Boeing decision. I would have to let them answer that question.

MR. PHILLIPS: Some time ago, a service bulletin was issued and an airworthiness directive followed to modify the servo valve in the main power control unit. Are you familiar with that event?

THE WITNESS: Yes.

MR. PHILLIPS: The compliance state for completion of the program, for the modification program, was set over a number of years. Are you aware of that?

THE WITNESS: Yes, I am.

MR. PHILLIPS: Are you aware of how many

years?

THE WITNESS: Five -- pardon?

MR. PHILLIPS: How many years?

THE WITNESS: Five years.

MR. PHILLIPS: Five years?

THE WITNESS: Yes.

MR. PHILLIPS: And that was to modify how many units?

THE WITNESS: I think the number is about approximately 2350.

MR. PHILLIPS: Twenty-three hundred and fifty units over five years. How did that five year number get determined? Who decided it would take five years to manufacture or modify 2350 parts?

THE WITNESS: I believe the FAA did.

MR. PHILLIPS: Did Parker have any part in that decision?

THE WITNESS: I'm not aware of anybody that did.

MR. PHILLIPS: So they could have decided to ask for two years and Parker could have complied with making parts to support a two year replacement schedule?

THE WITNESS: Well, they could have, but I think that they take into consideration the number of units and the capacity available to do the work. so I would say that that's given some consideration.

MR. PHILLIPS: In your experience with airworthiness directives that affect parts that Parker has manufactured, is five years a long period of time?

THE WITNESS: I think that five years is a long period of time, but I think it's all relative to the number of units that are in the field that you have to do.

MR. PHILLIPS: If there had been 200 units, certainly the time period would have been --

THE WITNESS: Five years would have been a very long time.

MR. PHILLIPS: Okay. Right now, I don't have any other questions, unless you have something you would like to add?

THE WITNESS: No, I don't.

CHAIRMAN HALL: Other questions from members of the Technical Panel?

(No response.)

CHAIRMAN HALL: Not. Any of the parties do have questions for this witness?

(No response.)

CHAIRMAN HALL: I see no hands. And we'll move to Mr. Clark.

MR. CLARK: With the current AD that's -- and there's a five year time for compliance to change the parts or assure that the parts cannot produce an over travel. Is Parker the only facility that can implement that change?

THE WITNESS: I'm not sure I know the answer to that, because I don't know what authority some of the third-party stations have. I will tell you this, that the service bulletin states that if the units come back, the work is done with no charge. I don't know that a third-party station would do that.

MR. CLARK: You stated earlier that one of the -- the primary description for returned PCUs is that the unit is in need of repair. What types of -- what causes the unit to be -- why does the unit have to be repaired typically?

THE WITNESS: Well, just being in operation, you've got parts in there that wear, and over a period of time, they're going to need replacement or rework.

MR. CLARK: How will a mechanic know that a part is worn?

THE WITNESS: Pardon me?

MR. CLARK: How would a mechanic find out that a part is worn?

THE WITNESS: The first thing that will tell him is the receiving tests. And it will tell him something's wrong somewhere in the unit. And he'll go to that area and he'll pull the parts out and run tests or inspection or whatever is required on those parts.

MR. CLARK: I follow on with it and then I'll get back to that question. During the receiving test, how comprehensive is that compared to the -- I assume there's a functional test when the part has been repaired and sent out. How does the receiving test compare to the final test?

THE WITNESS: The receiving test is identical. It's the same procedure. The ATP coming in is the same as the ATP going out.

MR. CLARK: For this over-travel issue that's arisen since the Mac Moore unit after the Colorado Springs accident, do he receiving tests check for that as the part comes in?

THE WITNESS: Yes, it does.

MR. CLARK: How many units have been found to have such tolerances that an over travel could occur?

THE WITNESS: John, I don't have those

numbers.

MR. CLARK: Are they finding some or many, a lot?

THE WITNESS: Frankly, I'm not aware of any that have come back to our facility and failed the receiving test.

MR. CLARK: On this receiving test and the functional test as it is today, if the original Mac Moore unit had come in, that test would have uncovered that over-travel issue?

THE WITNESS: Yes, it would have.

MR. CLARK: And at least right now, you're not aware of any that have come in in this overhaul procedure that would have failed that portion of the test?

THE WITNESS: No, I wouldn't say that. There were a couple of units that were brought in that had some events on them, had been repaired by someone else, and the FAA was there, the airline was there. I think Boeing was there. And there were one or two that failed that test.

MR. CLARK: What we're referring to then is the servo valve itself had been repaired by other facilities. You delivered the part to the airlines, the servo valve. And then subsequently, the servo valve had been repaired by other facilities and then the part was returned back to you. In your service -- in your receiving test, you found that it had a potential to over travel.

THE WITNESS: No, that's not quite true. We could have repaired that servo valve, but when it goes back to another party to install the servo valve, they've got to take it apart to put it into the main PCU. When they take it apart, if it's not put together properly, they'll have a problem.

MR. CLARK: In putting the part back together, what could be introduced into that part that would allow it then to have an over-travel issue rather than a part as you delivered? What would change from disassembly to reassembly that would allow an over travel to occur?

THE WITNESS: Probably the stroke is the most important. That's usually determined by an amount of torque. We know an area that the torque value --

MR. CLARK: Improper torque values --

THE WITNESS: That's correct.

MR. CLARK: -- on the end cap primarily?

THE WITNESS: Not on the end cap. On a nut that locates a spring guide down inside.

MR. CLARK: So in these issues, if that nut were properly torqued, which would have been proven as it left your facility, then if that nut's removed and reinstalled, there's a potential there.

THE WITNESS: There is. Yes, sir.

MR. CLARK: And within your setup and procedure and functional test as it leaves the factory, if you were to do the entire overall, you would -- if that nut were improperly torqued in your facility, you would find that in the functional test?

THE WITNESS: We certainly would.

MR. CLARK: In your estimation, the AD that's currently being implemented, is that sufficient enough to preclude that installation --

THE WITNESS: Yes, it is.

MR. CLARK: -- for other facilities? They now have to do proper procedures to assure that that problem is taken care of.

THE WITNESS: If theyfollow the procedures, they will be able to do everything properly.

MR. CLARK: Coming back to the questioning that started, as we've kind of jumped into the middle. My question was on the mechanics, I was not referring to the mechanics that work at the Parker facility that receive these parts in need of repair. I'm talking about the mechanics that make the original determination that the part needs to be repaired.

THE WITNESS: Oh.

MR. CLARK: What are they finding? What happens that prompts them to pull a unit, to say a part needs repaired?

THE WITNESS: Most common cause is external leakage.

MR. CLARK: When these parts come in with a tag that says that you need to repair it, do they note that the unit has external leakage?

THE WITNESS: Sometimes it's noted. Frequently, it's not. It just says "repair."

MR. CLARK: Do you ever follow up back with the mechanic to find out specifically what their issue was?

THE WITNESS: We do. You bet.

MR. CLARK: Is that routine or --

THE WITNESS: It's not routine. We run a receiving test. And if we can't find anything wrong with it, then we'll go back to them and we'll discuss it with them and ask them what they sent it in for.

MR. CLARK: Is that reported in your documentation?

THE WITNESS: Yes, it is.

MR. CLARK: In this history that's been going on for the last three or four years, if you do follow up, how many times are you finding reports that the PCU is behaving erratically or they perceived that the unit was behaving erratically?

THE WITNESS: I don't know what you mean by erratically.

MR. CLARK: Well, something that may have got the mechanic's attention or a flight crew attention. Something that alerted to somebody or made them feel that the unit was not functioning properly. I assume a mechanic would be alerted to that effect. They would perform some check out and then send the unit back to you.

THE WITNESS: I don't know if I can answer that. When we see the units, I don't know how it has been detected or determined that the unit should come back short of a pilot complaint or of someone who has been up in the area of the unit and has seen some leaking or something like that.

MR. CLARK: Now, this leaking we're talking about is an external leak.

THE WITNESS: Yes.

MR. CLARK: Hydraulic fluid is running out of the -- or leaking out of the unit, to some unacceptable standard.

THE WITNESS: Dripping out, right.

MR. CLARK: What about the issue of internal leakage? In some of the procedures, the mechanics have to listen to the unit to listen if there's flow bypass going on inside the unit.

THE WITNESS: I'm not familiar with the listening procedure. They have procedures, I think, for detecting internal leakage in a system on the airplane. I think they can pin that down to a specific area, but I don't know of anybody that listens for the leakage.

MR. CLARK: But in the -- with the internal leakage going on, could that be indicative that one of the servo valves is mispositioned or sticking?

THE WITNESS: I suppose that's possible. It more than almost all the time is wear on the servo or wear in some area.

MR. CLARK: On your incoming test would you be able -- would that test disclose that a unit had a sticking servo valve? One of the valves may be sticking?

THE WITNESS: Yes, it would.

MR. CLARK: If it were sticking at the time you were running the test?

THE WITNESS: Yes.

(Lengthy pause.)

MR. CLARK: During the functional testing on either -- well, either the receiving or the final tests, are you able to measure the friction of the primary and secondary valve movements?

THE WITNESS: Somewhere in the testing, they do measure that, yes.

MR. CLARK: Where you can actually within the functional testing move -- try to move the primary or the secondary and measure that amount of force that's required in the system?

THE WITNESS: That's correct.

MR. CLARK: In that type of friction, do you have any idea how often that you see that is out of tolerance?

THE WITNESS: No, I'm not normally in that area, John. So I don't know.

MR. CLARK: But you would have records that may indicate that?

THE WITNESS: We would have records, yes.

MR. CLARK: And this type of friction unit, is that part of the routine incoming/receiving tests?

THE WITNESS: Yes.

MR. CLARK: Do you know how they do measure that, that friction specifically?

THE WITNESS: I would -- no, I don't think I can talk about that. We have some people here that can help you, but I'm not out there enough to discuss that.

MR. CLARK: Part of your incoming test, do you evaluate the hysterias in the unit?

THE WITNESS: Hysterias is a test that's run, yes.

MR. CLARK: In the servo valve, it may take a certain force to push it out and a certain force to pull it back.

THE WITNESS: They check that.

MR. CLARK: When you bring these units in, are the servo valves routinely replaced? When a unit comes in for repair, is the servo valve routinely overhauled and are the servo spools replaced?

THE WITNESS: Are you talking AD or are you talking just normal routine repair and overhaul?

MR. CLARK: Well, I guess if the unit comes in, the AD has to be complied with, doesn't it?

THE WITNESS: That's correct.

MR. CLARK: Now.

THE WITNESS: Now.

MR. CLARK: And so if any unit comes in for any reason, you're going to replace the servo valve?

THE WITNESS: We're going to take it off and incorporate the AD, yes.

MR. CLARK: Does that require in each case replacing the servo valves or the primary and secondary valve?

THE WITNESS: No, it does not.

MR. CLARK: So you may be able to use the existing valve if it appears okay?

THE WITNESS: There are times when a valve will pass a test. If the primary and secondary are not of our manufacture, then we won't reuse them. They are not called out in the manual and they are not considered an acceptable piece of hardware.

MR. CLARK: Do you have a history or have you seen evidence coming in on the examination of the valve spools of chip shear or damage from chips?

THE WITNESS: John, I can't help you with that. I'm sorry. I don't know.

MR. CLARK: Have you -- and this may fall into the same category. Have you found any major contamination of any units coming? For example, in small passages or any evidence of existing silting?

THE WITNESS: I'm not aware of it and -- well, I'm just not aware of it. I'm not in that area, so.

MR. CLARK: If the unit -- if the hydraulic fluid were flushed, I guess that -- would that remove any evidence of silting that may be present?

THE WITNESS: Well, it would remove some, not necessarily all of it.

MR. CLARK: So in some of the hidden cavities, some of the far recesses in the unit, you would still expect to see evidence of silting?

THE WITNESS: It could be, yes.

MR. CLARK: Do you -- in the inspection procedure that follows, do you look for that or look for evidence?

THE WITNESS: No, we don't. Not on a routine repair. That would require tearing the unit down and you're talking a lot of time and a lot of dollars. It's just not --

MR. CLARK: I guess in the sense, has there ever been any history that you're aware of in complete tear downs or partial tear downs where silting has been found or layers of contaminates have been found within a unit?

THE WITNESS: I'm not aware of any silting problems at our facility.

MR. CLARK: Any evidence of pieces of o-ring material or some of the -- that have gotten in and contaminated servo valves or some of the passages?

THE WITNESS: No, not in the servo valve. I'm not aware of any in there.

MR. CLARK: Okay. Thank you.

CHAIRMAN HALL: Mr. Marx?

MR. MARX: Wally, congratulations on your retirement.

THE WITNESS: Thank you.

MR. MARX: During the -- are you aware of when the PCU was last overhauled on the accident aircraft 427? Do you remember?

THE WITNESS: I'm sure that we had the records if it had been in house, but I can't tell you when it was.

MR. MARX: During this overhaul, would they be taking some of the components apart and getting inside the PCU at anytime?

THE WITNESS: Depending on what they found wrong, yes, they could.

MR. MARX: What type of procedures are used to make sure that no contamination is introduced into the servo valve during these overhauls?

THE WITNESS: Procedures per se, I don't know of any that we have. We have clean stands and clean test areas and they're kept that way. We have quality control, who's always checking. I don't know of any problems at all.

MR. MARX: There's been a lot of talk about silting. I think you've already answered this question, but do you know what effects would be on the servo valve? What a person would look for if they had any evidence of silting?

THE WITNESS: What they would look for?

MR. MARX: Yes.

THE WITNESS: Well, if you're talking about checking the fluid for silt, they would have to take a sample and send it out. If you're looking for some sort of damage, I'm not aware of any myself.

MR. MARX: Is there other types of things that happen to the valves, such as erosion, that occur?

THE WITNESS: Years ago, there was a very serious erosion problem. Now, they go for years with no erosion.

MR. MARX: And is that erosion right away apparent when you look at the valve?

THE WITNESS: One would see that reasonably, yes.

MR. MARX: Eyeball it -- could you eyeball it?

THE WITNESS: In some cases, you can eyeball it. But most of the cases, they look at it under a microscope.

MR. MARX: Thank you.

CHAIRMANHALL: Mr. Schleede.

MR. SCHLEEDE: Yes, sir. Some follow up to Mr. Clark's question. Wally, when you were mentioned that a couple of units that had come in after some events and had been either improperly torqued, do you recall that discussion?

THE WITNESS: Yes, I do.

MR. SCHLEEDE: You said there were a couple of events. What do you recall were the events that prompted them to be sent to your facility?

THE WITNESS: I don't recall what the airline event was. They brought it into our facility. And like I say, we had people in there that came with it. The tests were run.

MR. SCHLEEDE: Are you aware of a unit that came off of Sahara Airlines 737 that had an accident in India?

THE WITNESS: I'm aware of the fact that we had one in from Sahara. I can't give you the details at this time.

MR. SCHLEEDE: Did you work on that one at all?

THE WITNESS: No, I didn't work on it.

MR. SCHLEEDE: And you say you don't know the details of it?

THE WITNESS: No, we have them back there, but I'm not there to see all the testing that goes on.

MR. SCHLEEDE: I just wanted to know if you were aware of the circumstances on that one. That's all the questions I have. Thank you.

CHAIRMAN HALL: Mr. Laynor has no questions. I've got just a few questions, Wally. Again, thank you. I appreciate the tour you provided me when I came out to look at your facility. How large an organization is Parker-Hannifin and what different types of products does your company manufacture?

THE WITNESS: Well, we -in the aerospace group, we manufacture engine valves, we manufacture most of the flight controls used on airplanes, and we have a lot of check valves that are located throughout the airplane business.

CHAIRMAN HALL: And the facility you were responsible for, were you in the manufacture or the service end of the operation?

THE WITNESS: Service.

CHAIRMAN HALL: And your service shop, did it just have this one rudder PCU coming through or were there other things that were coming through for repair?

THE WITNESS: No, we have many, many different types of units coming through.

CHAIRMAN HALL: Could you give us an idea of just some of the things that would come through?

THE WITNESS: Well, the ailerons, the elevators, the leading edge slaps, the flats, the rudders, all kinds of engine valves.

CHAIRMAN HALL: How many employees do you have at that particular location?

THE WITNESS: About 380.

CHAIRMAN HALL: About 380. And the power control unit that we're talking about in this particular hearing, what particular pieces make that up? I know the servo valve's in there. What else is in there?

THE WITNESS: There's a main manifold and a cylinder assembly.

CHAIRMAN HALL: When was that first manufactured, do you know, by Parker?

THE WITNESS: Gosh, I guess I would have to defer to someone else on that. I don't know what the original start date was on that.

CHAIRMAN HALL: But you've been responsible for that. How long were you responsible for the operation of that service unit?

THE WITNESS: For about 20 years. In-service, we started about 20 years ago.

CHAIRMAN HALL: An average year, about how many of those power control units would come through your operation?

THE WITNESS: Prior to the AD, probably 220 to 280. Somewhere in that range.

CHAIRMAN HALL: Now, you don't know what one of those things would cost, do you?

THE WITNESS: No, sir, I don't.

CHAIRMAN HALL: But I assume Boeing buys them from Parker and they're set up and placed in an airplane?

THE WITNESS: There's some arrangement, yes.

CHAIRMAN HALL: And there's no particular service life to them. So they could be around for how long? Indefinitely?

THE WITNESS: Yeah, I don't know of a time when they are ever removed from service.

CHAIRMAN HALL: Is that typical for the other airplane parts that you are responsible for?

THE WITNESS: Yes.

CHAIRMAN HALL: Very well. You were -- this particular power control unit is just used in the 737.

THE WITNESS: That's correct.

CHAIRMAN HALL: But you do repair other power control units?

THE WITNESS: Many.

CHAIRMAN HALL: Many. At this same facility. What is your procedures that you follow? You all have the manufacture and then you service. Do you have a tracking system so that you can feed back to the manufacture if there are improvements that need to be made in the unit?

THE WITNESS: Yes, we do. The reliability program, which is in our computer system, is available to all divisions.

CHAIRMAN HALL: How long has that been the and could you give us just a brief description of how that works?

THE WITNESS: It's been there probably maybe five years. I'm not sure on the date, but approximately four or five years.

CHAIRMAN HALL: Was that before or after the Colorado Springs accident that the reliability program was put in place?

THE WITNESS: It was in place before then.

CHAIRMAN HALL: Were there any changes to the reliability program made as a result of the Colorado Springs or Pittsburgh accident?

THE WITNESS: I dn't think as a result there were. There may have been some downstream. There may have been some prior to that.

CHAIRMAN HALL: Did FAA or Boeing request that you make any changes in how you tracked your repairs on these rudders as a result of any one of those accidents?

THE WITNESS: I'm not aware if they did.

CHAIRMAN HALL: Did you all generate -- you were familiar with those two accidents, weren't you?

THE WITNESS: Yes, sir.

CHAIRMAN HALL: I believe you were at the sites.

THE WITNESS: Yes.

CHAIRMAN HALL: Did you feel any need for you all to take a closer look in terms of anything in regard to the servicing of those 200 to 250 PC units -- PCU units that came through your shop as a result of those two accidents?

THE WITNESS: Well, I think that some of the impressions I came back with were lasting and I think there was tightening of the belt as a result of that.

CHAIRMAN HALL: But no particular changes in the procedures?

THE WITNESS: No, the procedures were pretty well in place.

CHAIRMAN HALL: You felt comfortable with the procedures that you had?

THE WITNESS: Yes, we did. Yes.

CHAIRMAN HALL: You've, I'm sure, have read much more than I have in regard to this unit. I know that you have a great -- a much greater deal of technical knowledge than I do in regard to this unit. Is there anything that we should be doing in this investigation? We've talked about a silting test yesterday. Is there anything that you all should be doing at your company that you would recommend to us to help us try to determine if there was any type of malfunction of this particular unit?

THE WITNESS: I think that anything I might suggest is already in place and being done.

CHAIRMAN HALL: I'm sorry, Wally, what?

THE WITNESS: I think the things that I might think of, they're already in place. Everything's pretty well covered, I think already.

CHAIRMAN HALL: How many customers, other than Boeing, use hydraulic cylinders, manufactured by your operation or serviced by your company?

THE WITNESS: When you say "customers," are you talking prime contractors?

CHAIRMAN HALL: Mm-hmm.

THE WITNESS: Gosh, we probably have, starting with the government, we have many airlines all the way through the computers and bus. jets. So there's many of them. I couldn't guess the number.

CHAIRMAN HALL: Any that have a similar design to this particular unit?

THE WITNESS: I think that when you say similar, you're talking cylinders and manifolds, most of them are built along that line. They're all a little bit different.

CHAIRMAN HALL: They have concentric valves with them?

THE WITNESS: One or two of the others may have dual concentric valves.

CHAIRMAN HALL: You followed this subject of the hydraulic fluid?

THE WITNESS: I'm sorry?

CHAIRMAN HALL: The subject of the hydraulic fluid and the contamination --

THE WITNESS: Oh, yes.

CHAIRMAN HALL: -- and you were here yesterday?

THE WITNESS: Yes.

CHAIRMAN HALL: Do you think there should be any suggestions that you would make to this -- what is it -- SAE team that may be looking at hydraulics or do you all have anybody from Parker that participates with that group?

THE WITNESS: I'm a member of the SAE. I'm on the A-6 -- I was on the A-6 panel.

CHAIRMAN HALL: Did you assist them in their work?

THE WITNESS: Not in that particular area, no. But I think what they're doing is pretty complete.

CHAIRMAN HALL: Okay. Any other questions?

(No response.)

CHAIRMAN HALL: Well, Mr. Walz, we appreciate very much your presence here and join the others in congratulations on your retirement and 35 years of service. You're excused.

THE WITNESS: Thank you.

(Witness excused.)

CHAIRMAN HALL: We will take a 15 minute break and reconvene at 10:15 for the next witness.

(Whereupon, a short recess was taken.)

CHAIRMAN HALL: Please be seated, so we can reconvene this board. We will call as the next witness, Mr. Tom McSweeny, the Director of the Aircraft Certification Service for the Federal Aviation Administration, Washington, D.C.

(Witness testimony continues on the next page.)

TOM McSWEENY, DIRECTOR, AIRCRAFT CERTIFICATION SERVICE,
FAA, WASHINGTON, D.C.

Whereupon,

TOM McSWEENY,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows:

CHAIRMAN HALL: Welcome, Mr. McSweeny. We appreciate you being here. I would ask individuals if you're going to have conversations, to take them outside the room.

MR. SCHLEEDE: Thank you, Mr. Chairman. Mr. McSweeny, please give us your full name and business address?

THE WITNESS: Thomas E. McSweeny. My business address is 800 Independence Avenue, Washington, D.C.

MR. SCHLEEDE: What is your position at the FAA?

THE WITNESS: I'm Director of Aircraft Certification Services.

MR. SCHLEEDE: Could you briefly describe your duties and responsibilities in that position?

THE WITNESS: The organization that I manage is responsible for all design, production, and continued airworthiness of aircraft products.

MR. SCHLEEDE: Would you expand a little bit as to who and what organizations are directly under your authority?

THE WITNESS: We have two divisions in Washington; one that is responsible for production and airworthiness, one that is responsible for general engineering. And I have four directorates that report to me, who are responsible for all matters with regard to various products. Those products being large airplanes, small airplanes, engines, and helicopters.

MR. SCHLEEDE: Thank you. Could you give us a brief description of your education and background that brings you to your present position?

THE WITNESS: I have a master's degree in aerospace engineering. I worked with the industry at Northrop Aircraft for about eight years before I came to the FAA. I have 22 years at the FAA in various jobs.

MR. SCHLEEDE: Thank you. Mr. Phillips and Mr. Jacky will be following up.

MR. PHILLIPS: Thank you. Good morning.

THE WITNESS: Good morning.

MR. PHILLIPS: I would like to start out our discussion this morning on the critical design review. Were you responsible in any way for the formation or the concept for the critical design review?

THE WITNESS: Yes, I was partially responsible.

MR. PHILLIPS: How did that come about, do you recall how that was instituted?

THE WITNESS I recall a phone conversation with Mr. Don Rig-gin, the manager of the Aircraft Certification Office in Seattle. I think at the time, he was acting for Mr. Ron Wojnar, who reports to me. We were discussing the events of Pittsburgh and what we might do next and the concerns we had about the lack of definitive findings coming forth. We talked a little bit about what might be the next step.

He, at that time, recommended the CDR. It happened to be the same kind of thinking I was having at the time. So that was my involvement in the formulation of it.

MR. PHILLIPS: Did you, at that time, discuss any of the foundations or the ground rules that the CDR would be conducted under?

THE WITNESS: Yes, we did. We talked about issues relative to bringing on board people who did not have past experience with the 737. Our main objective was to develop an effort that was not biased in any way. We didn't want any piece of information tossed out because somebody might have concluded prematurely that well that wasn't important.

We also talked about bringing people from outside the FAA that might have just a different look at the world. Every organization, as you know, has a culture within it, and we felt it was very important to bring people from outside the FAA into that effort. But we also wanted them to have the kind of experience that we thought would contribute to that team.

MR. PHILLIPS: Was this CDR modeled after any previous CDR?

THE WITNESS: Well, the operation of the CDR is fairly typical, gathering of information and data. But this one was different in that it brought people outside the FAA. That has, to my knowledge, not been done before.

It also in forming the team, because we were looking at the PCU and the control systems and we wanted to -- we were eventually going to look at failures, possible failures, we constrained the team from looking at probability of failures. We wanted them to only gather that information, which they deemed to be possible and let somebody else deal with the probabilities.

Again, we did not want them to throw out a piece of information prematurely. We wanted it all down on paper and then we would deal with it. That was unique. I don't remember that ever being done before.

MR. PHILLIPS: So you expected this team to give you a list if they found a failure, whether it was probable or not. As long as it was possible, you expected to find out about it from this team?

THE WITNESS: We specifically -- my deputy and myself met with the team at one of their first or second meetings. We were very clear in that regard. We didn't want them to ignore anything and we wanted the possibilities to be identified. Then later, we would determine the probabilities of those possibilities.

MR. PHILLIPS: Did that team at any time ever attempt to define the probabilities before they issued the report?

THE WITNESS: Not to my knowledge, no.

MR. PHILLIPS: Has there been any additional work within the FAA after the report's been issued to look at probabilities?

THE WITNESS: Well, the recommendation to the

Seattle ACO deal with just that, to establish the probability of some of the failure modes. And that effort is ongoing. We've heard previous testimony that documents have been submitted to the FAA. We're in the process of reviewing those and evaluating them. I'll sure there will be more exchange between the FAA and Boeing.

MR. PHILLIPS: Along those lines, when do you expect the review of those documents to be complete?

THE WITNESS: In discussions I've had with the transport directorate, they indicate that they will be complete by the end of this month. I don't know if the recent shut down and furlough is going to change that or not, but that was their plan.

MR. PHILLIPS: What's the process after the completion of the FAA's review, what will happen next?

THE WITNESS: Well, we would make a decision on what steps to take next. Whether it was a mandatory change of some sort or just a service bulletin approval or something like that. We do intend and it was raised early in this hearing -- we do intend to publish a final document that will summarize in explicit detail everything we have done on every recommendation.

We believe it's important to make that

information available.

MR. PHILLIPS: Have you had any additional -- did this CDR lead to your concept for an additional CDR for any other aircraft. Are there plans for additional CDRs?

THE WITNESS: I missed the first part of that.

MR. PHILLIPS: Has this CDR generated requirement for additional CDRs for other aircraft?

THE WITNESS: No, there are no other CDRs that have been spun off this particular one. We did do a CDR on another aircraft, but it wasn't connected in any way to this one.

MR. PHILLIPS: You've done another one since this CDR's stopped and started?

THE WITNESS: Yes.

MR. PHILLIPS: Yesterday we discussed with Mr. Zielinski the concepts of failure analysis and FMEAs. We had several terms. I would like to talk about that just a little bit in terms of certification. Again, yesterday we heard testimony that at the time the 737 was certified was in the 1960 time period?

THE WITNESS: Correct.

MR. PHILLIPS: We're correctly looking at a new generation of aircraft in the 737 series; the 600, 700, 800 series. Is that correct?

THE WITNESS: That's correct.

MR. PHILLIPS: Are we -- is the FAA planning to certify those aircraft to the standards of the 1960's era requirements?

THE WITNESS: We have an effort with every manufacture. That it's an effort that began about five years ago to upgrade the certification basis on derivative aircraft to the highest degree that is practicable.

We are in discussions with Boeing, as we have been with other manufacturers, to raise the certification basis of that aircraft as close as we can to today's standards. But one thing that I think is important to recognize is that every aircraft has many, many systems, many, many parts of the aircraft are operating properly.

There is no problem with them. And, quite frankly, it does not make a lot of sense to change those. So we look at -- we would look at each element of the aircraft separately, each rule separately, and we're in that process right now with Boeing on the derivative 737.

MR. PHILLIPS: At the time of the initial discussions about derivative certifications, who's involved in those discussions? At what level of the company at Boeing do you talk to?

THE WITNESS: Really at all levels. The technical people are talking to better understand the technical issues. There might be issues where mid-level management gets involved, and there might be a need for upper management to get involved.

MR. PHILLIPS: Ultimately, who decides then what level of certification basis is adequate for that airplane? Where does the buck stop?

THE WITNESS: The Aircraft Certification Office is the one that determines that. Now, it is real obvious, I'm sure, to many that even myself -- I would be involved in at least knowing what that certification basis is. And in the case of a 737, I am aware. I have read the early copies of the issue papers that deal with the certification basis. I am not, at this point, making the decision, though.

MR. PHILLIPS: Do we have a time table for that decision? Is it imminent?

THE WITNESS: I don't know. I really couldn't say.

MR. PHILLIPS: Is the certification basis decided before the airplane goes into production?

THE WITNESS: Our goal as the manufacture is really to try to get that completely resolved before the airplane is fully designed. It is very difficult if the design has to be changed at the last minute.

So we really try to get that resolved as early as possible.

MR. PHILLIPS: Do you recall a certification basis ever being changed for an airplane after it's been in production for some period of time? Have you ever gone back and made an attempt to recertify an airplane to a newer standard after some years of production?

THE WITNESS: No, I don't ever recall that happening. You could, though, make an argument that when we issue an airworthiness directive, we are in effect changing the certification of the basis, because we are defining by that airworthiness directive a particular level of safety on a particular component that must be complied with.

It is really through the airworthiness directive process that we, in essence, upgrade the certification basis of the aircraft when it is deemed necessary because of an unsafe condition.

MR. PHILLIPS: Does that fall into our discussions yesterday on the continuing airworthiness side of the house?

THE WITNESS: Yes. Yes, it certainly does.

MR. PHILLIPS: Is that -- in your opinion from your position as FAA senior manager, does that system work well as a continuing airworthiness approach? Does that guarantee safety of the fleet of any type of aircraft?

THE WITNESS: The continued operational safety effort with an aircraft certification has, I think, really stepped up in the last three or four years. It is, in fact, our highest priority. If there is any choice that an aircraft certification engineer or inspector makes day in and day out, if there's a continued operational safety issue on their table, that's what gets done first. And it is that change I would say in the cultural thinking, that we've accomplished over the last four or five years.

We have seen, I think, some very significant improvements in tracking service difficulties and making corrective action.

MR. PHILLIPS: What's motivated that change in corporate thinking over the last three or four years?

THE WITNESS: What motivated it was stepping back and thinking about what our reason for existence was. What was the most important thing we could do. What's the best way we could spend our dollars, since we don't have unlimited dollars. It doesn't take long to think through that and realize that keeping the system out there as safe as we can is our number one priority.

MR. PHILLIPS: Back into an earlier statement I made about failure analysis and hazard assessments, is that, in your opinion, a vital part of certification?

THE WITNESS: Yes, it is.

MR. PHILLIPS: Has it changed over the years, the approach to analysis?

THE WITNESS: Oh, yes. Yes. We have gone from what used to be single-failure thinking to now rules that talk about single failures must be accounted for and multiple failures not shown to be extremely and probable must also be accounted for. So that's what leads to -- basically, as was mentioned earlier, led to the faulty analysis techniques that we have with us today.

MR. PHILLIPS: The CDR report references a most rigorous methodology available, as far as hazard assessment failure analysis, and relates the thrust reversal review that was done a few years ago. Can you think of any other hazard assessment or failure analysis that fall into the same category of rigorous?

THE WITNESS: I would say the 777 was one. I would say the failure analysis that was done on the airbus 320, being the first all-electric airplane, was another one.

MR. PHILLIPS: Have you considered taking those methods of analysis back into older airplanes in production to see if you may have missed something?

THE WITNESS: Well, we haven't really thought about that.

MR. PHILLIPS: Does it seem like a logical idea to put together a team to do failure analysis assessments on older production aircraft?

THE WITNESS: It would be something that certainly could be done if we had enough resources to do it and we felt that it was a priority thing to do. I think the key about looking back is saying to yourself, do you have enough information that leads you to believe that that's the best use of your resources. Going back and recertifying aircraft to today's standards.

I think you have to recognize, to start with the recognition that the CFR, the standards that we have for the design of aircraft, are simply the best shot anybody has today at trying to define what a good aircraft should look like, what criteria should it meet. But once an airplane is out there operating, it's talking back, so to speak, to you all the time.

It's really that operation, those years of operation, that tell you whether you really did the job you should have done. That operation does tell us, from time to time, we need to make changes. From time to time, it also tells us that there are airplanes that have never had accidents. Obviously, something was done very, very right there. And we have to learn from both.

As far as just systematically going back, we have not really considered that.

MR. PHILLIPS: Is the review of the success of a fleet, is that a subjective review? The fact that one type of aircraft has never had a crash versus several crashes, has that ever entered into a decision to change regulations?

THE WITNESS: Well, regulations are changed sometimes, because of accidents. Regulations are also changed because we are smart enough to realize that there is a better way of doing something regardless of whether there is an accident. I don't -- I think they probably fall evenly on both sides.

MR. PHILLIPS: We had some testimony yesterday in regards to 25.1309, which is an advisory circular, which adds some definition to the probability -- using probabilities in failure analysis. Can you give me just a brief discussion or opinion about the viability of taking advisory circulars beyond the 1309 type to apply to other regulations, other portions of the FARs?

THE WITNESS: I'm not so sure I understood that question. Sorry.

MR. PHILLIPS: Let me try it a little differently. Thirteen O-nine specifically is a fairly new -- has been revised recently to cover very specific regulation. It talks about probability. If you wanted to -- say you have 25.671, which is flight control's definition. Would you want to generate advisory circulars independent of -- well, let's back off that question. I've lost my train of thought there.

Let me back up a little bit. I'm trying to think of a way to rephrase this. Let's go through the process of creating an advisory circular. How is that decided? When did you decide an advisory circular needs to be created?

THE WITNESS: It kind of depends on what the rule -- how the rule reads. We have many rules that are very objective in their safety goal. When you start applying them to specific technology, many times there's interpretative material that is necessary to say yes, this particular design is done a certain way. We'll, in fact, meet this rule or regulation.

The advisory circular simply capture that sometimes before and sometimes after we have been exposed to that technology. They present a scheme that tells the industry if you follow this scheme, you have the expectation that the FAA will accept it.

If they deviate at all, then, of course, we look top to bottom at their whole scheme and compare it with the rule. So the advisory circulars are of great benefit to the industry, because it really gives them when they're making their design decisions something that they can shoot at. It says, if I do it this way, I know the FAA will accept it.

MR. PHILLIPS: So advisory circulars are generally written as additional interpreted material for regulations?

THE WITNESS: Right. Advisory circulars themselves cannot be applied as regulations.

MR. PHILLIPS: Do you have ever go back and rewrite the regulation based on the interpretation that's been provided in an advisory circular?

THE WITNESS: I can't think of any cases now, but I know we have in the past changed rules, because of when we start looking at the application of them, we've discovered some things. Yes, but as I say, I can't think of any right now.

MR. PHILLIPS: Let's go back to a discussion yesterday about the certification basis for the 737 series of airplanes. What is your understanding of the level of probability of failure that was required for certification of that airplane? Could we -- did that airplane have to demonstrate capability to continue to safely operate with a single failure?

THE WITNESS: From all the information I've seen, it was basically a single-failure requirement that were applied to that aircraft at that time by the

FAA regulations.

MR. PHILLIPS: The testimony we heard yesterday, today the certification would be different?

THE WITNESS: It would be single failures and multiple failures not shown to be extremely improbable.

MR. PHILLIPS: And extremely improbable one more time means what?

THE WITNESS: It means -- an extremely improbable event is one that would occur -- first of all, it would be a series of events that would jeopardize a continued safe flight in landing of the aircraft, and it would occur once in the lifetime of that fleet of aircraft. It would be expected to occur no more than once in that entire lifetime.

MR. PHILLIPS: And do you agree with Mr. Zielinski's discussion yesterday that engineering judgment -- when you don't have operational data to support a probabilistic analysis, engineering judgment is adequate to certify an airplane on?

THE WITNESS: Yes, I truly believe that the engineering judgment, based upon the kinds of experience that people have when they come to the FAA, is certainly adequate.

CHAIRMAN HALL: Mr. Phillips, excuse me just one moment. Mr. Laynor has a clarification question he would like to ask.

MR. LAYNOR: Tom, I'm wondering if you can describe the single-failure concept? Do you mean that the airplane must be capable of continuing flying safely after tolerating a single failure? Is that the basis for this?

THE WITNESS: Yes, it is. And the failure could be either a movement of a control, for instance, to a full deflection or it could be a jam or it could be a breaking of any element of the control system.

MR. LAYNOR: So the original certification back in 1967 would have accounted for any of those possibilities and the airplane should have been able to tolerate that?

THE WITNESS: To the best of my knowledge, reading only documents because I wasn't there, yes, I think that's what it was.

CHAIRMAN HALL: Please proceed, Mr. Phillips.

MR. PHILLIPS: So following along Mr. Laynor's question there, so if a control surface was fully deflected, that would not be cause of loss of control of that airplane or would you not expect a control surface to be fully deflected?

THE WITNESS: At the time of the certification, the best knowledge we have is that the aircraft was not designed for full deflection. When we talked about jams, when we talked about failures, it was from the expected deflection of the control system. Again, we're somewhat hampered by the fact that there are no people around in the FAA that were there then. But the best we can get from the information we have and trying to resurrect things is that the aircraft was designed for single failures and for jams within a reasonable range of expected jams.

MR. PHILLIPS: This falls into the category of normal encounter that we talked about yesterday?

THE WITNESS: Absolutely.

MR. PHILLIPS: Do you have the same concerns with the definition of normal encounter as Mr. Zielinski and the CDR team?

THE WITNESS: I wouldn't say I have the same concerns. I would say I think Mr. Zielinski's concerns are valid and need to be looked at.

MR. PHILLIPS: Do you have a plan or does the FAA have a plan of attack for that?

THE WITNESS: Yes, we do. In fact, I think if my memory serves me correct, the advisory circular is in final draft. That deals with the definition of that and a couple of other terms that the CDR reports asked for definitions on.

MR. PHILLIPS: So normal encounter to you would be something that you would -- a place where you expect a flight control to be in a normal flight?

THE WITNESS: That was the definition that was used back then. I believe I would say that would probably be the definition I would use now, as well. I really hadn't given that much thought about today how would I define it.

MR. PHILLIPS: Just a few minutes ago, we were discussing engineering judgment, and you said that it lies in the engineers in the certification offices.

What kind of backgrounds and qualifications do you require of your certification office engineers?

THE WITNESS: Well, I may not use the word "require." Let me just use the words "what kind of people do we normally hire," because there are really no requirements. Most of the people, with very few exceptions, that come to the aircraft certification organization have years of experience. I would say most of them, more than five years experience with the industry. If they're engineers, they've worked with one of the design organizations in the United States. If they are inspectors, they've been either with a manufacturer or with the Air Force.

It's very difficult for us to train a large number of employees directly out of college. Really what needs to have -- what needs to be seen by everybody is both sides of every issue. If you've been out there trying to deal with the engineering and sciences in the design of products, you have one view. The FAA, you have a slightly different view. Science hasn't changed, but just kind of the view has changed.

We think the meriting of those two is really the best kind of person for us. I would just point to Mr. Cook, Werner Koch, in the example that he spent many, many years in industry before he came to the FAA. Those people are instantly full performance as far as we're concerned.

MR. PHILLIPS: It seems to me that the engineering judgment that you expect of these engineers is very vital to the safety and continued airworthiness of the fleet. Do you agree?

THE WITNESS: Yes, it is.

MR. PHILLIPS: Is there oversight of an engineer -- does the final decision for an airworthiness directive or any kind of an action, regulatory action by the FAA, lie on one person's shoulders?

THE WITNESS: The major decisions usually do not. There is consultation with more senior engineers. In fact, we are instituting just this year a senior engineer program within the FAA, with an associated grade raise and everything that goes with it, to encourage them to be facilitators of technical issues, to be the ones that the junior engineers come to. The supervisors also generally have years and years of experience. There's consultation.

We do try to educate and help the employees reach the right decisions, to reach the decision that is reached, rather than make it for them, though. That's generally a cultural thing that we have.

MR. PHILLIPS: When an engineer writes an AD -- and I'll use for an example the airworthiness directive directed towards the servo valve in this rudder power control unit. In some earlier discussion, we heard there was a five-year compliance state. Could you tell me how that engineer is part of the plan of saying that's acceptable or unacceptable? What would he do?

THE WITNESS: Well, the engineer in the Aircraft Certification Office that drafts the AD is the one that consults with the industry. Either that would be the Air Transport Association, if it were a large aircraft like we're talking about, or the Regional Aircraft Association if it was a commuter. From that consultation, they get information.

If it's an AD with comments, if we put it out first as an NPRM for comment, we, of course, receive comments from anybody who is interested during that process. If it's an emergency AD, the consultation with industry usually is a little more expanded than what it would be if we were going out with an NPRM. Our desire is to get it right. Our desire is to get the right kind of input, both from the manufacture and the operators that will use the -- will be required to meet the AD.

The Air Transport Association has a recent program where they have what they call lead airline, which really facilitates our getting the right kind of input, because the lead airline literally tries to comply with the AD before it's even issued to see if it's practical, whether you can do it, can you get at that component the way we said, the way the manufacturer says.

It's really the operators that understand how the maintenance is done on the aircraft. So that engineer would be the one to do that.

MR. PHILLIPS: Did we use a lead airline in the AD for the servo valve modifications? Do you recall?

THE WITNESS: I don't really know.

MR. PHILLIPS: Is the lead airline concept new?

THE WITNESS: It's only a couple of years old, yeah.

MR. PHILLIPS: The airlines are selected as lease airlines for any particular reason?

THE WITNESS: Because they probably have the most number of aircraft of that particular type. It's a function of type of aircraft. And that selection, by the way -- I mean, that's a consultation that goes on between the manufacturer and the airline to develop the right service bulletin. The FAA is just on the outside of that. I mean, it's not really a legal consultation in any sense of the manner.

MR. PHILLIPS: Yesterday, we heard testimony from Mr. Newcombe. Do you -- are you a manager who oversees Mr. Newcombe's work?

THE WITNESS: No.

MR. PHILLIPS: Are you familiar with the work of the AEG?

THE WITNESS: Yes, I am.

MR. PHILLIPS: How do you see the AEG in relationship to the aircraft certification service? What's the relative level of importance?

THE WITNESS: It's an important relationship. It's a relationship that I many times discuss with Mr. Bill White, the Deputy Director of Flight Standards, which is responsible for the AEG. When aircraft certification in the early '80s was created, it was realized -- actually, then it was called the Office of Airworthiness.

It was realized that there needed to be an operational input into many of the decisions that we make, maintenance manuals, whether particular ADs can be even accomplished in-service. So the AEG was created to form that bridge between the operations and the certification. I think it's worked quite well.

MR. PHILLIPS: Along the lines of SDRs, service difficulty reports, what's your opinion of the effectiveness of that system?

THE WITNESS: I think this system is performing the function that needs to be performed. We are, though, in the process of trying to improve it. We have an effort that was prototyped in Fort Worth on helicopters to do safety analysis of the service difficulty reports. To take the data that is in Oklahoma City and start analyzing it. Start analyzing it along with the accident and incident database. And that system has proven to be worth expanding.

So we've expanded it into small airplanes, and we're now in the process early -- the very early process of trying to expand it into the transport airplanes, because far more service difficulties get reported in the transport airplanes.

MR. PHILLIPS: What kind of people would do analysis in this program?

THE WITNESS: The program engineer for the discipline that the service difficulty is related to would be the one. That capability would exist at his or her desk. I'm a firm believer that that's where it has to be. They have the knowledge, I think, of the product. It's an air framer. They understand the air frame on that product. They actually are the ones that can understand whether a single event is important.

There are very few tracking systems and algorisms that I've seen that can identify when a single event is important. But the person that understands the structure or the system or the power plant is the one that can do that. So we have it up on the computer of that person that is really responsible.

MR. PHILLIPS: It seemsthat the operators would be an important part of this process, too. Do you have a method in place to take advantage of the reliability systems operated by the operators?

THE WITNESS: In the engine area, we do. We are sharing an enormous amount of data with the engine manufacturers, large turbo fan engine manufacturers, under a program which we called CAMS, C-A-M-S. Don't ask me what it means. I can't remember the acronym. But it is a program where we start to do safety analysis. It is very encouraging. It's, again, in its early stages.

We are also looking at in the long term trying to do the same kind of large data retrieval with transport airplanes. It's not just -- and we're going beyond just the warranty stuff. There are several databases out there that are being gathered to track events. And we're really looking at trying to see if in the long term we can design some kind of a computer engine that just goes out and finds all of this data, brings it all in, analyses it, and starts flagging what needs to be done.

It's interesting that the one I talked about in Fort Worth actually flags. If it flags something, it comes up on the engineer's computer, and they cannot log in to their computer to do anything else, until they deal with that service difficulty issue. So that's the kind of importance that we've given to those particular problems.

MR. PHILLIPS: Why does that program exist just for the engines right now? Why did you start with that?

THE WITNESS: Because that's -- well, why we started with it? I think it was probably one or two people in our New England engine directorate that had the vision along with the manufacturers and there was cooperation through some of the societies. SAE has been mentioned. And that would be the only reason I think it was done there first.

MR. PHILLIPS: Do you have any time table for implementation in the program, any hopes?

THE WITNESS: Well, I mean, we're using the

CAMS program right now. We see some improvements probably being made from it. As far as expanding the service difficulty program into large airplanes, it's probably a couple, three years away.

In the meantime, we're totally comfortable with the present system of the manual review of the service difficulties.

MR. PHILLIPS: Let's get back into the CDR report for just another short period here. One of the recommendations or one of the concerns was about fluid quality in aircraft systems. Are you familiar with that portion of the CDR report?

THE WITNESS: Yes, I'm somewhat familiar with it. Although, I'm not really an expert on fluid quality.

MR. PHILLIPS: I think we heard earlier testimony that some manufacturers require a minimum standard for fluid cleanliness, while others require -- leave it up to the operators. And we've also heard testimony that the FAA doesn't require a minimum standard. Is there any thought in your mind towards changing that?

THE WITNESS: Well, certainly our request of SAE is an openness to look at whether or not we should change it. Like everything else that we do, we work quite hard to not restrict design and not overly design products. We think that the people who design the products are better at it than we are.

If it was a safety need to do it, I would certainly support that. Absent a safety need, I would be fearful that we might constrain some free thinking on somebody's part to define a better widget by the way we regulate the fluid particulate.

So I would want to look at very carefully to insure that there was a safety reason to do it.

MR. PHILLIPS: In your opinion now, is there a safety reason to do that?

THE WITNESS: I don't know. My mind is wide open right now.

MR. PHILLIPS: Have you heard any testimony this week or has anything we've done so far in this investigation incline you to think we need to do something additional?

THE WITNESS: No, I think the key is to let the A-6 committee and SAE complete their task.

MR. PHILLIPS: You mentioned the A-6 committee and the SAE. Is the FAA affiliated with the SAE in any other actions or activities?

THE WITNESS: Yes, we have a significant number of engineers and inspectors on SAE committees. I, myself, am on the aerospace council that manages the cooperative engineering program under which all of those standards are developed.

We reference many of the SAE standards in our technical standard orders, TSOs, and we think that our involvement in those committees and my involvement in the aerospace council is an incredibly large leverage on government dollars being spent.

If it were not for those committees, you couldn't hire enough people in the government to write those standards.

MR. PHILLIPS: Also the ARACs, could you tell us a little bit about what the advisory groups are?

THE WITNESS: The ARAC, aviation rule making advisory committee, is a fairly new process by which the FAA through these formal public meetings is able to, what I would say, discuss rule making and discuss issues openly with the public. Without ARAC, we would simply form our own opinion, put it in the Federal Register and wait for comments.

We believe in the long run -- and there have been some growing pains with ARAC, but we believe in the long run, that this consultative open process enables us to have better notices of proposed rule making, better advisory circulars with everybody's input, and actually in the long run saves resources.

As I say, there are some early issues about bringing this whole new concept on line, but they're starting to go away now.

MR. PHILLIPS: Are you aware of the joint airworthiness regulations, the JA requirements?

THE WITNESS: Very much so.

MR. PHILLIPS: Okay. I would like to talk for just a minute or two about similarities of those requirements in the Federal Aviation Regulations. And specifically in regards to the areas we're discussing in this hearing, incontrollability of flight controls and assessment of hazards, 1309.

Do you -- could you briefly describe any significant differences in the JAA, JARS and the FARs?

THE WITNESS: Well, in the 1309 area, there are some differences. I can't discuss them in real detail, because I'm not an expert in that particular area of the regulations.

We do have what we call a harmonization work program between the U.S. FAA and the JAA with industry involvement to bring those two regulations together. The British, I believe, have four categories. It may even be that the JARS have four categories under 1309. But we are in the process of harmonizing those, so that there is one set of standards that the industry has to meet.

In the area of controls, I am aware that there is a difference. If you read the FARs, it says, "any single failure, -- I'll put in a comma -- or multiple failure not shown to be extremely improbable." We have discovered that in the JARs, that comma, in effect, is not there.

So they allow single failures -- they allow the use of probability for single failures. We do not allow the use of any probability on single failures. You must cut the single element or you must jam the single element. They allow the use of probability to determine whether that will actually occur.

In fact, there is an aircraft, which I will not name, that there was a required design change to meet the FARs when it was -- when the type certificate was issued by the FAA.

MR. PHILLIPS: And this was because of a comma in the regulation?

THE WITNESS: Well, I don't know that the comma is really there. It's how the regulation is read. I put it in only for emphasis here.

MR. PHILLIPS: I understand. In your experience, are the JARS generally more conservative than the FARs or vice versa?

THE WITNESS: I would say, no. They are very much on par. Where they're different -- you know, engineers differ quite a lot sometimes. I don't think the level of safety, general level of safety, either one of those regulations is any different than the FARs.

MR. PHILLIPS: Had we had very many changes from the JAA or the JARs coming back into the FARs?

THE WITNESS: We have harmonized or tried to harmonize all of the FARs and the JARs. There has been changes to either the FARs or the JARs. The basic general criteria, though, that we in management have given all of the teams that work on those harmonizations is that it is not acceptable to just draw an envelope over both conditions.

They must literally debate and reach an agreement as to which one is right or maybe there is some in between that's right. But we do not allow them to simply just draw an envelope. That is not harmonization. That's just simply trying to do your job as quickly as you can.

There have been some changes in both directions.

MR. PHILLIPS: Are the manufacturers part of the harmonization program?

THE WITNESS: Yes, they are. They are part of the harmonization program that's done through ARAC. So it is totally open to anybody who wants to be a part of it. The JAA is also a part of ARAC, both in the working groups and on the executive committee of ARAC. So they are involved, as well.

MR. PHILLIPS: I would like to talk for a minute and I'll change directions a little bit about in-service events that involve airplanes. As events occur that are required to be reportable by the FAA, what's the process of feeding information into the FAA while involving an in-flight upset or something like that?

THE WITNESS: Well, the engineers and the ACOs review the service difficulty reports that have been submitted by the airlines and operators and users. We also get reports under a regulation 21.3 of significant events directly from the manufacturers that are required to report specified events. In fact, the airlines are required under Part 21 to report SDRs, unspecified events.

We also, because of our frequent contacts with the manufacturers, get reports on many, many other things that aren't required to be reported under 21.3, but nonetheless get reported and get communication going between the regulators and the design organizations.

MR. PHILLIPS: Is there any requirement for the FAA to keep a record of these events, these reports?

THE WITNESS: I don't know of any regulations other than the normal government file regulations, for every original document you create, you must keep it X-number of years.

MR. PHILLIPS: So as far as putting together a database for a list of events that have occurred, where would be the best source to find out how many times an event's happened on a particular type of airplane?

THE WITNESS: SDRs is one I think is very good. There is a cut-off point, as was mentioned earlier. I don't know exactly what date it is. I know we've -- I've seen electronically recovered data back to 1980. So that's quite a ways back. I think the ASRS reporting system is a very good reporting system.

I've, in fact, personally looked at all the ASRS reports on the 737 after the accident. I think it's a very good system.

MR. PHILLIPS: In looking at those 737 ASRS reports, did you see any indication that the airplane has a particular problem?

THE WITNESS: I didn't see anything unusual from any other airplane. I was mainly looking to see if there were any possible precurses that would give us any ideas on this particular accident and I didn't really see any.

MR. PHILLIPS: Did you -- are you aware of anybody else in the FAA that may have made the same kind of an assessment or did an evaluation of the available data?

THE WITNESS: Oh, I think the critical design review team did it, and I think the ACO in Seattle did it.

MR. PHILLIPS: And none of those people have identified a significant issue, in your opinion?

THE WITNESS: We've talked many times. And, no, we have not.

MR. PHILLIPS: Could that be from lack of information available to you to make a decision?

THE WITNESS: Well, I mean, if you wanted a possibly it could, yeah, it probably could. But whether it's that highly probable or likely, I wouldn't put a high probability on it, no.

MR. PHILLIPS: Do you believe that using the best data available, that this demonstrates the airplane does have a problem?

THE WITNESS: I think historically, we have a pretty good record of being on top of issues and having been aware of issues in-service and have taken the appropriate action on them.

MR. PHILLIPS: In some of the previous testimony -- not in this hearing -- but one thing noted in your CDR report is what appears to be a somewhat high failure rate for yaw damper components on the 737 fleet. Are you aware of that issue?

THE WITNESS: Yes, I am.

MR. PHILLIPS: Are there any plans within the FAA to do anything about that?

THE WITNESS: Well, I support the critical design review recommendation on that. I know it's being evaluated by the ACL. I know there are some thoughts to redesign parts of it. I certainly support those efforts. The key is going to be whether it's really going to make an improvement and whether that improvement is necessary.

MR. PHILLIPS: Do you believe that these yaw damper events are -- do you believe these yaw damper events are safety of flight critical events?

THE WITNESS: I do not believe that.

MR. PHILLIPS: There's no possibility that any of them could have been anything other than the yaw damper, in your mind?

THE WITNESS: Now, you've confused me because you started out by talking about yaw damper events.

MR. PHILLIPS: Do you believe that the listing of yaw damper events that we're talking about are the yaw -- I'm sorry. The yaw damper failure rates, do you believe that would be the sole source?

THE WITNESS: Oh, okay. I understand you now. I saw nothing in the lists of events that I've seen to lead me to believe that they are anything but yaw damper. A typical yaw damper, a three degree, at most, failure.

MR. PHILLIPS: No auto pilotvents that may be misdiagnoses or anything?

THE WITNESS: Well, I think there are some auto pilot events in the data, but that's what originally confused me, because as far as the yaw damper events, which we have separated, which I would have separated from what apparently looked like auto pilot ones, yeah, there were some auto pilot events where there was a movement -- uncommanded movement of the auto pilot. But that's a condition that is designed for and tested numerous times.

MR. PHILLIPS: In youropinion, is it a safety -- an auto pilot failure, is it a safety flight critical issue?

THE WITNESS: No.

MR. PHILLIPS: We talked yesterday a little bit about failure analysis that requires operational action. I would like to talk about that for just a minute. Are you satisfied that the FAA adequately addresses the issue of operational actions required in failure assessments to be carried out by the crew, either to have training or to understand the crew's ability to react to a failure?

THE WITNESS I believe now we are doing it properly, yes. We have created a group of items and certifications called CMRs, certification maintenance requirements. When, for instance, you do a probability assessment and you expect that a certain event is going to be done, if that event is very important, we create a CMR to make sure that that is done.

Those CMRs are tracked. They are a part of the MRB process that was referred to earlier. And we have a whole advisory circular on CMRs that describes how they are created and how they are dealt with operationally.

It's a little difficult for the air carriers, because it mandates certain maintenance events. But the thought being if that maintenance event was critical to getting something to be extremely improbable, then that's an important one to do.

Most of the CMRs are to look for latent failures. Failures that are undetectable. To make sure a particular back-up circuit is working, for instance in a particular piece of electronics. so I think right now, yeah, I think they are working very well.

MR. PHILLIPS: It sounds like this is

something that is fairly recent. Has this concept ever been applied to the 737 series, other than the CDR review?

THE WITNESS: I don't know if there are any CMRs on the later 737s. The L-1011 has some CMRs. So it's not that all recent.

MR. PHILLIPS: You're not aware of any for the 737?

THE WITNESS: I'm not aware of any, no.

MR. PHILLIPS: I think that's all I have now. I would like to turn it over to Mr. Jacky. He has a few questions.

MR. JACKY: Good morning, Mr. McSweeny.

THE WITNESS: Good morning.

MR. JACKY: I wanted to ask you a couple of questions regarding certification of the 737. When the 737 was first certified back in 1965, 1966, were there flight tests accomplished in order to -- or as part of that certification?

THE WITNESS: Well, I don't have any evidence that there was, but I'm certain that there was. I don't think there's been a transport airplane that we haven't flight tested.

CHAIRMAN HALL: Did I hear you correctly, there's no one left with the FAA employed that was there at the time of the certification?

THE WITNESS: Not that I am aware of, no.

MR. JACKY: As part of the certification for the 300, 400 and 500 series of airplanes, were there also flight tests accomplished for that certification?

THE WITNESS: I don't have any personal knowledge one way or another.

MR. JACKY: You were talking with Mr. Phillips earlier about normal use of a control surface. Would that be in regards to the entire operating envelope of the airplane?

THE WITNESS: I would define it that way, yes.

MR. JACKY: Would that also mean that would be the basis for what you certified the airplane too?

THE WITNESS: I believe that's true.

MR. JACKY: So if say in the process of certifying the airplane, that if a control surface moved to a -- or could move, regardless of the probability of that happening, would you necessarily certify to that basis or to whatever the normal use would be?

THE WITNESS: Well, if we had a rule that required or had the words in it normal, normal use or normal operating environment, then I would say we would -- if it was a control surface, we would look at what we expected the normal use of that control to be.

If we had a rule that required it to be looked at for a full travel, then we would look at it for a full travel. Now, if we determine that in a normal operating environment there would be full travel, then, of course, we would look at it under that rule.

MR. JACKY: I wanted to refer you to Exhibit 13X-L, which is titled, "NTSB Flight Data Report or Recommendation Letters." And I would ask you to specifically turn to page number 12.

THE WITNESS: Okay.

MR. JACKY: I would ask you to look at the bottom of the page at the indented paragraph there, which is a recommendation that the NTSB made to the FAA regarding the -- adding of additional parameters to flight data recorders on the 737. I was wondering if you could describe for us any sort of actions that the FAA has had on this issue regarding this recommendation.

THE WITNESS: Yes. The FAA was taking

several actions with regard to this. I believe the recommendations themselves were issued -- I'm flipping back. Yes, February 22 of this year. As a result of this recommendation, which basically deals with adding parameters, new parameters to the 737 airplane or insuring that at least the seven parameters noted are on the airplane, we put a Federal Register announcement out or notice in the Federal Register of a public meeting in March.

And then in April, we held a public meeting to discuss these recommendations, to get early input from the operators, the manufacturers, the Airline Pilots Association, anybody that had any kind of input into the recommendations.

As a result of that public meeting and some assessments of our own internally into the FAA, we decided that we -- the quickest way to react and to reach action on this recommendation would be through a quick acting -- and I want to emphasis "quick acting" ARAC working group. So we asked the ARAC committee in June to take on this activity.

In fact, they had a meeting just yesterday. The document that the working group has prepared dealing with this recommendation and other recommendations on flight data recorders that the board has recommended that are issued to the FAA, is a part of that package.

CHAIRMAN HALL: Mr. McSweeny, can I ask you, is there anything ambiguous about our recommendation?

THE WITNESS: I don't believe there is.

CHAIRMAN HALL: What is the purpose of the ARAC committee and what is the purpose of the FAA studying this issue since February, since the recommendation was made?

THE WITNESS: As required by law, we must when we do rule making go into a consultative process. We believe that in the public hearing and in the ARAC committee, that that was the quickest consultative process before us.

CHAIRMAN HALL: Is there a process that you can go through if there is something that you think is of urgent nature or even an emergency to expedite rule making?

THE WITNESS: We can do one of two things. We can issue an immediately adopted rule, which is strongly opposed by the Department of Transportation. They do not like to do that. Or we can issue an airworthiness directive if there is an unsafe condition.

CHAIRMAN HALL: Were either one of those considered in regard to this recommendation?

THE WITNESS: Yes, they were.

CHAIRMAN HALL: Very well.

MR. JACKY: Did I take it correctly that you said that the ARAC committee forwarded the report yesterday?

THE WITNESS: I don't believe it forwarded the report from the facts or from the conversations I've had here at this hearing with people who were at that meeting. It's my understanding there was some discussion about one of the other recommendations from the board that dealt with, I believe it's newly-manufactured aircraft and whether it should be 57 parameters or 88 parameters. The expectation is that they will forward something to us very quickly after they finish that debate.

Our expectation is to get a notice out next month, regardless of what ARAC does or does not do.

MR. JACKY: You mentioned that the ARAC committee in this regard was a fast-acting committee?

THE WITNESS: Yes.

MR. JACKY: How does that differ in length of time to a regular ARAC committee?

THE WITNESS: Well, we gave this ARAC working group a very short specific time frame in which we wanted the job done. That isn't our normal practice with ARAC. And quite frankly, one of the reasons is as mentioned by the chairman, that there's not an awful lot of ambiguity as to the scope, as to the objective, the discussion really has to focus on how to get there.

In many of the other regulatory projects, there's all kinds of debate on scope and objective and all that. So it's generally, they're a little bit longer than the time frame we gave this committee.

This committee also is unusual in that the working group chairman is Mr. Frank Rock, an FAA employee. That usually is not the case. We also thought that was important to make sure the right kind of leadership was given to that working group.

CHAIRMAN HALL: How many members are on the committee and could you tell us who serves on the committee?

THE WITNESS: I really don't know exactly who that is.

CHAIRMAN HALL: Could you provide that for the record?

THE WITNESS: I will be more than happy to provide it. Now, let me clarify, if I could. I would assume you would want the working group that's actually writing the document. The ARAC committee is a much higher group that just lists it.

CHAIRMAN HALL: Well, both, if we could, Tom.

THE WITNESS: Fine.

CHAIRMAN HALL: If that's no problem.

THE WITNESS: No problem.

CHAIRMAN HALL: I mean, when we --

THE WITNESS: I can give you that almost tomorrow, I think.

CHAIRMAN HALL: That would be fine. Thank you.

MR. JACKY: Have you had any discussions with Boeing regarding implementation of this recommendation?

THE WITNESS: Yes, we have.

MR. JACKY: Could you characterize the discussion for us?

THE WITNESS: The discussion that I'm familiar with -- and I'm sure the people on the working group have had other discussions, because I would be surprised if Boeing isn't a part of the working group. The ones I recall dealt with the possibility of installing a bracket up into the rudder area in the horizontal -- vertical stabilizer area to measure cable position as a substitute for pedal position in the cockpit. Therefore, having cable position before the PCU measured and then surface after being measured.

MR. JACKY: Have you had any discussions with individual operators regarding this recommendation?

THE WITNESS: We have discussed the matter of timing, of what processes in the shop would have to take place to install parameters with the Air Transport Association and there's about three airlines that have submitted comments that we have placed in the regulatory docket.

MR. JACKY: Has there been any discussions within the FAA regarding implementation of portions of this recommendation?

THE WITNESS: Yes, there have been. We have discussed within the FAA and we have discussed with the staff at the board, the possibility of simply putting only rudder position, rudder pedal position, and lateral acceleration in very quickly, rather than the full, I guess, seven parameters that are on this recommendation.

It was -- there have been extensive

discussions about that within the FAA, all the way up to the high levels within the FAA.

MR. JACKY: Is there any -- let me ask you this. When you were talking about very quickly, what sort of time frame would we be talking about in getting that accomplished?

THE WITNESS: As short as a year.

MR. JACKY: And how would that be -- the putting out of those parameters onto the airplane, how would that be accomplished?

THE WITNESS: Well, they would certainly have to route wires throughout the aircraft and maybe -- well, I guess, almost without question take out parts of the interior to run wires back to the flight data recorder. If you used the position indicator, say, for instance on the cable in the vertical stabilizer in your FDAU -- and I can't remember the acronym for it. But the processor of that data is up in the avionics bay. You have to run the cable forward and then back again.

So all of those cable runs and the installations of the brackets would require the aircraft to be in some kind of a maintenance hanger.

CHAIRMAN HALL: But it is technologically feasible to do that?

THE WITNESS: Yes. I don't think we're talking about anything that's not technologically unfeasible. Or we're not talking about anything that's technologically unfeasible. Let me rephrase that.

MR. JACKY: Does the FAA believe that the addition of these parameters could be accomplished during one or a series of overnight maintenance checks?

THE WITNESS: From the information we have available to us, we do not believe that you can do these on a series of overnight maintenance checks.

CHAIRMAN HALL: Where did you get your information?

THE WITNESS: We received information from the air carriers. We also received information from a trial program of installation of these parameters at a repair station called Tramco, I believe in the northwest Seattle area.

MR. JACKY: Could you characterize the amount of time that we're talking about?

THE WITNESS: Well, the time depends on it seems quite significantly on an issue that has come up as to whether the AFT laboratory has to be removed or not. Times that we have been given and look reasonable to us are anywhere from two to three days down time for the airplane.

The Air Transport Association provided a chart showing all the tasks necessary to accomplish it. There are some 70 to 75 tasks, depending on whether you take out the laboratory. That chart shows a time frame of between two to three days.

MR. JACKY: So would it be fair to say that the FAA's belief is that the airplane would have to be taken out of service in order to accomplish the addition of those parameters?

THE WITNESS: Based on the data we have, yes, that particular PERK chart shows some events taking far more than the amount of available time in any evening maintenance program.

One of the other reasons that I think leads you to that conclusion is that if you were to do it, even though let's say it was physically possible, you could chop up all the times into little bits of time. You wind up taking apart and reassembling the same areas of the airplane many times. If I were an air carrier, I would want to minimize the amount of times I have to do that.

I am also personally concerned about

temporary installations in the rudder area, temporary installations of brackets and indicators and things. Opening it up, closing it with temporary installations. It just leaves you open to possible problems.

CHAIRMAN HALL: What would be the reason that you would want to do something temporary and not something that was permanent?

THE WITNESS: Well, by temporary, I mean that whatever is there would be a permanent part of whatever is going to eventually be the completed unit, but it's a temporary completion of the task. And maybe I used the wrong word there.

CHAIRMAN HALL: So, if I'm gathering, the main consideration here is the fact that the airplane would have to be taken out of service and the time and expense that that would involve? Is that what's driving the decision or what factor does safety play in the decision?

THE WITNESS: Well, the -- when we do an action, safety is the big player. Safety is number one.

CHAIRMAN HALL: Well, do you have any other -- does the FAA have any other responses that we should be doing to monitor the safety of this airplane, since we have two accidents and we have yet to determine the cause?

THE WITNESS: We have no programs like the flight data recorder program.

CHAIRMAN HALL: Do you consider that a prudent thing to do?

THE WITNESS: What? To monitor?

CHAIRMAN HALL: Yes, to put the flight -- to retrofit the 737 with the flight data recorders?

THE WITNESS: I think it's prudent to require increased parameters in the 737 and other aircraft, yes. I don't think that has ever been a debate within the FAA.

CHAIRMAN HALL: What time frame -- and let me again complement the FAA on prompt response on our flight data recorders on new aircraft. But specifically on the existing 737 fleet, what time frame do you think will have a decision?

THE WITNESS: I couldn't tell you for the simple reason that that would prejudge the decision. We are proposing -- in PRM, we're asking for comments on anywhere from two to five years. And until we see the responses to those comments, any judgment I would make now about a decision would just kind of prejudge that.

CHAIRMAN HALL: Is there anything we can do to accelerate the process to those comments or accelerate the rule making?

THE WITNESS: Well, I am very grateful that we've had the discussions with the board over reducing the parameters down to rudder position or pedal position and lateral. I think that has been a very good effort. I would say anything that we collectively can do to working with the airlines and the manufacturers to minimize the cost of the installation and the time of the installation, is really, I think, the key here. It's the time.

CHAIRMAN HALL: Well, I think this board would welcome any proposal in writing from the FAA or the ATA that we could sit down and consider. I know there's been a lot of discussion, but if there's a proposal on how we can address this situation, I think that you will find the staff and board very interested in being cooperative in trying to insure that the -- until we -- in the absence of information that would lead us to a probable cause of the Colorado Springs and the Pittsburgh accident, that some action should be taken to monitor the rudder on the existing fleet.

And if this recommendation is not acceptable, then we would sit -- certainly sit down and try to work out something that would be in the interest of safety. I know you and the airlines share the interest that we at the board and the American public has in safety of flight.

So I just want to put that on the record, because I have heard a lot of conversations, but I have not seen a firm proposal. Am I correct in that, Dr. Loeb, that we have received at this point? If we can move it forward, Tom, we're ready to move forward.

THE WITNESS: I appreciate your comments. We share the same desires.

MR. JACKY: I have no further questions. However, Mr. Phillips has informed me that he would like to ask a couple of additional questions.

MR. PHILLIPS: I found a question that I've lost, so.

CHAIRMAN HALL: I notice that you all have taken the chairman's prerogative away and our calling on each other over there.

(General laughter.)

MR. PHILLIPS: This shouldn't take but a minute. The CDR report on page 46, this is Exhibit

9X-A. There are three recommendations there; 20, 21, and 22. And they address the issue of third party as far as 36 approval to manufacture parts.

I just wanted to have a brief discussion with you about your view points on these recommendations and any response you may have to where we are on satisfying these. I would like to start with number 22. The team recommended that -- I'll paraphrase this. That a team go out and take a look at, assess repair procedure processes and tooling used to overhaul 737 PCUs and components.

Do you know if that's been accomplished yet or not?

THE WITNESS: My recollection is that that is still under development as an activity.

MR. PHILLIPS: So they haven't done any reviews, but they plan to?

THE WITNESS: We have -- 1 think we've looked at a couple of repair stations, but not in a formalized manner that this recommendation deals with, but we're in the process of putting that together.

MR. PHILLIPS: So you expect a positive response to this recommendation?

THE WITNESS: Oh, absolutely. Yeah, we

intend to do that.

MR. PHILLIPS: The other question I would like to ask is about non-OEM approval for critical parts. Is it your position, as an FAA senior manager, that OEM or non-OEM parts are -- should be remanufactured or modified by other than the original manufacturer?

THE WITNESS: The production of replacement parts is a multi-billion dollar business in the United States. There's been a lot of controversy over whether the FAA should let other people than the original equipment manufacturer make various parts.

There have been numerous suggestions that we just for critical parts allow nobody, but the production approval holder of the product to make those parts. I think there are ways of the FAA dealing with the issue of critical parts, internal to the FAA, and not rearranging all the business opportunities of everybody in this country.

The way to do that is as this team has recommended. We did -- this is something that we have been discussing at my level and my management team's level. We've basically been asking ourselves whether there is a small subset. I think it is reasonably small.

A small subset of parts on any product, be it an aircraft, an engine, whatever, that no after-market approvals of any kind should be given unless the Aircraft Certification Office has coordinated with full veto power on that approval. And the Aircraft Certification Office would be the one that originally granted the design approval for that product.

Now, we can do that. It's a work load. I think it is something that we need to do. We have not formalized it as a process. This is the opportunity and the avenue through which we will at least make that decision on the 737.

MR. PHILLIPS: So do I understand you are considering rescinding the approval of --

THE WITNESS: I didn't say that. I was talking about the future approval.

MR. PHILLIPS: Okay.

THE WITNESS: The approvals that are out there are going to be dealt with under recommendation 22. That gives a nice, neat package of today and tomorrow all tied up in a bow.

MR. PHILLIPS: So as a result of this work, will the FAA attempt to verify that the parts that are being manufactured for the 737 by third-party vendors now, meet the requirements of these recommendations?

THE WITNESS: Yes. In fact, I can tell you of -- I can't remember the repair stations involved, but there are two that I know of that I know the approval that was granted to that repair station was coordinated with the Aircraft Certification Office in Seattle. So in those two instances, this recommendation was met.

MR. PHILLIPS: Would that coordination involve an exchange of engineering data, the drawings, the tools, all the things required, to guarantee that that part meets the requirements of the original manufacturer?

THE WITNESS: It would be design, process, and quality assurance. All the processes necessary to make the parts, the design itself, and the quality assurance to determine that once the part is made, it does, in fact, meet the design requirements.

We have all that data. We have all that data.

MR. PHILLIPS: So functionally you could not tell the difference between whether it was manufactured by Parker or OEM?

THE WITNESS: If it's a critical part, there should be no form, fit or function difference.

MR. PHILLIPS: Des that exist today?

THE WITNESS: That is, I believe, in our present orders on PMA parts.

MR. PHILLIPS: I have nothing else.

CHAIRMAN HALL: Yes. Mr. Laynor wants to follow up.

MR. LAYNOR: Tom, pursuant to that same line of discussion, who determines whether the part's critical?

THE WITNESS: It's determined now by the ACO engineer that is doing the approval. In the new scheme, the one that's identified here in recommendation 21, it would be the ACO that certified the product that would come up with this list in the concept that we were talking about.

MR. LAYNOR: How does the ACO go about identifying what critical dimensions might be on a part? And specifically, I'm talking about the -- let's use as an example, the end cap and spring guide and the servo valve spools in the rudder PCU in the 737.

THE WITNESS: I would say in all cases, it would be by assessing the consequences of a deviation in that tolerance or whatever the process was. If a deviation would result in a continued safe flight and operation problem, then that would be a critical element of that part.

MR. LAYNOR: And that's left to the ACO without consultation with the original manufacturer?

THE WITNESS: There is -- oh, without consultation wiht the original manufacturer?

MR. LAYNOR: Yes.

THE WITNESS: I wouldn't say that. I would say that there is consultation between the ACO that's certifying the product and the manufacturer over what is critical. We certainly ask that, even on after-market supplemental type certificates and stuff. We ask and the manufacturers are fairly free to -- fairly freely give us that information about what their view of criticality is. We eventually are the ones that have to make that decision.

MR. LAYNOR: Okay. Thank you.

CHAIRMAN HALL: Questions from the Technical Panel? Mr. Haueter?

MR. HAUETER: Yes, I have a couple. Concerning the modifications to the rudder power control unit, do you know the status of those modifications, the percentage that have been completed or where that stands?

THE WITNESS: The Aircraft Certification Office in Seattle gave me a number of 75 percent. You're talking about the ones that I referred to in the airworthiness directive?

MR. HAUETER: That's correct.

THE WITNESS: Yes, 75 percent is the number I was given.

MR. HAUETER: Do you have any estimation of when that will be completed fully?

THE WITNESS: No, I don't have it. That number, by the way, came from surveys done by the Flight Standards Organization, the principal maintenance inspectors at the airlines.

MR. HAUETER: It was mentioned yesterday in testimony about changes to the standby rudder actuator in terms of relieving the galling, changing from a bushing to a bearing design. What does the FAA plan to do with that when it's approved? I may have missed that in the discussion.

THE WITNESS: Excuse me. I think I missed.

MR. HAUETER: What do you plan -- when Boeing finishes their design work, is there plans to make that an AD or how is that going to be handled, do you know?

THE WITNESS: Well, I think it's premature to say whether or not we're going to make it an AD. We're certainly going to look at it, look at the design, look at the consequences of galling one more time. We looked at it before. See if there's anything new we know about galling as a result of this hearing and make a decision.

If we think there's a safety problem with units out there that are galling, then we will write an airworthiness directive. But we do need to define an unsafe condition before we write an airworthiness directive. So we'll make that decision in reviewing the data that Boeing is going to send us or has sent us.

MR. HAUETER: You don't currently believe there's an unsafe condition with the standby rudder actuator, I take it?

THE WITNESS: No, we don't. We do not believe there's an unsafe condition.

MR. HAUETER: On something else regarding the reported events, the yaw damper and roll anomalies of auto pilot, are those normally reportable in any fashion?

THE WITNESS: Well, you're in an area that I'm not very knowledgeable of, the flight operations area. We certainly are aware of them. The ones that have been reported since the Pittsburgh accident, I've almost been personally aware of every single one and have seen the flight data recorders when that information was available. I've seen the printouts.

MR. HAUETER: Is there any requirement for the pilots of the airlines to report a yaw or a roll anomaly?

THE WITNESS: I really don't know. I'm not responsible for that area.

MR. HAUETER: Is the normal operating environment of an aircraft consist -- is an engine out considered a normal operating environment of an aircraft?

THE WITNESS: I really don't know. It would be an emergency.

MR. HAUETER: Is it something you could anticipate happening during the life of a given airplane or --

THE WITNESS: Yeah, you could anticipate that happening. Right. It is, though, an emergency, I would think.

MR. HAUETER: Would you require full rudder deflection to cope wiht an engine out, say on takeoff?

THE WITNESS: I think the rudder on every airplane is designed specifically for that condition.

MR. HAUETER: So for the 737, if you lost an engine on takeoff, it would require full rudder authority to cope with that kind of event?

THE WITNESS: I believe there is a capability in that airplane to do that, yeah.

MR. HAUETER: So I guess I'm getting back to the original certification. Why was the full rudder travel not considered as the normal operating environment, if that can occur during something that's foreseeable to happen?

THE WITNESS: As I said, I mean, we're all guessing based upon reading documents that were created in the mid to late '60s. And I really can't -- as much as I would like to know that answer myself, I just don't know where we would get that answer.

MR. HAUETER: Have you discussed the original certification with the Seattle Aircraft Certification Office?

THE WITNESS: I've discussed it personally with Mr. Don Rig-gin.

MR. HAUETER: Was Mr. Rig-gin involved in the original certification of the airplane?

THE WITNESS: No, he was not.

MR. HAUETER: When did he join?

THE WITNESS: I really don't know. I know it was -- he and I talked. I mean, I specifically asked him if he was involved in it and he said no.

CHAIRMAN HALL: Are there records still available?

THE WITNESS: Yes, there are records. They are in dead storage, but there are records available.

CHAIRMAN HALL: Have they been -- have you all retrieved those at all?

THE WITNESS: I believe we've retrieved a significant number of early certification records as a result of the accident and the critical design review.

MR. HAUETER: Just a few more, sir. Are you familiar with the results of the recent simulator validation tests that were conducted by the aircraft in the Safety Board's aircraft performance group?

THE WITNESS: I'm familiar with the simulator work to try to recreate the scenario of the accident. I'm somewhat familiar with it.

MR. HAUETER: Are you familiar with the study heading side slip tests that were conducted as part of the simulator validation?

THE WITNESS: Yes, now I'm with you. Yes, I'm somewhat familiar with it. I know it was designed to validate the simulator. The specific criteria and the specific maneuvers were recommended by Mr. Les Berven, who will be the next witness, and he might be better than I able to describe them.

MR. HAUETER: Are you familiar with the lateral controllability issues that have been discussed during the previous public hearing and also as a result of the simulator validation work?

THE WITNESS: Somewhat familiar.

MR. HAUETER: Has there been any discussion about re-evaluating the controllability of the aircraft based on these findings?

THE WITNESS: Based on the findings that -- I assume you mean based on the findings of the flight testing we did recently?

MR. HAUETER: Correct.

THE WITNESS: Yes, certainly I'm sure we're going back and going to look at every detail of that data to see what impact it's going to have on previous decisions we've made.

MR. HAUETER: On the Exhibit 9X-A, which is the critical design team report, recommendation 9, where they made a recommendation to insure the capability of the 737 lateral control system to provide adequate directional control, what's the status of that recommendation?

THE WITNESS: I believe there has been data submitted to the FAA from Boeing that is being evaluated. As you will see, it also has the "unless" -- unless it can be shown to be extremely improbable. And I believe there is a discussion at this point over that part of the recommendation with Boeing.

MR. HAUETER: I guess, back to the question the other day, it said, improbable by the most rigorous methodology available. What would be the most rigorous methodology, I guess?

THE WITNESS: I'm not an expert on that, but I can tell you that the analysis is being reviewed by the people in the FAA that we believe understand probability assessment the most. And that's irrespective of whether they work in the Seattle ACO or not.

MR. HAUETER: Thank you, sir.

CHAIRMAN HALL: Any other questions from the

Technical Panel?

(No response.)

CHAIRMAN HALL: If not, we'll move to the parties. Any questions for this witness from the parties? I see the hand of the Airlines Pilot Association and I see the hand of Boeing. Anyone else? Mr. Donner, you have no questions of your boss here? No.

(General laughter.)

CHAIRMAN HALL: You're going to miss this opportunity. Very well. We'll go to the Boeing Commercial Airplane group.

MR. PURVIS: Good morning.

THE WITNESS: Good morning.

MR. PURVIS: The various speakers have been discussing recommendations from both the Colorado Springs and the USAir accident. Following up on that, can you say what the FAA has done to follow up on the NTSB's recommendation after the Colorado Springs accident regarding asking you to study mountain weather phenomenon?

THE WITNESS: No, I can't. I'm not familiar with that at all.

MR. PURVIS: That's all I have.

CHAIRMAN HALL: Captain, Airline Pilots Association?

CAPTAIN LeGROW: Thank you, Mr. Chairman. Good morning, Mr. McSweeny.

THE WITNESS: Good morning. If -- I think it's --

CAPTAIN LeGROW: It's still morning.

THE WITNESS: Barely.

CAPTAIN LeGROW: Just a few questions. During your testimony, you talked about the reasonable movement of certain deflection of controls and a certification. Could you just tell us what reasonable -- your definition of reasonable? Would it be 60 percent, 70 percent?

THE WITNESS: Well, I don't think I would put a percentage on it. If you're asking me for my definition, I would say something that you would -- reasonable is something that you would expect somebody to do irrespective of a percentage or a factor or anything like that.

Now, when you get down to the flight test rules and regulations in what is reasonable, I'm certainly not the expert. Mr. Les Berven would be a better one to ask that question.

CAPTAIN LeGROW: Okay. I'll ask Mr. Berven. Along that same line, as I understand it in 1967 -- I guess there's nobody left in the FAA 28 years later?

THE WITNESS: Not that we know of.

CAPTAIN LeGROW: But during those -- during the certification of the 737 -- and I'm assuming that was the 100 at the time?

THE WITNESS: That's probably a good assumption.

CAPTAIN LeGROW: It did not take into consideration full deflection of any control. Is that my understanding?

THE WITNESS: It's my understanding that's true.

CAPTAIN LeGROW: In your view would a full deflection then today be considered an improbable, an extremely improbable criteria? Would that fit the criteria, extremely improbable?

THE WITNESS: In today's regulations, we would look at a particular aircraft, look at a particular control service. The aircraft could be safely controlled with that surface at full deflection. There would be no improbability we would be looking at. The airplane would be perfectly safe.

It's only when a condition results from a deflection that we do not consider to be a safe condition, that we get into then analyzing the probability of that occurrence.

CAPTAIN LeGROW: As I understand it, the FAA never -- during the certification process, never took the controls to 100 percent.

THE WITNESS: I have no knowledge of that.

CAPTAIN LeGROW: Would it be safe to say then if we had an event, assuming the -- just for the sake of argument, a control that were to move 100 percent would be twice in four years, would not be considered extremely improbable then?

THE WITNESS: Well, extremely improbable is with respect to the whole life of an aircraft, as we've defined it, and it's measured in so many occurrences per hour. It certainly -- 1 don't know how you equate it to how many events have occurred in four years. And I'm not trying to be evasive.

CAPTAIN LeGROW: Well, one event would not -- would be not be extremely improbable then, if there was one event?

THE WITNESS: Extremely improbable means an event would occur no more than once in the entire lifetime of a fleet of aircraft. It doesn't say that that event would occur in the very last year of operation or the very last aircraft.

CAPTAIN LeGROW: I understand that. If, for example, that the FAA found such an event, what would the reaction of the FAA be?

THE WITNESS: We would assess that event and look at whether we needed to fix whatever it was that caused that event. I mean, when we look at the probability assessments, it's a way of dealing with stuff that we kind of maybe don't know what might happen. We're all human. We do the best job we can, but we got to where we are with the level of safety -- this level of safety of 10 minus 9, or 10 minus 8, or 10 minus 5 for the probable events.

Once we see an event and we say, gee, that's an event we don't like, we ought to correct that event. We step back from the certification of the probability and we deal with that event.

CAPTAIN LeGROW: This will go back to your statement earlier about airplanes talking to us.

THE WITNESS: Right.

CAPTAIN LeGROW: After they're certified down the road, they talk to us.

THE WITNESS: Right.

CAPTAIN LeGROW: If we see something that happens, then we take action.

THE WITNESS: Right. We, for instance -- let's say we were for some reason measure that the flap loads were ten percent more in-service than what was designed for. We wouldn't say, well, yeah, but we put a factor of safety unlimit load anyway. So we don't have deal with that. No. The factor is there for the fact that we're human.

CAPTAIN LeGROW: And to state the hypothetical situation, if you would, where the airplane has not been certified for a control. Let's just take for the sake of argument, the rudder was never certified, never demonstrated to be deflected 100 percent in flight. And if that were to be shown as an event, would the FAA then consider that being talked to and taking some action?

THE WITNESS: If we certified an aircraft under the assumption that a full rudder deflection was an event that was improbable or extremely improbable and we found that that assumption was not true, we would certainly go back and relook at the impact of that.

CAPTAIN LeGROW: The new derivative 737-300, the 600, 700, and 800 --

THE WITNESS: Right.

CAPTAIN LeGROW: -- it's my understanding that -- or is it your understanding that the airplane will be certified to the same standards as the 757 and 767 and 777 or will it be certified under the same certification criteria of 1967 and the 100, 200, 300, 400, and 500?

THE WITNESS: I can say it's not going to be the same certification basis as the 100, 200. Whether it reaches the same certification basis of the 777 or, quite frankly, beyond that, because that basis was set some four or five years ago, and is what's being discussed right now. The 57, 67 basis is ten years old.

We would like to see it as close as practical to today's certification basis.

CAPTAIN LeGROW: And the basis of the original certification of which the 300, 400, and 500 were derivative are 27 years old. Is that correct?

THE WITNESS: Yeah, close. It's probably more than that. If the certification took place in ‘67, the cert basis was probably established when the application was made in, I would guess, '62 or someplace like that.

CAPTAIN LeGROW: Does the FAA consider latent failures?

THE WITNESS: In today's probability assessments, absolutely we consider them.

CAPTAIN LeGROW: Does the consideration of latent failures affect the extremely and probable criteria?

THE WITNESS: It is many times a part of the equation that reaches that.

CAPTAIN LeGROW: Is there a means -- does the FAA have a means to re-evaluate that extremely improbable based on the fleet history?

THE WITNESS: We can do that any time we see a need to, yes. We know from the reports exactly what assumptions were made to arrive at that probability assessment. We also, as I mentioned before, have the CMRs that enable us to track some of those latent failures.

CAPTAIN LeGROW: You talked earlier about the 737 when it was certified. The full deflection of the controls were not a criteria in the certification. What guidance were flight crews given to this? In other words, to rephrase that, were the flight crews -- did the flight crews know that that was not a criteria in the certification of the airplane?

THE WITNESS: I have no knowledge one way or another on that.

CAPTAIN LeGROW: So crews would have no knowledge of how much control availability was used in the certification of the airplane? Would that be a safe statement?

THE WITNESS: It wouldn't be a statement I would make, because I really don't have the knowledge.

CAPTAIN LeGROW: If you would, please, in the CDR, the Exhibit 9X-A, page 17, it would be B-2. Are you familiar with that paragraph, sir?

THE WITNESS: Yes, somewhat. I mean, I read the report a couple of times a while ago.

CAPTAIN LeGROW: I would like to also refer to page 41 of recommendation 9 that Mr. Haueter referred to earlier.

CHAIRMAN HALL: This is page 41 of the same exhibit, Captain?

CAPTAIN LeGROW: Yes, sir, and that would be recommendation 9.

THE WITNESS: Okay.

CAPTAIN LeGROW: I think Mr. Haueter asked a couple of questions. My question is, has the FAA, to help satisfy this recommendation, considered mandating Boeing to either increase the lateral control of the 737 or limit the yaw capabilities of the 737?

THE WITNESS: I wouldn't go as far as we considered mandating anything with Boeing. We have certainly discussed the issue internally. I know we've had some discussions with Boeing on the matter. Each one of those solutions has some other things associated, which would concern me a little bit.

The rudder, as we mentioned earlier, is sized for engine out to a great extent. You reduce the rudder affectivity in any way and you've got a problem. You've got to deal with engine out. If you increase the roll authority -- if you go too far on the ailerons and I'm not an aerodynamics expert, but it seems logical to me that if you go too far up on the ailerons or down on the ailerons, you could get flow separation.

I'm sure the affectivity of the aerodynamics, the affectivity of the aileron tails off quite greatly as you go into higher angles. So it would be really an enormous challenge to try to bring all those factors in. What we don't want to do is unfortunately design the next accident.

CAPTAIN LeGROW: I understand that, but what we're trying to do is prevent the next one.

THE WITNESS: Right. I understand that.

CAPTAIN LeGROW: But there has been some discussions with Boeing -- there's been discussions with other industry people besides the manufacturers?

THE WITNESS: I couldn't say other people. It's only second-hand conversations that lead me to believe that there have been discussions between Boeing and the ACO.

CAPTAIN LeGROW: Has there been any discussions along the same line or same recommendation or changes to the operation of the airplane?

THE WITNESS: Yes, there have been some discussions about that.

CAPTAIN LeGROW: Could you elaborate on those, please?

THE WITNESS: Well, you're in an area where I'm not, again, an expert in the piloting and the performance. But there have been discussions about different speeds for the flaps, raising the speeds. The part of that that I am familiar with is the structural part. And operating more frequently at a higher flap speed will, in fact, cause the higher loads on the flaps to occur more often, which affects the fatigue life on the flaps.

There's also been discussion of not staying at flaps one and flaps five and flaps ten for as long a time as presently being done in operations today. That certainly has some possible benefits to it. The operational aspects of that, what it does to the operation, what it does to pilot training, what it does to the air traffic control system and stuff, are certainly issues that have to be dealt with.

We are discussing all of that internally still.

CAPTAIN LeGROW: I have one other question, if I could shift gears for just a moment, on the flight data recorder issue that Mr. Jacky brought up. The temporary, as I think you referred to it, as fixed or to gather data for the rudder and rudder position, are you -- you said that Tramco out in the northwest, you had some discussions with them on doing this modification on the 737-300s. And I think you said it would take two or three days on normal overnight to do that.

Did they give you any indication of exactly how many man hours that involved, from start to finish? From the time the airplane got in the hanger until the airplane went out, how many man hours it would take to do this?

THE WITNESS: First let me not take credit for something that I think the board said. They were the ones that I think had the big input into the Tramco thing. But the total hours -- I don't recall total hours, quite frankly, because to me total hours aren't important. What's important is the total length of time. You can have sometimes several people working on several parts of the aircraft at the same time. It's really how quickly you can get the whole job done that was the thing I was focusing on.

Other people that have to do the economic analysis and stuff, of course, were focusing on total time.

CAPTAIN LeGROW: Thank you. I have no more questions of this gentleman.

CHAIRMAN HALL: Thank you, Captain. I do feel that I should point out that a statement that you made, which I'm sure you were intending to be a hypothetical statement. I don't want there to be any misinterpretation by the audience, that there has been a full rudder deflection on the plane twice in the last five years.

In the Colorado Springs accident, we did not -- we were unable to come to that conclusion. And, of course, we have not completed our investigation of this accident. And one of the main reasons we do not have that information is because the airplane was not equipped with the flight data recorder that provided information on the rudder deflection.

CAPTAIN LeGROW: My statement was -- it was a hypothetical situation, if that were the case. I did not make that as a statement of fact.

CHAIRMAN HALL: I just wanted to be sure we clarified that. Thank you. The parties, any other questions from the parties?

(No response.)

CHAIRMAN HALL: If not, we'll move to Mr. Donner, Federal Aviation Administration.

MR. DONNER: Mr. McSweeny, just to clarify something Captain LeGrow just said. Did you make the statement that the modification involved two or three days of normal overnight?

THE WITNESS: It imolves two to three days of consecutive down time.

MR. DONNER: Thank you.

CHAIRMAN HALL: Mr. Clark.

MR. CLARK: The Safety Board issued three basic recommendations on the FDR upgrade. One dealt specifically with the 737 and the urgent nature of that and then other existing airplanes and new airplanes. What is the status of the 737 rack right now? Are we looking at a short-term effort directed at that?

THE WITNESS: We have not made the final decision on the short-term effort. We see some significant difficulties. If I were to be honest, I would tell you we see some significant difficulties in a short-term effort based upon the data we have seen, the data that's been submitted that's in the regulatory document -- the docket.

MR. CLARK: Now, basically that data is the biggest impediment right now to implementing the recommendation directed at the 737?

THE WITNESS: Yes, it is a major impediment.

MR. CLARK: Who provided that data?

THE WITNESS: The Air Transport Association provided it. The chart was developed by one of the airlines specifically.

MR. CLARK: But the airline feeds their

information through ATA, Air Transport Association?

THE WITNESS: Sometimes. Sometimes, it's direct. I mean, that's the normal way we use to get operational impact.

MR. CLARK: Are the airlines generally in favor or disapprove of trying to implement this recommendation?

THE WITNESS: I don't -- I can say that I haven't heard anybody at the FAA or the airlines say they don't agree with the objective or the recommendation. The timing is the big issue.

MR. CLARK: That they have several years to do this.

THE WITNESS: And I know there is some discussion about -- and I mentioned earlier about 57 parameters versus 88 on brand new airplanes.

MR. CLARK: But that's on the other existing airplanes or new airplanes, the 57 parameters.

CHAIRMAN HALL: Mr. Clark, if I could just join this with you for a second. I just want to be sure that it's placed on the record here that there were two recommendations made for the board in this area of flight data recorders.

One of them was an urgent recommendation.

The other was not an urgent recommendation. There is a difference in how we treat those recommendations and how you accept those recommendations.

I think that our concern is that it appears at present that the recommendation that we made that was urgent on the 737 retrofit is included in the same rule making that addresses the retrofit of all existing airplanes. A process that traditionally, I believe -- and if I'm incorrect, tell me I'm wrong -- is it takes approximately two to five years.

What we are requesting is that that recommendation be treated urgently and I -- that, again, is why I had asked about the possibility of expediting the process. I just want to be sure that we don't mix the status of these two recommendations that were made by the board to the FAA. One was urgent. That one is extremely important, but it was not in the urgent category.

Please proceed.

MR. CLARK: The estimate of the two to five days, you indicated, came through ATA.

THE WITNESS: Two to three.

MR. CLARK: Two to three, I'm sorry. We've talked about possibilities and probabilities. Is it possible that ATA inflated those figures to forward the urgent nature of this recommendation, so they can take the two to five years?

THE WITNESS: I would prefer you ask them that question. I really don't have any basis on which to make an opinion.

MR. CLARK: Well, let me follow up. You're the one that has to deal with their estimate of time.

THE WITNESS: Right.

MR. CLARK: If it's possible that they've inflated those numbers, what action would the FAA take to find out what the real numbers should be?

THE WITNESS: In every rule making we undertake, we recognize the possibility of whatever the side of the issue the people are on, that they will inflate their position. It would not surprise us that somebody inflated their position.

We just consider that in everything we do, and we have people, economists, that have abilities to go out and to do their own assessments of costs. We also have a lot of people that work for the FAA that used to work for the airlines, that can give us opinions on what is maybe inflated and what is not.

MR. CLARK: Is that discussion going on

within FAA today on this --

THE WITNESS: Yes, it is.

MR. CLARK: -- two to three day estimate?

THE WITNESS: Yes, it is.

MR. CLARK: Do you have experts working on this to use their judgment, if this can be handled on a series of overnights or whether the time can be cut to a day and a half?

THE WITNESS: It is. It is something that the people that are on the team from the FAA have some experience in, yes.

MR. CLARK: Back to Chairman Hall's question. What is the status, is it still actively being considered right now for the urgent part of the 737 rack? Is that still actively being considered within the FAA at this time?

THE WITNESS: It is, yes.

MR. CLARK: So within the rule-making process, there's still a possibility that the FAA will find that--

THE WITNESS: Yes, there is.

MR. CLARK: -- it can be accomplished in a series of overnights or that it is important enough to implement these recommendations, even though the airplanes may be on the ground for an extra day or two?

THE WITNESS: Yes, there is that possibility.

MR. CLARK: Within the -- are you familiar enough with the issues that this two or three day estimate might be accomplished concurrently with C-checks at this time?

THE WITNESS: I don't have a lot of personal expertise on the C-checks. The data that we are receiving is that the C-checks are quite full right now. Many of the airlines just recently finished their 11 parameter upgrades that took -- that was done during C-checks. People are putting, have put in wind shear equipment, heads up displays. Things that they are trying to do to improve their operational usage of the aircraft are all being done on C-checks.

One of the comments we got about the C-check was that if you look at the tasks that are being done to put in the flight data recorder parameters, you're routing wires and you're connecting wires. Safety tells you to take power off the aircraft when you're doing things like that. That is certainly going to disrupt other activities in the C-check.

The airlines seem to think that really even to do this on a C-check, it will require an extension of the C-check. By how much, maybe we're in the area of inflated numbers. I don't know. But if you extend the C-check any amount, you reschedule every airplane in the system, because they are all scheduled based upon they're going to be in this place at this time and then the C-check is due.

It's a very complicated task to look at the impact of this.

CHAIRMAN HALL: But the impact we're looking at is primarily an economic impact. Is that correct?

THE WITNESS: Yes.

MR. CLARK: Are you familiar with the data that the economist put together to evaluate this?

THE WITNESS: Not intimately, no.

MR. CLARK: In one sense, and I may be mixing apples and oranges, you commented earlier about the two and a half years to implement part of the recommendations for the existing fleet, other than the 737. Are there considerations made to implement the 737 concurrent with C-checks or is the -- wouldn't that at least minimize the time that the airplane would be down?

THE WITNESS: I'm not so sure I fully understood which recommendation you were talking about?

MR. CLARK: Well, I'm still talking about the 737.

THE WITNESS: Just the 737?

MR. CLARK: To look at trying to implement as much as possible concurrent with the C-check?

THE WITNESS: I think, yeah, I mean, that's clearly being considered as part of our package. I guess, what is a C-check, 3200 hours or something like that?

MR. CLARK: How often do they come up?

THE WITNESS: Thirty-two hundred hours, I think, is a fairly good number, if my memory serves me correct.

MR. CLARK: How long will an airplane fly before it accumulates to 3200 hours? Are we talking a couple months, a couple of years?

THE WITNESS: Gee, I really don't know. Give me a couple of minutes, I could probably give you a guess.

MR. CLARK: Can you describe for us the nature of the meeting yesterday that apparently dealt with the ARAC committee? You don't know all the players. Or you can get us a list, I'm sure. But what was going on yesterday in that effort?

THE WITNESS: In ARAC, there's a formal ARAC committee. That's where the public discussions of matters take place. That committee then forms working groups to deal with the details. Yesterday's meeting was where the working group reported out a product to the ARAC committee for the ARAC committee's thumbs up, thumbs down vote on the package. And there were, I'm told, a couple of issues that needed to be dealt with. One was economic analysis and the other one was the parameters.

MR. CLARK: Who writes those issues?

THE WITNESS: I don't know.

MR. CLARK: Was that within the working group or was that --

THE WITNESS: I think it was within the ARAC committee itself.

MR. CLARK: The higher level committee rather than the working group?

THE WITNESS: Yes.

MR. CLARK: I'm going to change subjects here back to the recent flight test, the simulator development flight test. You indicated you're aware of the issues that arose out of that flight test, about controllability with a simulator rudder hardover and lateral controllability.

THE WITNESS: Some of the issues, I'm familiar with.

MR. CLARK: Some of the issues.

THE WITNESS: I think Les Berven is far more familiar than I am.

MR. CLARK: Okay. In the specific area, he's the test pilot, the FAA test pilot that was involved.

THE WITNESS: Right.

MR. CLARK: But within those issues, since those issues did arise, whose responsibility is it at the FAA to take those issues and resolve them? Whose task is that to --

THE WITNESS: We would first expect Boeing to take the issues and resolve them. Then the ACO, the Aircraft Certification Office, would be the one that would oversee to make sure that what was done is something we agree with.

MR. CLARK: That's basically Mr. Riggin?

THE WITNESS: Mr. Riggin's organization, yes.

MR. CLARK: But the fact is, who gives Mr. Riggin's the guidance? I mean, is the FAA raising issues on that also and tasking Boeing to assist in resolution of those or how is all that implemented?

THE WITNESS: I don't know. The only issue I'm aware of from that testing that preceded the wake vortex testing is the issue of blow-down angle on the rudder. I know -- I mean, I've been told that that's been put in the simulator and reflown already. But I know there are other hinge moment data and stuff like that, that needs to be put in and Mr. Riggin's organization of either one that would be following that effort were at Boeing.

MR. CLARK: But in the larger context, if we have -- whatever the blow-down limit is, whatever that rudder is that we can deflect the lateral controllability issue, is can the airplane maintain real control or are there training issues or equipment changes that can be made? Who defines those issues? It becomes a question of certification issues or possibly recertification by new rules today that were not in effect. Who handles all of that?

THE WITNESS: It would be --

MR. CLARK: Who sets the policy for Mr. Rig-gin to make sure that those are all properly resolved?

THE WITNESS: It would be Mr. Riggin's responsibility to do it with appropriate management oversight by Ron Wojnar, the manager of the transport directorate, Mr. Stu Miller, who's the manager of the transport policy staff who gives transport policy, and myself and my deputy Beth Yost. I can assure you that all of those people will be in that chain.

MR. CLARK: And they're busy on this issue right now?

THE WITNESS: I mean, Icouldn't tell you how busy they are, because I haven't talked to them about it. I'm sure they are.

MR. CLARK: The issue is present all the way down through that -- all the way to Boeing, in your estimation?

THE WITNESS: I have personally had discussions over the blow-down angle.

MR. CLARK: With all of that in progress, either from Mr. Riggin's level or below up to your level, how does the FAA view the criticality of that issue?

THE WITNESS: Oh, I think it's important to get the simulator corrected where it needs to be corrected, where those corrections are important to studying the events of the Pittsburgh accident. And I'm sure it will be given the appropriate priority both at Boeing and the FAA.

MR. CLARK: But the issue is -- is the issue simply the simulator? I mean, the airplane gave us a demonstration of controllability and we'll be discussing that with the test pilots here in a little bit. But the issue comes back -- am I reading, that you're going to use the simulator to explore those issues further in the reliable controllability?

THE WITNESS: I don't have knowledge at this point of exactly what our plan would be to revalidate or relook at the simulator. The point is that if we're going to use the simulator to go out and look at areas of the envelope of that aircraft that we didn't look at in flight tests, we ought to have that validated simulator in there -- that simulator data in there, and that's why we really thought those tests were important.

MR. CLARK: Get the simulator down and then you can go do the --

THE WITNESS: Right, we're not going to fly to some parts of the envelope.

MR. CLARK: -- parameter studies.

THE WITNESS: That's not the safest thing to be doing.

MR. CLARK: Sure.

THE WITNESS: The other thing that you're going to get out of the simulator that you don't get out of the actual airplane is all the what ifs that you want to set up, that you really want to explore instability or marginal conditions.

MR. CLARK: Pilot reaction and pilot recovery?

THE WITNESS: All of that, right. Although, you're recognizing that the end cap simulator doesn't give you G's.

MR. CLARK: The one feedback in the vertical direction.

THE WITNESS: Yeah.

MR. CLARK: The last area that I would like to cover. We talked about the airworthiness directive dealing with the servo valve and the over travel. That comes under your area also, somewhere down the certification line. Are you aware if any other manufacturers or, I guess, Mr. Walz talked about third party. Are any other third-party people out there approved to implement this AD?

THE WITNESS: I don't specifically know the answer to that. But let me, though, describe what the

AD requires and that partially answers your question. The AD requires that a specific part number be placed in that PCU. That part number is manufactured by one person, one company.

If any other company under a PMA or an S-FAR-36 or an owner-operator of an aircraft were to decide they wanted to manufacture their own part, it would require an alternate means of compliance to the airworthiness directive, because that part number would be a different part number than the one referred to in the AD. That would require the by AD language, that would require the ACO in Seattle to approve that.

It's exactly the chain that the CERT team recommended be done for critical parts. So we feel very comfortable that if there's anybody out there that would ever want to make one of the new parts, we've got the right surveillance of it.

MR. CLARK: But you're not aware right now if anybody is doing that --

THE WITNESS: No, I'm not aware.

MR. CLARK: -- other than Parker?

THE WITNESS: I'm not aware at this point.

MR. CLARK: They may be, but you're not aware.

THE WITNESS: I thought I heard Parker was providing them for free.

(Laughter.)

THE WITNESS: I don't know. But if they were, I can't believe that anybody would ever want to go out and pay for one.

MR. CLARK: Well, okay. Thank you.

CHAIRMAN HALL: Mr. Marx.

MR. MARX: I'm a little bit confused about what -- I've heard the statement on the standby rudder as any galling in that position would not be an unsafe condition. I also heard that this is not a safety of flight issue. Could you tell me what your reasons why you think this is not an unsafe condition?

THE WITNESS: We articulated those in a document, which withdrew an airworthiness directive dealing with the galling on the standby actuator. It was a proposed AD. And basically -- I don't remember all the details, but it was basically four cues that we thought were available to tell the pilot. And I don't know if maintenance was also involved in that list, but four cues that would identify that galling was taking place.

We also believed that if there was galling, if there is a full seizure, that it would not be an unsafe condition. So on the basis of that, we withdrew that proposed airworthiness directive.

MR. MARX: Do you know what thoseues are?

THE WITNESS: Not offhand, no.

MR. MARX: Do you consider galling on the standby rudder to be an extremely remote condition, a probability or would you consider it?

THE WITNESS: I really wouldn't know. I don't have any numbers on how often it occurs.

MR. MARX: If you knew that it occurred on two airplanes or even three airplanes, would you consider that extremely remote?

THE WITNESS: Sixty-seven million flight hours is about 1.5 times ten to the minus eight reliability. If it occurred three times, that would be 4.5 times ten to the minus eight. So that's a pretty remote event.

MR. MARX: Well, has the FAA looked at the actual bearings, the shafts and the bearings to find out if they had galling and taken a check of airplanes and fleet to find out what the probability is for galling?

THE WITNESS: I really don't know if the ACO has done that. The people that would be doing it would be the systems engineers, Ken Frey and others like that in the Seattle ACO. I have really no knowledge of whether they have done that or not.

MR. MARX: What's a consideration for a single hydraulic failure in an airplane? Is that considered something that we would need to take into account?

THE WITNESS: Under today's rules, you must account for a single failure.

MR. MARX: I would like to refer you to Exhibit 9X-1, page 3 and page 4. Actually, it's at the end of page 3 and at the end of -- and the start of page 4.

CHAIRMAN HALL: Nine-X what again, I?

MR. MARX: I.

CHAIRMAN HALL: Nine-X-I.

THE WITNESS: Okay.

MR. MARX: This states and I'll say, it says, "In the event of a single hydraulic system failure, the standby hydraulic system will come on automatically when the flaps are not in the up position." What is your understanding of that?

THE WITNESS: I'm not familiar with that part of the design. I couldn't tell you. My assumption is that's a valid description of the Boeing airplane.

MR. MARX: So if we had a single hydraulic failure, it would expect that the standby would then be operational if the flaps were not in the full up position?

THE WITNESS: I mean, I don't know. I'm not familiar with this part of the design and what triggers the single -- what is triggered by the single hydraulic failure.

MR. MARX: Well, if this was true, if you had a single hydraulic failure and you had galling that occurred onto the bearing of the standby and all the rudder control is now by the standby, would this be a safety of flight issue?

THE WITNESS: To determine that, we would have to -- I would have to look at what the resulting -- deflection of the rudder, what the resulting reaction on the airplane would be. I couldn't give you that answer off the top of my head now.

MR. MARX: Okay. Thank you. That's all the questions I have.

CHAIRMAN HALL: Did the CDR team look at that issue, Mr. Marx, are you aware?

MR. MARX: Well, I think we've asked some questions that deal with the standby, but I don't think that -- there isn't anything that I could find in that exhibit that would indicate that they did.

CHAIRMAN HALL: Mr. Schleede.

MR. SCHLEEDE: Thank you, Mr. Chairman. I just want to try and clarify several issues here that are not quite clear to me, but might be to other people. First of all, Mr. McSweeny, could you describe what the principal differences are between -- or principal differences between the certification requirements for the 737-100 to 500 versus what would be required today on a new airplane?

THE WITNESS: I mean, without bounding it and even if you bound it, I'm not so sure I could do it. I couldn't really give you paragraph or even conceptually what the differences are. I mean, I'm sure we can provide that, but I wasn't prepared to speak to it.

MR. SCHLEEDE: Well, I understand there's a great bunch of detail and different amendments and so forth to the rules, but in a general sense, we've been talking about the requirements for FMEAs and probability analyses, those type of things. The broader certification requirements.

THE WITNESS: If you're talking about control systems, it's basically that back when the 737 was certified, it was what we call a single failure rule. We now have single failures and multiple failures not shown to be extremely improbable. That change came about approximately the time and I believe was connected to the fact that airplanes were moving from manual reversion airplanes to full all-powered non-manual reversion airplanes. That kind of thinking going to multiple failures would be very logical kind of thinking at that time.

MR. SCHLEEDE: And please describe for us again the single failure philosophy?

THE WITNESS: Well, the single failure philosophy is your protect against single failures.

MR. SCHLEEDE: And at that time, you did not have to calculate -- quantify the probability of failures?

THE WITNESS: I don't believe so, no.

MR. SCHLEEDE: Well, it's my understanding then. I just wanted to see if that's a fact. You were not required to do the probability analyses in 1965?

THE WITNESS: Probability analyses in 1309 was not on the books in the '60s, in the late '60s.

MR. SCHLEEDE: Do you have Exhibit 9X-N as in November? Its title is "Critical Design Review, Executive Summary."

THE WITNESS: Right.

MR. SCHLEEDE: And the pages aren't numbered, but there's slide numbers down in the bottom left corner. I would like to go to slide number 10. I don't believe there's a page number on it. It's like three from the end. These are the results of the CDR executive summary of their report?

THE WITNESS: Correct.

MR. SCHLEEDE: I would like to talk about the first one there, "The Boeing 737 meets all certification requirements." Do you agree wiht that conclusion?

THE WITNESS: Yes.

MR. SCHLEEDE: And that's based on the CDR findings?

THE WITNESS: That's based on the CDR team's full assessment of the certification of the aircraft. Those are the certification requirements listed in the type data sheet for the 737 airplane.

MR. SCHLEEDE: And did that basis require -- or include the failure analysis of certain components?

THE WITNESS: I don't believe it did.

MR. SCHLEEDE: It did not?

THE WITNESS: I don't believe it did, no.

MR. SCHLEEDE: Well, there was a failure analysis produced for the airplane as part of its original certification, various items --

THE WITNESS: I'm aware that there was one --

MR. SCHLEEDE: Have you ever reviewed it?

THE WITNESS: -- that the team looked at. I'm not aware of it. I haven't looked at it myself.

MR. SCHLEEDE: You haven't looked at it?

THE WITNESS: No.

MR. SCHLEEDE: You've described and defined for us an extremely and probable event as one that can occur one time in the life of the aircraft?

THE WITNESS: Life of a fleet of aircraft.

MR. SCHLEEDE: The fleet of the aircraft. I presume that means then it cannot occur twice. If one occurs twice, that definition -- it cannot be characterized as extremely improbable?

THE WITNESS: Technically, no, it could not.

MR. SCHLEEDE: Could not. Okay. If it was -- something was certified under that and determined to be extremely improbable and then there were -- if there's one failure, first of all, is there any action necessary?

THE WITNESS: It would really depend on the failure. As I mentioned before, when you have a failure in-service and that failure is a serious failure, I think you're compelled to correct it. I don't think you can go back and recalculate the number and say, well, gee, that was ten in the minus, still ten in the minus. So we're going to forget about that failure. I don't think anybody in the FAA would think that way.

MR. SCHLEEDE: And how is that number calculated?

THE WITNESS: With a lot of experience and a lot of engineering knowledge. We, for instance, have reliability and probability assessment training courses for our own people just because it is an art. It takes a fair amount of experience to know how to do it. And it takes experience with equipment.

Most people that do it --like, for instance, engine manufactures. I speak of that as an example, because I -- we recently had some discussions at my level about it. When they look at the probability, say a fan blade failure or things like that, they throw in factors about that count for the fact that the system is maybe a new technology. They'll maybe knock it down by a factor of three or four.

It's probably very conservative, but yet they recognize that some of the estimates that they might be making aren't that all fact based yet, and so they account for that, and we would certainly require that kind of a conservatism on new technology.

MR. SCHLEEDE: If I recall right from some of the testimony or from the earlier testimony, other witnesses and yourself -- but I think Mr. Kullberg has told us that since the CDR, that Boeing Company -- based on the CDR recommendations, the Boeing Company has submitted to the FAA its analysis of the rudder directional control system and determined that a hardover failure to be extremely improbable. Were you here during his testimony?

THE WITNESS: Yes, I was.

MR. SCHLEEDE: Have you -- has the FAA evaluated and agreed to that submission from Boeing?

THE WITNESS: We have not finished our review of it. And, in fact, we're asking some of the more knowledgeable people within aircraft certification in the area of reliability assessments and probability assessments to take a review of all of those reports that have been submitted.

MR. SCHLEEDE: And is that one of the reports that you think you will have your results done at the end of this month?

THE WITNESS: The ACO has indicated to me they plan to have their assessment done by the end of this month.

MR. SCHLEEDE: Along the same lines, there's a couple of terms that we've used here and are used in the regulations, and I'm not sure you've been asked to define it. If you can, the term "uncontrollable event" and "unrecoverable event."

THE WITNESS: Right. I can try to do my best. I'm sure Mr. Berven will be able to probably do a far better job than I. But uncontrollable is a flight test term. It's what I would in my mind say is an arbitrary term. And what it usually means is that the particular event has exceeded what we consider to be either a requirement limit or a reasonable limit and it's simply that. That we have set a limit.

Let's say you're in a stall and you fully recover from that stall after three turns. The rule says you can't go three turns. So we would say that maneuver is uncontrollable, because it has exceeded this limit that we have set. But yet that maneuver might still be fully recoverable, as the example I gave, the stall.

MR. SCHLEEDE: That's the uncontrollable. Now, how about recoverable? Did you --

THE WITNESS: Well, recoverable means that you would recover the aircraft without an accident, in my mind.

MR. SCHLEEDE: So you could go out of control, yet not crash --

THE WITNESS: Be recoverable.

MR. SCHLEEDE: -- and be recoverable.

THE WITNESS: Absolutely. Now, the problem that I see is I believe that not everybody is using the word controllable as it was used when it was first controlled or conceived by the flight test community.

MR. SCHLEEDE: So uncontrollable is in the regulations and in the certification process is defined by some arbitrary --

THE WITNESS: I don't know if the word -- well, I don't know if the word "uncontrollable" or even -- well, I'm sure the word "controllable" is in the regulation some place. But some of our -- like our flight test advisory circular goes through all the various regulations in Part 25 and says there's a lot of pilot judgment that goes into a lot of stability and handling qualities and things like that.

And we've issued advisory circulars that says, for instance, on an auto pilot runaway, you can't exceed X number of degrees of roll angle. I think it's 60 degrees or something like that. We consider that uncontrollable. If you had 65, sorry, you didn't meet the intent of what we think the rule meant.

MR. SCHLEEDE: Well, I'm sure wean ask Mr. Berven some questions, but I just wanted to ask you some on the same area. We also -- in some of the certification language and documents we've seen, the phrases are certain events that occur are rationalized by the pilot of being able to recover or maintain control -- I'm not sure of the exact word -- without using exceptional --

THE WITNESS: Exceptional piloting skills.

MR. SCHLEEDE: -- piloting skills. Could you help us figure that one out?

THE WITNESS: I will decline that request. I do -- I am not an expert on exceptional piloting skills. I am not a pilot. I would really not want to hazard any kind of an opinion on that.

MR. SCHLEEDE: I appreciate that. But it is a term that's used in the certification --

THE WITNESS: Yes.

MR. SCHLEEDE: -- in the world and the documents, and it's something that we're trying to understand.

THE WITNESS: Right. Frankly, because it is subjective in some regards, when we do a certification program, if we have any doubts about that subjective criteria, we can form what we call MEOTs, multiple expert opinion teams and it would basically -- in this case if it was a pilot thing, it would be three or four pilots that would fly the same aircraft. And that team would come up wiht a decision that they would then submit to management as the team's opinion of that particular aircraft.

Now we have done that in the past. Not very frequently, but we have done it.

MR. SCHLEEDE: I'm going to try to pull this together in one more question. If we have an extremely improbable event that occurs and it results in an uncontrollable situation and unrecoverable, in both, is that in the certification world an acceptable situation?

THE WITNESS: Yes, because the rule says you must protect against multiple failures not shown to be extremely improbable. If the failure condition is extremely improbable, it is acceptable.

MR. SCHLEEDE: Well, part of our dilemma, I think, or at least mine -- maybe I'm the only one -- is that the FAA has not made a determination about the rudder hardover being an extremely improbable event. That determination has not been reached by the FAA. And yet, what we understand from the data and from our investigation, that in certain flight regimes, the lateral control system is insufficient to handle a hardover rudder.

Can you help me understand, see my perplexion here? Does that airplane meet requirements?

THE WITNESS: Well, the airplane, as the CDR team correctly determine, meets its certification basis.

CHAIRMAN HALL: What is its certification basis, 1960?

THE WITNESS: Right. That certification basis listed in the data sheet. Now, the CDR team went beyond that, and that's -- and I think the question you raised is the question that they have raised to themself, which I would say postulated the recommendations they made, let's go back and look at that. And that's what we're really trying to do right now.

MR. SCHLEEDE: Well, maybe I'm confused because of the summation in the results section of the executive summary says the Boeing 737 meets all certification requirements.

THE WITNESS: Right.

MR. SCHLEEDE: I was just trying to fair it out. It's all of the certification requirements that existed in 1960.

THE WITNESS: That it's required to meet, right.

MR. SCHLEEDE: I've still got some more here.

THE WITNESS: Now, keep in mind, we have not stopped at just that statement. That's what the whole CDR is about and that's what the whole discussion is about at this hearing, I would say, or Board of Inquiry. Let me be correct there.

MR. SCHLEEDE: In some of the original -- and I asked these questions of some other witnesses earlier. In the original certification failure analysis, there were certain items listed and responses as used as a basis for that failure analysis. One of them was a jam in the directional control system that would lead to a hardover rudder and that was the condition listed to be evaluated. The result or the response to that was that the pilot could deviate hydraulic systems.

My question and I know the CDR team looked at this, but they didn't come to definitive conclusions. They just raised concerns. My concern is that there is no procedure in the flight manuals for pilots for hardover rudder situations to turn off the hydraulics, even though this condition was cited as the proper response to that condition. How do you reconcile that, so that I can understand it that's not a problem?

THE WITNESS: Well, I would look at any condition like a full rudder deflection in two phases. The first phase that I would look at is getting control of the aircraft. And then second phase is now troubleshooting what happened and how can I resolve the problem I have in front of me. I would contend that that is the way the original certification looked at it based upon the small amount that we can glean out of some of the material we have from some of the type board meetings.

So the first step is gain control of the aircraft, level the wings or whatever. Gain a reasonable altitude, and now try troubleshooting it. I think it's the troubleshooting phase that this shutting off of the A&B hydraulic system was talking about. I don't think anybody would suggest that before controlling the airplane, that anybody would start shutting off hydraulic systems.

Unfortunately, I would say in this particular accident, they never reached phase two.

MR. SCHLEEDE: Do you think there is the ability to get to phase two under when those circumstances exist?

THE WITNESS: Under the circumstances of 427, I think there is, yes.

MR. SCHLEEDE: Could you explain?

THE WITNESS: Well, I think if the aircraft were to accelerate slightly, it's my understanding from talking to the people that work in aircraft certification, that you would gain more authority then of the ailerons. You would be able to at least write the wings and pull up the aircraft. Then is the time you enter phase two.

MR. SCHLEEDE: Then it goes back to my original question about that type of a failure mode. I'm not aware of any procedure or training in that maneuver existing or required for pilots. So how could that be an acceptable situation?

THE WITNESS: I think we're looking at what was perceived in the minds of the certifiers back in 1967. I wouldn't disagree with your assumption or with your statement that there are no procedures spelled out. We, though, have over the years many, many events where pilots have been very -- have used great ingenuity in troubleshooting aircraft. And it comes from their understanding of the systems during pilot training on that particular aircraft during their type rating.

I think, like some of the other things that we've tried to deal with here that have given us difficulty, we're trying to resurrect in the minds -- in our minds what people had in their minds back in '67.

MR. SCHLEEDE: Thank you. I would like to skip to a couple other subjects here. On the service difficulty reporting system, I don't think you mentioned specifically -- well, on the subject of how you get incident input. I want to go beyond the SDR system to input from the international community or from the arena. How does the FAA get service information on international?

THE WITNESS: There are a couple of ways. Service information is provided back to the manufacturers from the international operators through a network that the manufacturers have. We have access to that any time we want. We would become aware of events that are of significance.

Also as authorities -- the authorities of Europe and the United States have pretty close working relationships. If there are any significant events, that information is shared immediately. We talked earlier about or some people talked about the roll event or the oscillating roll event in England. I was aware of that the day after it happened by a fax sent from Peter Harper, my counterpart at the U.K. CAA.

Those kinds of communications are almost routine. There are even -- there are more communications between the working levels of those authorities and the various ACOs or the Brussel's office.

MR. SCHLEEDE: And is that frame work for that type of communications within any ICAO annexes or requirements?

THE WITNESS: Well, the only ICAO requirement that I can think of that would be related would be the requirement for us to provide as say the certifying authority of U.S. products, service information worldwide. And we do that with the airworthiness directives and if there are matters that are of -- we deem to be significant that aren't airworthiness directives, we sometimes writes letters and send them to a list of authorities that we have.

We know by authority throughout the world which authorities have which aircraft on their registry.

MR. SCHLEEDE: Another subject. On the service bulletin issue, we understand service bulletins when they're issued are not considered safety of flight items. There was earlier testimony on that.

THE WITNESS: Service bulletins themselves generally aren't. The manufacturers sometimes issue redline service bulletins or make recommendations that there be mandatory. They are not mandatory in the sense of the FAA until we issue an airworthiness directive.

MR. SCHLEEDE: But when a manufacturer issues a plain service bulletin with no other adjective, is it considered a reliability, maintainability issue or is it content?

THE WITNESS: My impression is that most of them are that or product improvement. Anything that would, for instance, reduce the amount of inspection time that a carrier would have to take on a product by working a service bulletin, they would certainly want to do that.

MR. SCHLEEDE: And we understand that Boeing has testified they're preparing service bulletins for and working on yaw damper situations and standby rudder actuators. If an event such as a yaw damper malfunction that's not considered a safety of flight item causes an accident, does that change the --

THE WITNESS: Yes.

MR. SCHLEEDE: -- definition?

THE WITNESS: If an event can be proved to cause an accident and a service bulletin is issued to correct that event, there's almost certainty that would be an airworthiness directive.

MR. SCHLEEDE: And this might be nitpicking. But if a flight attendant gets knocked down and breaks an arm, which is defined as an aircraft accident, would that count?

THE WITNESS: Yes. We would give great consideration to that event as being an unsafe condition.

MR. SCHLEEDE: One other question regarding the testimony of the SAE committee and the assistance that you've asked for on the fluid contamination. Was it -- 1 think I understood from the testimony yesterday from Mr. Knerr, that the FAA came to him or the committee in October for assistance? The SAE --

THE WITNESS: A-6.

MR. SCHLEEDE: The SAE committee, is that correct, in October?

THE WITNESS: I don't recall, but that sounds like about the right time.

MR. SCHLEEDE: That's all I have, Mr. Chairman.

CHAIRMAN HALL: Mr. McSweeny, we have kept you up here a long time. I have some questions, however, and I want to try to go through them and I'll try and do them as quickly as I can. First, in your position as the director of the Aircraft Certification Service, how many employees report to you and do you have an idea of what your budget is?

THE WITNESS: We have a little over 900 employees, and my budget, hopefully this year, which was just --

CHAIRMAN HALL: Well, we both know -- well, it was signed.

THE WITNESS: Ours was signed. We're back in business. It's around $71 million.

CHAIRMAN HALL: Well, while all of us here have an interest and the parties in this organization, you and the members of the FAA and the NTSB are in a slightly different category, because we're funded by the public.

We have this system set up which has seemed over the years to work pretty well, but it requires extent scrutiny in regards to accidents and particularly major accidents in this country involving scheduled airline service. We have a situation before us that with these two accidents that, of course, has commanded a lot of our resources and obviously a lot of your resources, as well, as the parties.

My interest in this is to try and be sure that we are doing everything in as timely a fashion as possible and reporting to the public in as timely a fashion as possible, and that was one of the reasons that I wanted to have this, what I guess has been called an unprecedented second hearing on this investigation. But we have expended or you have expended quite a bit of resources in terms of this critical design review.

There are, I believe, 27 recommendations that have been made. And rather than try to walk you through those, what I was wondering is would you be willing to provide for the record within say a seven-day period of time, the current status of the FAA on those 27 recommendations?

THE WITNESS: Yes.

CHAIRMAN HALL: Mr. Haueter, if you could please follow up on that. And, again, my interest is that we are sure that -- and this hearing reflects to the public everything that has been identified -- everyone is moving with the type of diligence that I'm sure the public expects, to address concerns that have been raised and recommendations that have been raised in this report.

In that regard, there was a discussion, I guess, earlier of the Boeing 737 events that have occurred. That, I believe, is Exhibit 13X-C. Of those events, I believe 15 of those events have been reported by USAir. That gets me to the subject that Mr. Haueter has raised in regard to this retrofit that is a modification of the power control unit, which is called the Mac Moore phenomena, in which the industry had five years to complete this modification.

We received testimony in Pittsburgh that USAir had accelerated this replacement program from Mr. Michael Cohen, their vice president of maintenance, stating that they anticipated having the 235 aircraft retrofitted with the reworked power control units by the end of 1995. Do you know the status of that, sir?

THE WITNESS: No, I do not, but I certainly can provide it to you.

CHAIRMAN HALL: General, would you know and could that be provided to us, sir?

GENERAL ARMSTRONG: We can provide that to you.

CHAIRMAN HALL: Thank you very much. I would also like that to be part of the record. Again, insuring the public that we are doing everything in this investigation to insure that every item is followed up on.

In addition, if I can find my notes here --

I've got so much paper I can't see over it.

(Pause)

CHAIRMAN HALL: Just again to clarify the results of the study where it says, "The Boeing 737 meets all certification requirements." Would you please tell me, in your opinion, what that statement says?

THE WITNESS: In my opinion, it says that the airplane meets the certification requirements embodied in the certification of the basis of the airplane as it was type certificated originally.

CHAIRMAN HALL: Thank you. I'm going to find this hear in a minute, if you'll bear with me.

(Pause.)

CHAIRMAN HALL: I had some follow up here on if you were aware of some reported incidents regarding a phenomena called "blue water."

THE WITNESS: Somewhat, yes.

CHAIRMAN HALL: Could you explain for us what blue water is and what information the FAA has on that particular item?

THE WITNESS: There have been some events on aircraft where there have been unusual attitude changes, roll events, or pitch events. And after the fact, they've observed that in the forward avionic's compartment, there is either blue water or reminisce of blue water. The blue water being water coming from the laboratory receptacle.

CHAIRMAN HALL: And have there been a number of these incidents?

THE WITNESS: There have been a number of cases where that liquid was discovered in the avionic's bay. I would say numbers -- I don't know. Number being somewhat below ten and greater than five maybe, that I'm aware of.

CHAIRMAN HALL: Well, what is -- what can happen if that -- what are the consequences of having blue water in the avionic's bay?

THE WITNESS: I'm not so sure we fully know what the consequences are. There appears to be some correlation between electrical conductivity and that blue water. Whether that is water or a dry compound. In one case when it's liquid, I believe, it clearly transmit electricity, and when it's powdery, it's less. But it does -- like any other liquid, impact on the electrical transmission, shorts if it should get into connectors and things like that.

CHAIRMAN HALL: How did you all -- how did this come to your attention, of the attention of the FAA?

THE WITNESS: I believe it was as a result of an incident on an airplane in which -- and trying to troubleshoot the cause. They were in the avionic's bay and they discovered it. I don't know exactly who discovered it.

CHAIRMAN HALL: It didn't come out of the service SDR?

THE WITNESS: I don't believe so, but I'm not really that up to date on that issue.

CHAIRMAN HALL: Let me ask you just one question and kind of -- so, I guess, just in the common sense category, in my opinion. Is one individual -- we've heard testimony yesterday that one of the witnesses, Mr. Newcombe -- I guess, he's the fellow that handles the SDRs?

THE WITNESS: Yes, the flight standard's AEG.

CHAIRMAN HALL: Is one person adequate to do that for the 737 considering the fact that we've had two unexplained accidents?

THE WITNESS: Well, he was, I believe speaking about his role in the flight standards organization dealing with service difficulty reports.

In addition to him, there are several people in aircraft certification that would deal with the report.

CHAIRMAN HALL: Just give me some comfort. Tell me how that process is handled and how many people are involved in it and has there been any changes made in that process as a result of Colorado Springs and Pittsburgh?

THE WITNESS: The service difficulty reports that deal --

CHAIRMAN HALL: Again, I guess, Tom, what got my attention is he said he did the ATR, as well, and that happens to be another accident that we're working on, so.

THE WITNESS: But we get the service difficulty reports as does flight standards. When they reach the Aircraft Certification Office, they are organized according to discipline. Is it an avionic's problem, is it an airplane problem, is it a power plant's problem. They then go to the branch that deals with that discipline and in that branch, there is a person that is responsible for that product, be it the 737.

So in the Seattle ACO, there would be a minimum of five people that would be following design issues related to service difficulties. And the system itself has -- and the transport directorate has been evaluated, I think, a year or two ago and more formalized to insure that the follow up and appropriate action was being taken on all the service difficulties received.

CHAIRMAN HALL: Do you feel comfortable, because this area is under your responsibility, that there is adequate personnel to do that function and you have adequate resources to provide it?

THE WITNESS: Yes.

CHAIRMAN HALL: Okay.

THE WITNESS: And the reason being that it's our number one priority. We always are going to have resources to do our number one priority.

CHAIRMAN HALL: Well, I believe that covers most of my questions. Unless other members at the front table, the technical staff have questions? Captain, all the parties?

CAPTAIN LeGROW: Thank you, Mr. Chairman. I just have one follow-up question. During Mr. Schleede's questioning, you talked about the single failure as opposed to multiple failure, and you said that that changed around the time that airplanes went from manual reverse into fully powered flight control.

THE WITNESS: That's my recollection.

CAPTAIN LeGROW: Can you tell us whether the 737 has manual reversion on the rudder?

THE WITNESS: It does not have manual reversion. It has a standby system.

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

CHAIRMAN HALL: Well, Mr. McSweeny, you have certainly been patient. I appreciate very much on behalf of this board and this investigation, the time that you have put forward. I will say we just continue to look forward to working with you under Mr. Haueter's direction, to continue to use the public funds that we are provided to insure that we have done everything on these two accidents to see if we can determine a probable cause and come up with remedies.

I would assume that with the action of your CDR team, that you're looking very closely at your certification process and monitoring very closely everything in regard to this plane until we all put to rest any questions that we have to satisfy our responsibilities in the safety area to the American people.

I look forward to continuing this with you and with the other outstanding individuals that work with the FAA. Thank you and you're excused.

THE WITNESS: Thank you.

CHAIRMAN HALL: We will take a one hour lunch break and return here promptly at 2:15. We stand in recess.

(Whereupon, a lunch recess was taken.)

AFTERNOON SESSION

(Time Noted: 2:15 p.m.)

CHAIRMAN HALL: I would like to resume the Board of Inquiry hearing. I'll call our next witness, Mr. Les Berven. He's a Flight Test Pilot for the Federal Aviation Administration, located in Seattle, Washington.

Welcome.

(Witness testimony continues on the next page.)

LES BERVEN, FLIGHT TEST PILOT, FEDERAL AVIATION
ADMINISTRATION, SEATTLE, WASHINGTON

Whereupon,

LES BERVEN,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows:

MR. SCHLEEDE: Mr. Berven, will you give us your full name, please, and business address?

THE WITNESS: My name is Lester Berven. I'm employed with the FAA at Seattle, Washington.

MR. SCHLEEDE: And your position with the FAA?

THE WITNESS: I'm currently the supervisory flight test pilot in the flight test branch of the Aircraft Certification Offices in Seattle.

MR. SCHLEEDE: Would you please give us a brief description of your education and background that qualifies you for your position, including your ratings?

THE WITNESS: Sure. I have a BS degree in aeronautical engineering from California State Polytechnic University in California. I have some graduate work in aerodynamics and advanced math. I have been a pilot since I was 16 years old. I have about 7,000 hours and about 3,500 of those are in certification or engineering flight test.

I have ratings in all the Boeing airplanes, except the 707.

MR. SCHLEEDE: Thank you. Mr. Jacky will proceed.

MR. JACKY: Good afternoon.

THE WITNESS: Hi.

MR. JACKY: We spoke together up in the first hearing up in Pittsburgh and I welcome you back this afternoon. Before we get started, I would for you to give us just a little description about what your job duties are as a supervisory flight test pilot.

THE WITNESS: Well, I'm kind of a playing coach, so to speak. I pretty much fly a lot and I also assign and direct four other pilots -- five other pilots within my branch and assign them to different projects and monitor their operations and make sure that they're following all procedures and techniques correctly and they coordinate with me if there's any kind of a problem or a controversy comes up.

MR. JACKY: And you have been involved with the 427 investigation for quite some time. I was wondering if you might tell us what sort of participation you have been included in?

THE WITNESS: I've been kind of acting as a consultant to the NTSB. I'm not on the performance board or a member of the accident board, but they come and ask me questions from time to time and want me to fly the simulator, because I have a fair amount of time in the 37 and I have done some certification work on the follow-on programs and on the 1984 certification.

MR. JACKY: When you refer to the 1984 certification, would that be for the 737-300?

THE WITNESS: Three hundred, right.

MR. JACKY: As far as the work you did, that would be flight test certification?

THE WITNESS: Yes, it would.

MR. JACKY: Could you briefly describe describe the type of certification flight test that you did in support of the 300?

THE WITNESS: I didn't do a lot of that, because I was involved in other projects at the time. I did some of the stability control work and some of the engine out VMCA and VMCG tests. I'm kind of a local expert on engine out stuff.

So the rest of the pilots did probably 85 percent of it, and I just kind of kept my hand in on that project.

MR. JACKY: As part of the certification requirement or part of the certification test, what sort of hardover or jam conditions would you have to do for any of the primary flight controls?

THE WITNESS: We don't really do hardover tests for any of the primary flight controls. We do jam tests, which are somewhat different. A jam assumes that the pilot puts a control there and he can't get it back out again. We use the deflection that we can think are most probable the pilot would be using in his normal operations.

So we look at jams of the rudder and we look at the jam of the aileron and we also look at the jam of the elevator. And typically, we look at these at the worst-case conditions. For instance, on the elevator jam, we go out to VMO, the redline air speed at full forward CG, and assume that the elevator gets stuck right there, the stabilizer gets stuck right there. Then you come back and land it without having to retrim it. And there's some limitations on the force and you can do that quite readily.

So the jams themselves are not too big a problem. You can come back and land the airplane. We had to show that for any of the flight control systems that jammed at any probable flight condition, that the pilot would use a normal operation and you could make a continued safe flight and land it, and we did demonstrate that.

MR. JACKY: So then if I could summarize perhaps. Then the work that you did was jams to whatever the maximum extent you would expect for a normal operation of the airplane?

THE WITNESS: That's correct.

MR. JACKY: That's correct. Okay. What about trim systems, do you have to test for runaways or hardover trim conditions?

THE WITNESS: Yes, we check trim runaways primarily on roll and yaw, because the pitch control system on the Boeing airplanes are basically multiple redundant and has a break, as well as cut-out switches, and that's considered so reliable that we don't do it. Because the instinctive pilot reaction in a trim runaway is to push on the stick. And if you push on the stick, an opposition to trim motion locks it up. So basically you can't really get a trim runaway that gets to any significance.

For the directional control with trim, we run that all the way to the stop in all flight conditions and come back and land that way. And the aileron trim also. Those are very low authority systems. So it's really not a problem.

MR. JACKY: So then you would look at the system at the maximum trim position authorized by the system?

THE WITNESS: That's right. We run until it won't go anymore.

MR. JACKY: Is there any sort of -- when you're doing the certification for that, do you look at it in terms of a static position? Do you put the rudder out there, or do you actually try and run the trim at its normal trim rate to that position and then hold it?

THE WITNESS: We just run it up to the normal trim rate until as far as it goes and then we fly back and land that way.

MR. JACKY: I would like to talk to you a little bit about some flight test work that has been referred to at least this morning and probably some other times yesterday. What I would like to talk about is the simulator calibration flight. So I was wondering if you could give us a brief description about your participation in those flights.

THE WITNESS: Certainly. We basically set those flights up to insure that the simulator tests and evaluations that we have been doing for the NTSB were going to be correct. So we basically took the airplane out and did some -- it wasn't a totally comprehensive test, but it was mostly just on the lateral directional axis. We did a couple of tests.

The primary thing that we were looking at was what we call aileron rudder trades. In other words, if you stabilize at a given speed and configuration and flat setting gear, if you push on the rudder in a normally stable airplane, you have to counteract with the aileron.

So basically the lateral directional stability is measured by how much of that you have to put in, how much aileron you need for a given amount of rudder. So basically what we wanted to look at was what the relationship was between the aileron deflection required to counteract the rudder input and still maintain constant steady heading flight.

So we did this primary at flaps one and 190.

MR. JACKY: Which basically are the Pittsburgh --

THE WITNESS: That's correct.

MR. JACKY: So then would it be accurate to say that the objective of the test would be to collect data to be able to compare to the engineering simulator?

THE WITNESS: Yes, basically the simulator step is very complex and very sophisticated and quite accurate, but it's not exactly like the airplane in a lot of cases. You just can't do that. Of course, you can't simulate the dynamics and the motion and stuff like that and whatever. But you can get the static and some of the dynamic derivatives very, very close.

Basically we went out there just to validate, to see what the simulator, how close it was to the airplane actually.

MR. JACKY: And during these tests, what specific types of maneuvers did you accomplish?

THE WITNESS: We did essentially three types of maneuvers -- well, four actually. The basic one I just explained was the constant straight heading --

steady heading side slips all the way out to the full deflection of the control. And we picked increments like one-quarter, one-half, three-quarters, and full rudder. And we did this at three or four different speeds from 150 all the way up to about 225 knots to look at the relationship with speed and to get a little bit more expansion, a more comprehensive look at our comparison with the simulator data.

In addition to that -- and from that data back out, you can plot the aileron required to counteract the rudder input at a constant heading. And that's a very important lateral directional parameter that you use to make your simulator work correctly.

In additianal to that, each time I got to what I call -- what you call an end point -- in other words, you were stable there with X amount of rudder at a given speed and holding constant heading. As I finished that point, I would release the ailerons and look at the resulting roll rate, take the aileron forced back to zero and watched the airplane roll and look at the roll rate. Basically, to see how fast it would roll, because that's another extremely important simulator parameter.

In addition to that, we did really some

rudder hardovers. And the way we did that was to mistrim the rudder to a certain X amount while the pilot was holding it steady to neutral and then release the rudder. The way we did that was try to make it consistent between each point, because it's not really possible to put in a fixed deflection rudder hardover, unless you have some kind of a restriction on the pedal and we didn't want to do that.

So basically, we trimmed the rudder over to a certain deflection holding the pedals neutral and then quickly release the rudder pedals, which essentially resulted in a hardover rudder to whatever position we had selected on the trim. We did that to one-quarter, one-half, and three-quarters rudder deflection. We were unable to do the full rudder deflection because of structural problems with the maneuver at that flight condition.

MR. JACKY: What sort of structural problems are you referring to?

THE WITNESS: As I understood it, during the safety analysis and the safety briefing we went through to look at this maneuver, the Boeing structure's people indicated that if you did that maneuver to full deflection at 190 knots, in that configuration, that you would come very close to reach the limit load on the fin.

Now, that's not exceeding it, but it's up to limit load. And Boeing rightly so says that they don't want to go to more than I think it's 80 percent of any limit load in any structure unless it's instrumented. And they were willing to do that, but we had to pay more and wait longer.

MR. JACKY: Before we go on, maybe I should back you up a bit. Could you tell us what type of airplane was it that you were doing the tests on?

THE WITNESS: It was a 737-300. I don't know the end number. It was a USAir airplane, 533-AU, I believe.

MR. JACKY: Thank you.

CHAIRMAN HALL: Who was paying more now?

THE WITNESS: Whoever was paying for the tests.

CHAIRMAN HALL: Well, we divided that test four ways, didn't we?

THE WITNESS: I don't believe that structural instrumentation on the rudder was part of the original deal.

CHAIRMAN HALL: But it's something that can be done?

THE WITNESS: Yes. And they would have done it if we had had instrumentation.

CHAIRMAN HALL: Well, I just didn't want to leave the impression that Boeing had nixed it --

THE WITNESS: No.

CHAIRMAN HALL: -- because all four of us were participating. Mr. Seth Schofield had gotten that plane for us, which we greatly appreciate.

THE WITNESS: No, they didn't nix anything. Basically, it was just brought up as an important safety item and a consideration to be done. And the fact that we were getting data at one-quarter, one-half and three-quarters made it a very simply and reasonable extrapolation to the last quarter of the travel. It wasn't cost-effective to do it.

MR. JACKY: Were there any other maneuvers, specific maneuvers that were performed during this flight test?

THE WITNESS: Well, I also did what I call a slow-down turn, which is basically in the configuration that I was in, I went up to 225 knots and put the aircraft in a one and a half G turn and held one and a half Gs at idle power, as the airplane slowed down until I got into stickshaker. And basically that's a maneuver we do to look at stall warning and other characteristics. But basically what I wanted to do was to evaluate that to validate the drag model on the simulator, to see if the deceleration rate was the same and also if the stall warning came on, the same angle of attack and G speed.

MR. JACKY: Were there any maneuvers done in comparing roll rates due to wheel combined?

THE WITNESS: We did do some roll rate testing, too. We had modified our mark, the control wheel position on the column, so we could get proportional deflections of the aileron there. And we did a bunch of roll rates due at one-third, one-half, and three-quarters and full to look at the roll capability.

We did -- several of these tests were done both with and without the yaw damper. It's quite a lot of data. I think they're still trying to analyze it all.

MR. JACKY: And from these maneuvers and -- I should ask you this. How many of the flights were you participating in?

THE WITNESS: I had made one flight. I think the flight that I was on was two and a half hours or something like that.

MR. JACKY: Okay. And during this time in any of the maneuvers that you performed, were you surprised in any way? Were there any differences from what you would expect in the engineering simulator?

THE WITNESS: There was nothing that I thought was unusual. We had basically done all of these maneuvers, except the hardovers prior to this. So it was nothing unusual. In the comparison to the simulator, we did notice that the rudder deflection that we were achieving in the airplane was somewhat more than it was in the simulator, about two degrees. Eighteen in the simulator and a little over 20 in the airplane.

MR. JACKY: Was there any reasonable explanation for why this occurred?

THE WITNESS: I have no idea.

MR. JACKY: Then in comparison with the engineering simulator, when you were performing -- or how were you able to determine the differences between the airplane and the simulator?

THE WITNESS: Basically, we had the rudder deflection instrumented. For an important part of this test, was to calibrate the rudder deflection at different air speeds. And basically, we got to that point on the straight steady heading side slip at the last, at the end point where we were at full deflection on the rudder.

So we could just look at the instrumented gage or read it from the instrumentation on the back and they would tell us what the rudder deflection actually was.

MR. JACKY: And you mentioned the steady heading side slip test. What were the varying speeds again that you attempted or accomplished these positions at?

THE WITNESS: I remember we did them at 150 knots, 170 and 190, 210, and 225.

MR. JACKY: And there's been some talk here about lateral stability and lateral control. Could you tell us for each one of these air speeds, approximately how much rudder you believe that you could counter with full aileron?

THE WITNESS: Well, it depends on entirely pretty much on your air speed. There's a cross-over point at about 190 knots or just a little bit less. At which point, the rudder -- full rudder deflection can be counteracted with full aileron deflection.

Now on the airplane, that was right at 190 knots, maybe just a hair less. In the simulator, it was a little bit less than that, but it was very close, within two knots or so. That's about as good as you can do.

At 210 knots, you could only go to -- the maximum rudder deflection there was only 14 degrees with full pedal. So you could counteract that easily with the ailerons. At 170 knots, you couldn't use full rudder. You were out of aileron before you got to full rudder. At 150 knots, you were considerably out of aileron before you got to full rudder.

So below about 170 knots, basically the full rudder deflection over rolls the roll capability of the airplane.

MR. JACKY: At the 150 knot condition, could you remember how much rudder you actually could control with full aileron authority?

THE WITNESS: It wasn't exactly 150. It was a little less, 146 or 147, when we finally got stabilized. The data that I've seen here shows 14 degrees of rudder with maximum wheel, which resulted in about ten degrees of side slip.

MR. JACKY: And you've flown all these types of maneuvers on the engineering simulator also?

THE WITNESS: Yes.

MR. JACKY: And how does the difference that you said you saw in the rudder, how would that play as far as the lower speeds in the side slip maneuvers? Could you tell a difference?

THE WITNESS: Little changes like -- well, in the simulator, you also over roll the ailerons at slow speed, too. Once you get considerably below 190 with flaps one, the simulator is actually pretty representative of the airplane except for the small change in the rudder deflection.

So the principle is exactly the same. The cross over speed is just a little bit less, because in the original simulator, we didn't have quite the right rudder deflection. With the new updated simulator, it's very, very accurate.

MR. JACKY: You mentioned updating the simulator. Out of all of these tests, how much difference or updating would you see of the simulator?

THE WITNESS: I believe they only did the rudder hinge moment update. So that any stability and control derivatives that came out of our testing have not been put into the simulator. They only upgraded to the new rudder deflection versus air speed.

MR. JACKY: But in terms of the other flying that you've done in the simulator, the maneuvers that you performed in the test airplane seem to be fairly representative?

THE WITNESS: Yes, they were.

MR. JACKY: So it was only the difference in the rudder. That is the only obvious thing that you noticed in flying it?

THE WITNESS: And the effect of having less rudder. You've got different speeds in the simulator before it had been upgraded.

MR. JACKY: Okay. You mentioned a speed affecting the stability. Are there any other factors that would affect the stability? The center of gravity, for example, weight?

THE WITNESS: The center of gravity has a fair amount of effect on stability, but not a lot on lateral directional. Basically, the only effect is in the length of the tail arm, which is kind of a secondary thing.

So I think we were at a relatively representative CG with respect to the simulator testing. I'm sure that when they do the simulator analysis, the data -- the analysis of the data that we took and incorporated into the simulator, you can easily correct for the CG position.

MR. JACKY: What would the effect be as the CG, say, moved from aft of the airplane to forward of the airplane? Would you expect the stability air speed to rise, to lower?

THE WITNESS: Probably from the standpoint of the lateral directional trades, if the farther forward in the CG that you are, the longer your rudder arm and more effectiveness that you would have. So your tradeoff speed would move up slightly.

MR. JACKY: As a flight test pilot, do you have any way of comparing the type of flying that you do to a typical airline pilot?

THE WITNESS: Well, it's considerably different. We don't get to fly with too many airline pilots. Sometimes we jump seat places to places to kind of watch what's going on, and sometimes we get to fly with people during evaluations, like we did here on the USAir.

It's pretty much a difference, more of a difference in attitude, I think, than anything else.

What we're looking at is to go out and find something new in the airplane and do something strange. And most of our tests are done under pretty controlled conditions with smooth air and good weather and preplanned by 25 engineers.

And airline pilot, on the other hand, is put in all kinds of unusual situations in a short order with darkness and bad weather and flying with different crews all the time. So it's a whole different ball game.

MR. JACKY: Have you ever flown at conditions of approximately 190 knots, flaps one degree?

THE WITNESS: Certainly.

MR. JACKY: What sort of phase of flight would that be in?

THE WITNESS: Well, it's typically you're there on a short period of time during your acceleration on takeoff when you're retracting the flaps, but that's a very short duration, maybe only 20 seconds or something.

So where you would spend a lot of time on there, sometimes you're in a congested terminal area and ATC wants to space you in with another airplane that has that same speed, and they want you to go 190 or some speed like that. So you basically don't want to slow down below 210 and without any flaps. so you put the flaps down and go to 190. And you're going along there for a while until ATC tells you to turn here or you're clear for the approach or slow down or do something.

So you can spend five, even ten minutes at flaps one.

MR. JACKY: In what speed range could you typically use flaps one setting?

THE WITNESS: The maneuvering speed for flaps one, at least on a reasonably light airplane, the ones that we fly all the time, is 190 knots. They basically recommend that speed, because it gives you a reasonable maneuverability margin there. I don't know what the actual number comes from. I think it's 1.4 times the stall speed or something like that.

MR. JACKY: But would you say you leave the airplane in the flaps one configuration say down to 150 knots all the way or all the way up to 225 knots or what is that range that you typically operate the airplane at flaps one?

THE WITNESS: Well, typically the margin that we use is about plus or minus 20 knots. At flaps one, you're allowed to go to 230, which is the flap placard speed, and you can go all the way down to stickshaker if you wanted to. I guess, that would be down around 130 or 140 with the flap setting like that.

The training that we get basically says to put the flaps down when you're decelerating toward the speed within 20 knots of it or if you're accelerating towards, you can raise it once you're within 20 knots of it. So if I'm decelerating from flaps up, I would start the flaps down at 210 and then fly at 190 if I was going to be flaps one for a long time.

If I'm raising the flaps from five, basically I would start them up to one at 170 if I'm accelerating.

MR. JACKY: So can I characterize the speed range as say maybe 170 to 210 knots? Would that be fair?

THE WITNESS: That's correct.

MR. JACKY: And during this time, would you be -- how much use of the rudder would you expect to be doing?

THE WITNESS: Well, basically none, as long as both engines were running.

MR. JACKY: Would you have your feet on the pedals?

THE WITNESS: Yes, I would.

MR. JACKY: You mentioned in talking about the simulator and the things that you saw in the simulator calibration flights -- as part of your job duties, is there any sort of report or documentation that you have to make to your superiors or would you with Boeing in regards to the flight tests?

THE WITNESS: Are you talking about basic certification or this simulator test?

MR. JACKY: Not basic certification, but just the flight tests that were accomplished in Seattle.

THE WITNESS: Well, it happens about the same in both ways. Your basic certification test and this test were handled pretty much the same way by the Boeing system. We wrote a test plan and in the cert program, we write a TIA, which is a type inspection authorization, which is an approval of the test plan.

Then FAA and Boeing gets together and agree on the test plan and say, here's how it's going to be and then okay. Then they write a test sequence, which is each altitude and each speed and what sequence you're going to do it in. Then go up and do the tests. And the engineers get the data, and we come back and land and have a post flight and discuss what we saw and whether it was acceptable and whether we need to go do some more or not.

Then the engineers get together with that data off of their instrumentation system and analyze it, look at what we did, and then they ask us is there any questions on pilot comments. They get together with us. And then they write up a report called the certification report, and they send it to us. And if we like it, we sign it. And that becomes part of the certification documentation, the type inspection report.

In this case, it will just go back to whoever asked for the test.

MR. JACKY: In the certification report, would you expect comment about this two degree rudder difference that you're talking about?

THE WITNESS: I would think so, yes.

MR. JACKY: Is there any sort of procedure within the FAA that you would send that to your supervisor or what sort of reaction would you expect from the FAA on something like that or to yourself?

THE WITNESS: What type of report would I expect, is that what you asked?

MR. JACKY: Do you have to indicate to anyone that there is a difference or is that a concern?

THE WITNESS: No, that basically comes out in the post flight. In fact, I did that when I said, it looked like to me there's more rudder deflection on this airplane than there was in the simulator, and they wrote that down. That's going to be included in the CERT report with a little paragraph about how they're going to address that. Basically, they're going to upgrade the simulator to the new deflections.

MR. JACKY: If and when the simulator is updated, is there any sort of requirement for you to go back and check that and say, yeah, that looks like the airplane or sign off or anything like that?

THE WITNESS: I don't think there's a requirement. I think there's an interest in both parties in getting the simulator as accurate as possible, but I don't think we do a very comprehensive test. Before they got around to analyzing all the data and upgrading the simulator to the maximum to all the data that they have. That may take several months.

MR. JACKY: Now, I would like to switch gears a little bit and start talking about the wake vortex flight test. Could you tell us a little bit about your participation in those flight tests?

THE WITNESS: Yes, I was basically the FAA project pilot, along with the Boeing project pilot, Mr. Mike Carriker. And the requirement came that we were going to go out and try to evaluate what the response of the 737 would have been at a certain number of miles behind the 727 to evaluate the encounter that looked like happened on the 427 accident.

So the first thing we did was just get together and talk about it and say, how are we going to do this and how is it going to be safe? So we looked at the technology and we had a simulator that basically had the vortices shown visually in the picture of the outside view of the simulator. And they were set up technically so that as you flew into the vortex, that you got the same rolling moment or the same vortex intensity that they felt that had occurred during the USAir accident.

So we flew the simulator to start with. We looked at it from the standpoint of what the reaction to the airplane would be, how safe it was going to be, and we also used it to write up the test plan, to look at some reasonably valid things we could do. Configurations to use and entries to use and bank angles and rates and such like that.

So we used the simulator as a tool not only validated from a safety aspect, but also to come up with a reasonable test plan. Once that was done, we coordinated with the other people at the FAA Technical Center to make sure we had the airplane and the people interested in what we were doing. It was an overall coordination between all the people involved; the NTSB and USAir and Boeing and the FAA. It was pretty much a coordinated effort.

Then once we got down to the point where it looked like it was going to happen at X number of days or whatever, we wrote up what we called a safety plan. And we looked at every aspects of the tests to make sure we hadn't forgotten something that could bite us during the test program.

So we looked at all the aspects of the interface between the chase pilot, when one was needed and how much and how long and what type, and the briefing between the flight crew in the 737, a briefing between the 737 and the 727 crew, any external people from the tower and ATC and such as that, and all the responsibilities and duties of each individual involved in the project.

Each one of us sat down and said, what could possibly go wrong. And we had four or five or six pages of things. Some of them were a little bit far out, but at least we over shot, rather than under shot. So we had every possible thing that we thought of that could happen and we addressed it. Where if this happened, what do we do, and what are the consequences if we do it wrong and what would be better. Is there an alternative if it doesn't work.

So we had pages and pages of this stuff. And we got together with all the pilots involved and the flight crew and briefed everybody on this before the mission. And this was a test plan that was agreed to and sent up to the highest levels of the FAA, all the way up to the administrator, I believe.

MR. JACKY: Was the test conducted under or to the conformity of the test plan then or the hazard plan?

THE WITNESS: Pardon?

MR. JACKY: Was the test accomplished per the hazard plan?

THE WITNESS: Yes, it was. We briefed everyone. We spent an hour or more before we ever made the first flight and explained to everyone exactly what was going to be and we had weather minimums and such as that. It turned out very well.

The test was actually flown very, very professionally. Everyone did an excellent job.

MR. JACKY: Could you tell us exactly how you were able to fly into the vortices of the 727?

THE WITNESS: Well, the 727 had been modified with smoke generators on the wing tips of the airplane. That was loaded up with the same kind of smoke that they use at air shows. It's called orcopus oil, I believe, which is an actual system that lights off and it's a combustion type system and burns the oil and makes a thick white smoke. They had it on the wing tip of the airplane. So that as it came out of the back of the smoke generator, the flow field around the wing picked it up and you could visualize the vortex. You had one of those on each wing.

So they would light these off basically when we got where we thought we were at the right spacing behind the airplane and had adequate weather and good clearance and the chase plane was in position. They would light off these smoke generators. And then a minute or so later, however long it took us to fly the three-mile separation, you would start picking up these smoke trails. They were very, very easy to see. In the morning, especially, with the low sun angle, they were just iridescent flight.

MR. JACKY: What time of day were the flights flown?

THE WITNESS: Well, we were willing to fly just about any time of day, except for when it was dark. But we ran into some weather problems and got delayed a day or so there. It was low ceiling and visibility. Finally we found what looked like a good size hole. So we launched both of the airplanes and headed out to where we thought our test area was, but the weather was too bad and we couldn't get joined up.

So we called air traffic and they let us go out in some warning area off of the coast of New Jersey, about 50 or 80 miles off the water, and found a big hole out there.

As part of our safety plan, we required that we do this at high altitude first, 15,000 feet or greater, in case there was some type of an upset that would take some time to recover from. So we did our initial tests. And, in fact, we were above a deck of clouds at about 18 to 19,000 feet for the very first encounter. We found a big enough hole that we could have the 27 going straight and the smoke generator on, and we could pick up the vortex trails quite easily.

This first interaction was not a loffo quantitative stuff. Basically, it was kind of a proof concept to see if we could fly in and out of this thing without causing any trouble with the airplane or if it was going to be an unusual rolling rate or some kind of other problem.

So basically both of the pilots decided that we would go out and go ahead and give this a try. So we just flew formation on the vortex and took a look at it and then basically stuck one wing in it and that didn't seem too bad. We stuck the other wing in it and that was all right, too. We got a little farther and then we flew below it and stuck the tail up in it, and then we came down through it and up above it and across it.

Then we tried it in other different ways. We tried it with the auto pilot on, the auto pilot off, and we tried it hands off. And it turns out that we got about, it must have been 30 minutes of evaluation during that very first flight on the very first morning out over the water. And it did give us some indication that basically the vortex interaction was kind of like what we thought it was going to be, no big deal. And the airplane wasn't rolling very rapidly or very far, and that the G forces that were being counted on a perpendicular or a high angle entry were not going to be significant either. And that the airplane had controllability to recover from or to control it as you go through any part of the vortex, left, right or both.

So we decided since the weather was getting even worse, we would break that off and decided that we had, in fact, fulfilled the requirements of the safety plan, to look at this as a proof of concept from a safety standpoint of high altitude. So we checked that off.

The next one we wanted to do was a bunch of visual stuff under very, very good conditions, so we could get pictures and some data and good comments on each different small angle changes and roll rates and angles and stuff like that. So we had to wait for good weather on the next one.

So we were down for a day or so there waiting for that, because there was a lot of fog.

MR. JACKY: When you were performing the vortex interaction, what type of maximum upset or roll angle did you see during the encounter?

THE WITNESS: It varied between how you did it and where you came into it. But as a general rule, what we saw was there was four different cases we looked at. One with the pilot flying normally, as he would react as he went through the vortices. And the other one was with the auto pilot on, with the auto pilot in CWS. And then one, we could --

MR. JACKY: Would you explain what CWS is, please?

THE WITNESS: Oh, excuse me. The auto pilot has two modes; one is command mode where it follows the heading bug or tracks the localizer, and the other one is CWS, which is control wheel steering, which is kind of a submode of the auto pilot that basically says that if you're less than five degrees, I'll level the wheels for you. If you're between five and 30, I'll just hold that bank. And if you're more than 30, I'll roll back to **30**. It's kind of an assist to the pilot. It's kind of a submode to the auto pilot.

We looked at that from the standpoint that somebody might actually be flying in that when they ran into a vortex. And the fourth one was just completely hands off. Just trim the airplane and fly through the vortex without touching the controls.

MR. JACKY: For the four different types of interactions they were talking about, as far as control, what in general would give you the greatest amount of upset?

THE WITNESS: Well, let's see, I'll just give you the angles on all four intercepts and you can see. Basically, if you intercept at the vortex trails at a more than a ten degree angle, you basically got no roll at all. It was just a couple of bumps at about 1.4 Gs, but very sharp -- bang, bang -- as you went across, but no roll at all.

To get any roll out of it, you had to be less than a ten degree intercept angle. Between five and two is pretty good. So the ones we tried were five. It's hard exactly to tell you exactly where the track angle on the vortex was. So we just kind of guessed at it. So it was somewhere around five or maybe a little less.

When you flew the airplane with normal control inputs, you could see the vortex coming up like this, and you basically could just put her right through your window. You can into it at about five degree intercept angle. If you stuck -- if you just flew beside it and stuck the wing tip in it, you would just get a little trim change and you could sit right there and fly like that.

If you went into it at an angle, basically the airplane would start to roll as you went into it. And basically it would roll up into the vortex like this and then it would spit you out into the middle. And then as you hit the right vortex, it would roll you back up to level again or maybe a little bit less.

So we did a whole bunch of those. The most representative angle that I found was about a ten degree roll angle if you were flying an airplane normally and a maximum of about 20 degrees. That was the same numbers we got on the auto pilot also and also with CWS.

The difference in the CWS controllability was that you had a little bit more force to go with. But if you're willing to put it in, it was not a problem.

On the hands off conditions, where we trimmed the airplane up and basically just held onto the bottom of the column to steer the airplane to go through the vortex without putting any lateral directional inputs in at all, those angles are a little bit bigger. I would say the typical roll in that case was about 20 degrees, and the maximum I saw was about 30.

We did some other stuff, too. We were trying to get into the left rolling vortex in a left bank. And to do that, basically we came across the vortex trail underneath and rolled up to 30 degrees into the right vortex, and you got basically the same answer. With hands off, they would roll you 30 degrees more.

So the numbers that I just gave you were basically incremental to whatever bank you went into it with. If you were 20 when you went in, you would be 30 when you came out or something like that, if the pilot was flying.

Another test that we did interacting with the vortex was to try to stay in the middle of it. That was a very difficult maneuver, because basically the vortex doesn't want you in there. It spits you out. So that if you're hands off and if you don't really fight with it, it will just shoot you out one side or the other, and you're only in it for a second or two, which is the reason you don't get much bank out of it.

If you try to fight with the vortex, basically we found that the most roll angle, roll inputs required was to have the vortex coming right up over the cockpit, right on the top of the airplane and hitting the vertical fin. In that case, at flaps one and 190, you basically needed almost full aileron deflection to stay there.

We were able to stay in there from two to three to five seconds a couple of times, with maximum aileron deflection without rolling it off. So we felt that was a good indication, if we knew the control power of the airplane, what the intensity of the vortex can be. I think you can calculate it out of that.

We did other interactions, too, where we flew up between the vortices and down between the vortices. And in those cases, there was very little roll at all, just a couple of little bumps again.

MR. JACKY: Did you try flying into a wake that was descending at all?

THE WITNESS: Yes, we did. We had the 727 descend at a three degree angle and basically flew through that. And that was essentially no difference than a level wake where you flew up through it at three degrees, depending on once you hit it. If you hit one of them, it would roll you a little bit one way or the other. If you came up between them exactly symmetrically, basically it wouldn't roll. It would just bump as you went through there.

MR. JACKY: If you weren't trying or

attempting to stay in one of the vortices or between the vortices, could you characterize how long it took for you or how long the interaction was that you felt like you were being affected by the vortices?

THE WITNESS: Well, it was pretty consistent. The vortex itself was not totally homogeneous. In other words, it was oscillating a little bit. It didn't get bigger and smaller and like that. It was really hard to track it, especially when you're sitting there with full aileron deflection and the vortex was hitting the windshield and you can't see where it's going. But it was basically a stable roll situation as long as you were in it. As long as you were in the middle of the vortex, it took basically full aileron.

MR. JACKY: Full aileron which way?

THE WITNESS: Opposite to whichever way the vortex was turning. In other words, if you were in the right vortex which was turning left, you would have to have a right aileron.

MR. JACKY: Could you make some comments about, in general, the behavior of the vortices and how the vortices behaved, I guess?

THE WITNESS: They varied anywhere from perfectly straight and parallel to incredibly complex.

I was just astounded at how durable they were. We would get into some -- the top of some clouds or in some thermal turbulence or something like that, and they would become practically an art form, if you want to call it. It would be so convoluted that you couldn't even tell which way they were going, intermixing with each other, but they were still unique. Each vortex was still a constant rotating vortex.

The ones that we found that were the best was -- seemed to be more of a function of temperature. Really cool in the morning, were the smoothest and more well-defined and constant stable vortices. As it got warmer, you got closer to the top of some clouds where there's energy in the top level and more moisture, they would become more and more up and down and left and right. But they stayed together quite well. At three to four to five miles even back, they looked exactly the same as they did brought up the wing.

MR. JACKY: Now, you mentioned being three or four or five miles back. How did you determine the distance that you were behind the 727?

THE WITNESS: As I understand it, we had a radar tracking system. It was calibrated with respect to the 737. He could tell us exactly how far back we were. So he would keep telling us, 3.1, 2.9, and we would close it up or back off from that. We had T-CAS also, which was kind of a rough indication. We could get into position with that and he could tell us exactly within a tenth of a mile where we were.

MR. JACKY: And at what distances behind the 727 did you attempt these encounters?

THE WITNESS: I flew the first part of it and I think I flew four and three mile. I think they got a little closer earlier than that -- later than that, but the only encounter I saw was typically around four miles or a little closer.

MR. JACKY: And could you characterize the upset, if you will, based upon the distance behind the airplane? Was it more upset at three miles or four miles?

THE WITNESS: I think you'll have to talk to the second crew here, because I didn't do anything closer than about three and a half miles.

MR. JACKY: So you couldn't tell much of a difference in the --

THE WITNESS: I couldn't tell any difference between four and a half and three and a half, no.

MR. JACKY: Have you received any training at all on vortices or encountering vortices or how to avoid or minimize encounters?

THE WITNESS: Sure. Typically, you learn that in basic flight training and some recurrent training that you go through the airlines. They basically say stay at or above the other airplane's flight path on takeoff or landing. In other words, make sure that you touch down after he has touched down, so that wake vortices are gone and take off before he lifted off to keep out of the vortices, as general rules.

MR. JACKY: And did you see anything during your -- during the flight test that would make you change or update the training that you received?

THE WITNESS: No, I wouldn't say he would change. The training, I think, was quite validating what we saw. The vortices off the 27 were typically almost always 300 feet below his altitude and they stayed there. And they came right up the wing, and a 100 yards later, they were where they were going to be and they stayed that way all the time, even back to five miles back.

So 300 is a good number, if you want to know where the vortices are on an airplane you're trailing behind. It was an amazing test to be able to see these things and visualize them and know exactly where they were and fly into them and look at them from all different angles and all different positions.

I guess I did get a different -- have a different feeling about vortex interaction after I saw this test, if we did this for a couple of hours. It's hard to explain, I guess. But, again, as a pilot, you see these things all the time. You've been in and out of the vortex encounter a 100 times if you fly in an airline environment at all.

Typically, you'll be flying along doing something and all of a sudden, whoosh, you'll be rolled up a little bit and back out again and you'll say, ah, a wake encounter. And sometimes you'll say, boy, we really dodged the bullet that time because we must have been very, very close to this other big vortex over here, because that wasn't very much. So you say, wow, got out of that one again.

And in truth, after having done this test, there is no big vortex. What you see with that little ten degrees or 15 degrees roll rapidly, but not very -- it doesn't last too long. That's as bad as it gets.

You're never going to see anything worse than that.

So basically it validates that the three to four mile separation for ATC is not a problem, at least on this class of airplanes.

MR. JACKY: You mentioned in a roll up set, did you happen to notice in encountering these vortices, any upset in the pitch access?

THE WITNESS: No, there was very little effect on pitch or yaw. There was some turbulence, of course. But no sustained pitch or yaw at all. In other words, it was difficult in pitch tracking, because the thing was so convoluted in going like this. So you're really tracking the airplane to keep in the vortex, if that's what you were trying to do. But I didn't see any kind of a pitch up set at all. It was a very slight trim change as you went through it up and down, but nothing you couldn't handle with four or five pounds of stick force.

MR. JACKY: And then you mentioned yaw. Was there any large change of heading after you flew through or during in the encounters?

THE WITNESS: I saw very little. A couple of times we would be flying on a vortex and it would curve back like this. And I think as you went -- when the rudder went through that, it would kick a little bit, but nothing significant. There was no sustained yaw or anything you could even talk about. Just light turbulence, like moderate turbulence.

MR. JACKY: Could you feel the vortices hitting the airplane?

THE WITNESS: From time to time you could. It was a very interesting interaction. If you got just in the right place and the vortex hit the windshield, you could hear it. It was kind of a strange sound, like you're being hit by a stick on the outside of the airplane. It would go woomph. And that was only one time when the vortex was right in the middle of the windshield.

If you came up and flew right in there, it would smack you right in the windshield and make that sound. You couldn't actually feel it. I mean, it was just a sound. It was very unusual.

MR. JACKY: Were you able at any time, able to get the vortices along the side of the fuse1 lodge or maybe into the engine galling or something like that?

THE WITNESS: We tried it about in every place you could think of. We put the wing tip in it and both sides, and we walked it all the way down the wing and into the fuse1 lodge and under the fuse1 lodge and then on the tip of the tail, the middle of the tail and on both windshields, and every place you wanted to look at. The interesting point -- I time I flew over and stuck the vortex in the engine and that was an interesting point, too, because I was interested to see if it would have any affect on the engine operating characteristics.

So I stabilized over there and let the vortex go in the engine inlet, watching the engine instruments, having somebody else watch the engine instruments. Basically, it was really, really interesting. You could see from the visual, from the chase plane.

What happens is the vortex is about -- it must be four feet in diameter, at least the smoke trail part of it is. And that's much smaller than the in lot of the airplane. And the vortex goes straight in the in lot of the airplane and comes right out the back, the size of a fan diameter. So it's small when it goes in and big when it comes out. And you could actually hear it when it went inside the engine. It was kind of a strange sound like blowing over the top of a bottle.

It had no effect on the engine. I think it was just an acoustic phenomena and there was no effect on the engine, other than the fact that you could smell it as it came through the air conditioning system.

MR. JACKY: What would it smell like?

THE WITNESS: Orcopus oil.

(General laughter.)

MR. JACKY: I'm surprised.

(General laughter.)

THE WITNESS: G-E processed orcopus oil.

(General laughter.)

MR. JACKY: We were talking about the upsets on any of the three axis. At any time during your encountering at vortices, were you surprised or startled or did you ever feel like you got into a condition that was of concern to you?

THE WITNESS: No. I think my final conclusion was that there was one uncomfortable condition that we flew. It was with the ones with the auto pilot in the CWS mode and you try to stay in the vortex. That was an extreme workload from a forced standpoint, because the aileron deflections and rates required there meant that you had to bottom out the servo on the roll axis. And basically, you were holding from 30 to 40 to 50 pounds of roll force to keep the aileron fully deflected and move in those back and forth. About two minutes of that is all you want to put up with.

But the airplane certainly had enough controllability to do that. It was just kind of obnoxious maneuver. I would say probably you wouldn't want to be doing that with the auto pilot on.

MR. JACKY: Would you say that the auto pilot would be trying to correct the airplane for entering and going through the vortices?

THE WITNESS: Yes, it would.

MR. JACKY: Would you feel like it would a fairly effective job of riding the airplane?

THE WITNESS: An effective job of what?

MR. JACKY: Riding the airplane or balancing of the wings?

THE WITNESS: Yes. As I said, if you had the auto pilot on, it was about essentially the same reaction as the crew did. If the auto pilot was on, it didn't roll more than about ten degrees.

MR. JACKY: Did you feel that after flying through these -- or the encounters that you did, were there any sort of geometry or condition that you didn't fly or are you pretty well satisfied that you accomplished everything you could, as far as geometries and what not?

THE WITNESS: I think we covered just about everything that could be done. Like I say, we put the vortex in every relative position of the airplane, wing-wise and tail-wise and fuselage-wise, and we went up and down and cross ways and rolling and non-rolling. We stayed in the vortex for it must have been a half an hour total right in the middle of one or two or both of them.

So basically if you watch the video, I think that's coming up later, you'll see that you can just pull right up in there with absolute impunity and fly anywhere you want with respect to either one or both of those vortices without a controllability problem.

MR. JACKY: And could you compare the flight test to flying the airplane in the simulator or through the vortices that were in the simulator?

THE WITNESS: I was pleasantly surprised to see that the simulator was extremely accurate. The roll angles that we got out of the simulator before we did this test were almost exactly the same as we got in the airplane. The only difference that we did see was the vortices pair in the real world were a lot closer together than the one in the simulator. I don't know why that is. But basically, it had the same effect. It just happened quicker.

In fact, in the real world, you would go through the front one and roll back out quicker than you did in the other airplane. In that simulator, you would roll up and go for a while and then roll back out again. So it wasn't a substantive difference. Only in the geometry of the vortex. The intensity of the vortex and the effect on the controllability of the airplane is exactly the same, as far as I could see subjectively.

MR. JACKY: What was the difference in the distance between the vortices cores?

THE WITNESS: Pardon?

MR. JACKY: Well, you mentioned that the only difference would be in the amount of distance between the two cores.

THE WITNESS: Yes.

MR. JACKY: What was that distance?

THE WITNESS: I think it probably must have been half, maybe a little more than that.

MR. JACKY: So during the flight test, how far apart would you typically say the vortices were?

THE WITNESS: I would say they were about -- it's hard to guess. But you'll see it from the picture. You can get both wing tips and the vortices at the same time. In fact, more than -- in board from there. You'll have to see it from the picture.

MR. JACKY: So wing tip to wing tip, how far apart would that be then?

THE WITNESS: I don't know. What's the wing span, a 100 feet, 60? I don't know.

MR. JACKY: And during the encounters, did you feel like the airplane was on the verge or out of control at any time?

THE WITNESS: Not ever, no.

MR. JACKY: Have you ever taken any sort of unusual attitude training?

THE WITNESS Yes, I had unusual attitude training during my initial instrument training and I've done aerobatics at night and I flew air shows for about three years and I taught aerobatics for about three years.

MR. JACKY: Did any of that training help you towards the wake vortex encounters?

THE WITNESS: No.

MR. JACKY: And the reason being?

THE WITNESS: Well, the angles and the rates were so small and so slight, that it was nothing approaching any kind of an aerobatics maneuver or anything you would want to consider as an unusual upset or an unusual attitude.

MR. JACKY: During any of the encounters, did you happen to see the rudder moving at all?

THE WITNESS: Well, you can't see the rudder moving. There's no indicator. You would have to ask the chase pilot.

MR. JACKY: Is there any sort of indication in the cockpit or rudder movement?

THE WITNESS: The yaw damper indicator, I think.

MR. JACKY: Did you happen to look or observe the yaw damper during -- the yaw damper indicator during any of the encounters?

THE WITNESS: I didn't pay particular attention to it. I assumed that it would be working, because it was turbulent, but I didn't pay particular attention. I think it was probably instrument. You could tell -- you could see what the rudder deflection and the frequency spectrum of it was from the data output from the maneuvers.

MR. JACKY: I don't believe I have any further questions. Thank you very much.

THE WITNESS: Okay.

MR. HAUETER: Mr. Chairman, thank you. Just a couple. First to help clarify the record, one of the reasons we didn't go past the 80 percent limit load is this was a -- the airplane was going back into revenue service. And there was considerations that if we did any damage, we would have to buy a new vertical stabilizer. I just wanted to clarify that a little bit.

You mentioned there was no problem during the wake encounters between the 727 and the 737. That it was all controllable.

THE WITNESS: Yes.

MR. HAUETER: That's strictly for that combination of aircraft. Correct?

THE WITNESS: That's correct.

MR. HAUETER: I wanted to make sure that the private pilots weren't out there thinking this was not a problem.

THE WITNESS: No, I said for that class of airplanes.

MR. HAUETER: Okay. Good. Going back to the steady heading side slip work that you did, that was done as a steady. What results would you think there would be if there was more dynamic, if the rudder came in much faster, at 190 knots, flaps one?

THE WITNESS: Wel, we did do that test. We did dynamic rudder inputs at a quarter, one-half, and three-quarters. So we'll have data on what the difference is between the static value and the dynamic value. Typically, the side slip that we got in the simulator was about at 190 knots, full rudder side slip would give you about ten degrees. And the dynamic rudder input would give you about 14. So it's 30 to 40 percent more side slip. And, therefore, more rolling on it due to the dynamic input than you have when it's steady.

So it will roll faster if you put the rudder in dynamically than it will statically.

MR. HAUETER: Okay. Thank you. At 190 knots, flaps one, if you had a dynamic rudder input, would that be a controllable event, in your opinion?

THE WITNESS: Well, I guess we'll have to get back into the philosophical discretion of controllable and recoverable here. That depends again on what you do with the pitch control. Basically at 190 knots, if you don't change the air speed at all and you have a dynamic full rudder input, the airplane will roll rapidly and it depends on how long you delay it too.

Some background on controllability and recoverability. These terms were basically invented during spin testing, where you have an airplane that's not approved for spins and you have to do a one turn anyway to make sure that during the postal gyration that nothing unusual or bad happens and you can recover it. After that one turn spin intentional, you have to be able to recover in one additional turn.

Now, if it didn't meet that, if it didn't meet the requirements in the rules for that spin recovery, we said that it was uncontrollable. So basically, if you had a spin that was supposed to be recovered in one turn and it took three, then that was what we called uncontrollable but it was recoverable. It was only unrecoverable if you had to jump out.

So this became kind of a flight test shop talk. And it may be a bit confusing to people who don't do that all the time. So I think better than using uncontrollable will change that over to a little bit better syntax and say that it's less than acceptable controllability. I think that will be better.

So now you have an airplane that can be less than acceptable controllability, but recoverable. And I think that's what we have in this case.

The auto pilot requirements -- in other words, using the auto pilot as an example. If you have an electric flight control system or any type of stability and controlled augmentation to hook to the flight controls that's electric, you have to look at it from a failure standpoint. And if the failure is not extremely improbable, you have to demonstrate it in flight. Then you have to pick a number that you decide for yourself what is acceptable controllability and what is it.

Obviously, if the thing goes hardover, that is a full maximum, as fast as it will go, as far as it will go and stays there that rolls the airplane inverted in one second. Most all pilots are not going to make it out of that one. If it rolls five degrees in 20 seconds, everybody's going to recover from that.

So somewhere between those two, there's a limit of acceptable controllability. And what the FAA has chosen, based on experience and the type of pilots that are flying the airplanes, little airplanes, and the business jets, as well as the airline operators, we have chosen to be in the roll axis 60 degrees after a three second delay. That's the crew's case. We assume the pilot is on -- the auto pilot is on and the pilot is reading this map or talking to the co-pilot or talking to ATC, and when something happens, he doesn't see it immediately. Then when he does see it, he says, what's that? Let's get rid of this auto pilot, but then he has to reach up and grab it and disconnect it.

So we give him a reasonably conservative three seconds to do that before he gets to an unacceptable angle. And the angle we used for a tradeoff between those configuration of acceptable controllability and unacceptable is a 60 degree bay, after three seconds after the pilot recognizes something is wrong.

The British, the CAA use a little bit more precise, I think. And they use four seconds from the input of the hardover. And it comes out about the same in most cases. So if the airplane rolls more than 60 degrees in three seconds after the thing has moved far enough for the pilot to see it, then we say that's an unacceptable level of controllability.

Now, it's not unrecoverable in most cases. And generally the case is you can get back out of it, but you have to look at it from the standpoint of human factors and look at it from the standpoint of the whole cross section of the pilot community that's going to be flying it, levels of experience, and the mood that day. Whether it's nice or dark or is it a rainy night and it's turbulent, and what the workload is. And basically, our feeling is that if it rolls more than that, you're going to start picking up a significant number of people who are going to lose it from a standpoint of disorientation.

So we say 60is the limit. so --

MR. HAUETER: Um -- I'm sorry. Go ahead.

THE WITNESS: Pardon?

MR. HAUETER: Have you -- I'm sorry. I interrupted you.

THE WITNESS: I was just going to say that there's also -- there's an equivalent requirement in the pitch axis or plus or minus 1 G for three seconds. And that's basically two to zero are the limits. You can't go any more than that in pitch or more than 60 degrees in roll.

MR. HAUETER: Just going back and clarifying that you would say this is undesirable --

THE WITNESS: I would say --

MR. HAUETER: -- controllability, unacceptable controllability?

THE WITNESS: Well, we're going back and looking at the effective -- the pitch inputs on this hardover at 190 knots. Basically, in the simulator, at least, we didn't do the full deflection in the airplane. But once they had upgraded the rudder deflection, we did some hardovers in the simulator, too, with a three second delay to take a look at it.

Basically, it's a lot -- how far you go is a lot of function of what you did with the stick. If you don't do anything at all, you just let the other pilots stante on the rudder and hold it there, when you see it start to move, you count -- mark one thousand one, one thousand two, one thousand three, and then go quick full ops of the aileron, leaving the rudder in, assuming that you can't get it back out again, and the airplane rolls up to about -- depending on how you did it. If you don't use any pitch input at all and let the airplane nose drop and accelerate, you'll wind up with about a 75 degree bank.

Now, the other move that I did was I tried it again. And instead of letting the airplane go on its own and accelerate any way it wanted to, I held enough back stick to keep it at 190 knots in that maneuver. If you do that, it rolls up to past 80 degrees, almost 90.

So basically, in this condition, if you put in -- the more back stick that you add to it, the worse it gets. If you try to keep the wings level and slow down below 190, it's going to go on over, I think.

MR. HAUETER: In the trials that you had in the simulator, about how much altitude loss did you see in the recovery?

THE WITNESS: It wasn't a real significant altitude loss, because we didn't go on over. Basically, we considered that -- at least I did. Based on the three second delay in recovery that it was an unacceptable level of controllability, but it was always recoverable.

In other words, we could always get the thing to roll back out, especially if you accelerated. On the one, that at 190, it wouldn't draw out. It basically stayed at about 70 degrees and just sat there in a spiral. Until I dropped the nose and let it accelerate out until about -- at 200, it started coming back. And at 210, it's not a problem. A little bit of air speed increase helps you out a lot.

MR. HAUETER: Did you lose 2,000 feet in the recovery or --

THE WITNESS: No, I don't think it was that much. I don't even think it was even 1,000.

MR. HAUETER: Do you think it takes special training for pilots to recognize this more than they currently get to be able to recognize or recover from such a maneuver?

THE WITNESS: That's hard to say, I guess, because it presumes that they are going to handle an auto pilot hardover. I don't think they're trained to do that. Basically, the presumption is that that three second leg gives them time to figure out what happened and instinctively correct for it by going opposite in the opposite axis of which way is going hardover.

So I don't think we've ever done any auto pilot hardovers in any airline recurrent training that I've ever been to.

MR. HAUETER: Okay. Thank you, sir.

CHAIRMAN HALL: Other questions from the Technical Panel?

(No response.)

CHAIRMAN HALL: The parties? I see Boeing, the Airlines Pilot Association, the FAA, Boeing Commercial Airplane Group. Mr. Purvis.

MR. CLARK: Can we follow up just on that last question, just real quick?

CHAIRMAN HALL: Mr. Purvis, would you mind if Mr. Clark follows up on that last question?

MR. CLARK: This last discussion you had with Mr. Haueter, I thought you were talking about an event with the rudder hardover. And then right at the very last, it seemed like we jumped over to auto pilot failures.

THE WITNESS: I think we were just relating the two. He asked me if a pilot, an airline pilot should be trained to handle -- specially trained to handle an auto pilot -- not an auto pilot, but a flight control system hardover. And I said, I didn't think so, because the -- that is analogous to having an auto pilot hardover right now and they are trained to do that.

MR. CLARK: But just the immediately previous discussion was still dealing with the rudder issue for a flight control hardover?

THE WITNESS: Yes.

MR. CLARK: Okay.

CHAIRMAN HALL: Mr. Purvis.

MR. PURVIS: Good afternoon, Mr. Berven. How many of the flights did you fly at Atlantic City? I think you said you flew one in Seattle. How many did you do at the Atlantic City tests?

THE WITNESS: I flew two in Atlantic City. The first one for the safety evaluation, and the one for data.

MR. PURVIS: At the previous hearing in Pittsburgh, I recall that you said a wake encounter was like a giant hand grabbed you. And today, you also used the phrase, boy, we just ducked a bullet there, when you were answering questions from the tech panel.

During the wake encounter test with the smoke on in Atlantic City, could you prepare and anticipate for the wake -- prepare for and anticipate the wake?

THE WITNESS: Certainly.

MR. PURVIS: Under those circumstances where you can see the wake coming, is it less surprising to you do you think?

THE WITNESS: Well, certainly. You basically know when it's going to happen. If the wake is not there, it's a surprise, but it basically is nothing that's going to -- it's just unusual.

MR. PURVIS: Thank you.

CHAIRMAN HALL: Captain?

CAPTAIN LeGROW: Thank you, Mr. Chairman. Good afternoon, Mr. Berven.

THE WITNESS: Hi.

CAPTAIN LeGROW: Just a couple of questions. First of all, during your career at the FAA -- how long have you been with the FAA, by the way?

THE WITNESS: Nineteen years.

CAPTAIN LeGROW: You weren't here in 1967 either?

THE WITNESS: No.

(General laughter.)

CAPTAIN LeGROW: Have you, during your career, participated in the certification flight tests?

THE WITNESS: Yes. That's all I do mostly.

CAPTAIN LeGROW: Have you participated in the 737 certification?

THE WITNESS: Yes.

CAPTAIN LeGROW: What model?

THE WITNESS: Three hundred, 500, and 400.

CAPTAIN LeGROW: During those certification tests, did you use the same criteria that the 100 and

200 were certified to?

THE WITNESS: Yes, except for the propulsion system.

CAPTAIN LeGROW: But as far as the controls -- or the controls of the three axis were the same criteria used in 1967?

THE WITNESS: That's correct.

CAPTAIN LeGROW: You talked about doing some tests with jammed controls. I believe you said that you used the rudder trim -- how much rudder trim authority do you have?

THE WITNESS: Well, let's see. The rudder statically deflects 26 degrees. I believe on the ground, you get 16. You don't get that much in flight, of course, because for the blow down.

CAPTAIN LeGROW: But you've never done any with a full -- until the simulator validation tests in Seattle last month, you had never done any tests with full rudder hardover?

THE WITNESS: No, we did not.

CAPTAIN LeGROW: During your tests in Seattle for the validation tests, were you surprised at the control or lack of control with the full rudder hardover?

THE WITNESS: Not particularly, because basically, that's not an unusual characteristic for a transport airplane.

CAPTAIN LeGROW: During Mr. Jacky's questioning, you referred to flying some of the tests at one degree flap between 170 and 220 knots, I believe. Is that correct?

THE WITNESS: Yes.

CAPTAIN LeGROW: so you -- and I believe you said that something under 190 knots, 185 maybe, would be a good number. That with a full rudder hardover, you did not have enough lateral control.

THE WITNESS: That's correct.

CAPTAIN LeGROW: And you say this is something you expected?

THE WITNESS: Yeah. If you want a further explanation on that, it comes from the fact that we don't do primary flight control system hardovers. Because by definition, they're designed with enough control power to have the pilot do whatever he wants to the airplane. Therefore, if a primary flight control system does go hardover and stay there, you'll very likely lose the airplane every time.

Just look at the pitch axis. If you get a full aft stick elevator hardover and if you can't get rid of it, you're done. So basically the flight control system, primary flight control system has to be basically reliable enough that that does not -- it doesn't happen.

CAPTAIN LeGROW: I guess that's why in the earlier airplanes we had an angle reversion. Is that correct?

THE WITNESS: It's what now?

CAPTAIN LeGROW: In the earlier airplanes, we had an angle reversion.

THE WITNESS: The 737 has been the same all along, as far as I know.

CAPTAIN LeGROW: Were you here for Mr. McSweeny's testimony?

THE WITNESS: Yes.

CAPTAIN LeGROW: Do you recall I asked him a question about manual reversion in the 737 and his answer was, that the rudder in the 737 did not have manual reversion, but it did have a standby system.

THE WITNESS: That's correct.

CAPTAIN LeGROW: Is that standby system hydraulic or is it manual?

THE WITNESS: It's hydraulic.

CAPTAIN LeGROW: Thank you. During your tests in Seattle for the simulator validation tests, were there any other regimes of flight that you flew or any of the other pilots that you're aware of flew with a full rudder hardover and there was no lateral -- not enough lateral control of the airplane?

THE WITNESS: We didn't do a real comprehensive test, because that wasn't what we were looking for. We were basically just checking it against the simulator. We did a bunch of other stuff in the simulator. I think it's agreed now that with flaps one, five or even possible ten, that you can over roll the roll access with the rudder input at slow speeds.

CAPTAIN LeGROW: On this -- your discussions about recoverability, I find those terms quite interesting. Does not altitude and time affect recoverability?

THE WITNESS: Certainly. If you're too low, you can't make it.

CAPTAIN LeGROW: But still -- I guess, it's still recoverable even though you crash?

THE WITNESS: I'm speaking of it from a flight control standpoint. You have to presume that you have enough altitude or you'll crash, yeah.

CAPTAIN LeGROW: Have you participated in any of the certification flight tests in the newer model Boeing airplanes?

THE WITNESS: Yes, quite a lot of times in the 777, 57, 67.

CAPTAIN LeGROW: How would you compare the rudder system in the 57 to the 37? Let me put the question another way. During your flight testing on the 75, you have done any full rudder hardovers in the 757?

THE WITNESS: No, we have not.

CAPTAIN LeGROW: Could you tell us what the difference in the certification criteria and the certification of the yaw control in the 75 as compared to the certification of the 73 yaw control?

THE WITNESS: It's really very similar. In the older airplanes, the lateral directional stability tests were kind of segmented into a couple of different parts. One of them was just straight directional stability, where you just stabilize in a certain air speed and flap condition and gear and just push the rudder in for a while and release it and see that it came back to zero to check that it was directionally stable and didn't have too much friction.

Another test that we did was to put the airplane in a straight steady heading side slip and like what we were doing on these evaluations tests. Is look at the relationship between the rudder and the elevator to make sure there was a positive grady and opposite to each other. And then you would release the stick or release the wheel and see that it rolled into the rudder so that it ha& positive dihedral effect.

Later on, we decided that those were all the same test. Basically if the airplane had directional stability -- in other words, if you push the nose up and it comes back and if when you released the controls on the side slip, it rolls up, you can tell both of those by just doing a straight ahead side slip.

In other words, if you're pushing more side slip and your rudder force is going up and your ailerons are going opposite, it's obvious that if you're holding an aileron force, if you let it go, it's going to roll away to the rudder.

Basically, we've combined those tests, synthesized them into just a straight steady heading side slip for static directional -- static lateral directional stability. You get the same effect. So the tests are essentially the same.

CAPTAIN LeGROW: Thank you. You're familiar with the CDR?

THE WITNESS: Yes.

CAPTAIN LeGROW: And the exhibit that's been offered here at these hearings?

THE WITNESS: Yes.

CAPTAIN LeGROW: And I refer you to recommendation 9. I asked Mr. McSweeny earlier if in light of that or if he felt that increasing the lateral control of the 737 or reducing or restricting the yaw control on certain regimes of flight, maybe one way to get to that recommendation.

I would like to ask you, in light of your surprise or what you -- 1 don't want to use surprise. I don't want to put words in your mouth. But what I'm assuming from your testimony is what you saw wasn't necessarily what you expected. Would that be a fair statement?

THE WITNESS: With respect --

CAPTAIN LeGROW: With respect to a full rudder hardover.

THE WITNESS: No. I guess, that I never had any expectations, because I was always under the presumption that it couldn't happen. It never entered my mind that we would even consider it.

CAPTAIN LeGROW: In light that we know that it does happen and this has been going out in the tests in Seattle, do you think that it would be helpful for the FAA and/or the Safety Board to make recommendations to either increase the lateral control of the 737, restrict the yaw controllability of the airplane, or perhaps change some of the operational procedures in the airplane to help get the recommendation in line?

MR. PURVIS: Mr. Chairman?

THE WITNESS: I think that's four different comments. I think I'm going to answer the first one. Number one, I don't think anybody --

MR. PURVIS: I would like to object to the question, to start off with. If he's presuming many, many things that are not verified and including, in particular, full rudder hardovers -- I mean, that's done as part of a test. But that it occurred in this accident is a presumption.

CHAIRMAN HALL: Do you want to reconsider the question, Captain, or do you want to restate it and let me --

CAPTAIN LeGROW: Well, I'll restate it, if need be, but I wasn't referring to the accident. I don't believe I mentioned the accident. What I was referring to is the test conducted in Seattle for the simulator validation tests.

THE WITNESS: The simulator validation test was an in-flight test. And basically, we did the rudder hardover just to validate how accurate it was dynamically with respect to the simulator. Your first presumption that -- in other words, to talk about changing procedures and improving lateral control and decreasing the yaw control, you have to start off with the presumption that you have a rudder hardover to address. Now, I don't think that's been concluded yet.

If you want to say if a rudder hardover occurred, what would you do, I can give you a few suggestions on that.

CAPTAIN LeGROW: Okay.

THE WITNESS: If a rudder hard -- if I was going to go out and fly the 737 and during that flight of an hour and a half or whatever it was, I knew that I was going to have a rudder hardover somewhere in there and I was going to have to handle it or not come back there's a couple of things I would do based on my experience in the airplane and the simulator and all the stuff that I've learned.

Number one, I would go faster to start with. If I was at flaps one, I would 200 as a minimum. The second thing I would do is I would keep my hands on the controls. So I don't have a three second delay. I've only got one. Any time that I was out of flaps one, if I was at one, five, or ten, I would either be manually flying the airplane myself or following through if the auto pilot was on.

And another thing I would do is basically minimize my time at those flap settings. I would ATC to stay at 210 until I could go to 160 or 170 or 150 and slow down to flaps 15.

CAPTAIN LeGROW: Thank you. I have no further questions, Mr. Chairman.

CHAIRMAN HALL: Mr. Donner?

MR. DONNER: Just two questions, sir. Mr. Berven, we've talked a lot about auto pilot hardovers and the three second delay for pilot recognition of the event. Then you've talked about the 60 degree limit. My question is does the 60 degree limit include the pilot's reaction after the three second recognition time?

THE WITNESS: Yes, it does.

MR. DONNER: Concerning the possible rudder hardover at various flap settings, is the rudder hardover at landing flaps 30 degrees or more capable of being balanced by the aileron?

THE WITNESS: Based on all the information and the tests that we've done, yes. Either flaps up or flaps 15 or more, the lateral control system has enough control power to handle it.

MR. DONNER: Thank you. I have no further questions.

CHAIRMAN HALL: Mr. Clark?

MR. CLARK: I have one question in one area. You talked about an event in which, as you were finishing up with the questioning with Mr. Haueter, a three second delay in a 60 degree bank angle. And then I think you talked about possibly going for speed to effect the blow down if you were dealing with rudder hardover. Is that an intuitively reactive -- would that be an instinctive reaction or an intuitive reaction by the crew, by a typical line crew?

THE WITNESS: I really don't think it would be, no.

MR. CLARK: So that if you were to address that, that would be a training issue then?

THE WITNESS: If I had never seen or encountered or even heard of a rudder hardover, basically my job right there was hold altitude so I don't get violated. So if something happens, I'm going to try to solve the problem and get back into control, but I'm also going to try to stay legal at the same time. So you would probably instinctively try to keep the airplane on this altitude until you reached a point where this is more serious than an ATC violation.

MR. CLARK: So basically if you were to address this issue, we've been looking at a training issue?

THE WITNESS: If you're going to presume that a flight control system hardover can handle, you have a really big training problem.

MR. CLARK: Sure. Thank you.

CHAIRMAN HALL: Mr. Marx?

MR. MARX: No questions.

CHAIRMAN HALL: Mr. Schleede?

MR. SCHLEEDE: Just a couple, Mr. Berven. These values that you gave when you defined acceptable controllability -- you gave us some numbers -- are those specified in some material?

THE WITNESS: They're in an advisory circular wiht respect to auto pilots. It's 1329-1, I think. Either that or it's been put in our flight guide 2570.

MR. SCHLEEDE: Thank you. Is there a definition in there also for exceptional pilot skills as mentioned in FAR 25-671?

THE WITNESS: No, I think that's part of all the regulations. It says that all the CFR requirements for airworthiness have to be able to be met without exceptional pilot skill. So that's kind of a very subjective call, too.

Basically what we have to do is to just presume that when we see some unusual flying qualities or something that's outside of the norm that you wouldn't see instinctively, we have to say would the normal pilot using normal flying techniques be able to pick this up and handle it without causing a problem. Because we go out there sometimes and we do 200 or 300 full stalls in the airplane.

So by the time we're done with that, we're pretty proficient at it. So we have to ask ourselves if an airline pilot never having done a real stall and the airplane gets into one, what's he going to do? So an airplane that we could recover and meet the rules every time after 300 practice stalls, would not be acceptable for a pilot who only has to do it one time in his entire career.

So basically our requirements are that the airplane would really be easy to fly through all the maneuvers required by the regulations, because the airline pilot really encounters a lot more different and unusual conditions than we do.

MR. SCHLEEDE: Is there guidance of any sort that helps you reach the subjective evaluation of pilot skills required in any documents or --

THE WITNESS: I don't believe there is. It basically comes from just meetings between our flight test pilots and meeting with the airline pilots and flying with them on the jump seat rides and seeing how they fly and what their attitudes are and going to recurrent. We go to the airline recurrent once a year, each one of us. We don't fly with the airline pilots. We fly with their instructors and take the same check rides. So we see what level of proficiency they're trained to.

So we try to basically find compliance to a pilot that doesn't require exceptional skill or a lot of practice.

MR. SCHLEEDE: Thank you very much.

CHAIRMAN HALL: Mr. Laynor?

MR. LAYNOR: Just a couple, Mr. Berven. I think you've hit upon it. But in talking to Mr. Jacky about the tests that were conducted, this steady heading side slip test, were they done with all the different flap configurations at the speed -- through the speed range that you discussed?

THE WITNESS: They were done mainly just at flaps one, just to check against the simulator.

MR. LAYNOR: I'll carry on then. How do you establish what the real control margin, lateral control margins were in fact at the different flap settings that you were referring to in your answer to Captain LeGrow?

THE WITNESS: The extrapolation of our comments to five and ten is based on both aerodynamic characteristics of the airplane and the simulators. We did do those tests in the simulator.

MR. LAYNOR: Okay. In bounding the ranges that you would recommend as a procedure or if you did recommend any procedural changes, did that include the margin necessary to recover from an upset that would occur with the dynamic control movement or is that just what's needed to balance the two -- the directional lateral controls?

THE WITNESS: If I understand the question, at 190 knots, you statically balance the rudder and aileron. So that if you have a dynamic input, you can't stop it until you speed up. Depending on -- with the three second delay. If your hands are on the controls and you only use a one second delay, you can stop it at about 25 to 30 degrees.

MR. LAYNOR: But you would have to change your speed in order to have the margin to recover --

THE WITNESS: That's right.

MR. LAYNOR: -- to a level flight. As strictly hypothetical, because I don't think you could expect the line pilot to do it in the dynamic situation that we're talking about. But you've commented about sitting there expecting such an occurrence and how you would respond to it.

Would you consider isometric power or would you consider turning off the hydraulic pressures as a possible response?

THE WITNESS: I think those are kind of secondary items that you would do after you try to get control of the airplane, because you have to get on it really quick. To find the hydraulic switches and turn them back off again, you would probably have to have the other pilot do that and you would have to go through the command process to tell him to do that.

You could split the engines, you know, if you got to a position finally. In other words, you rolled all the way there and it stopped and you can't get it back out, you can split the engines and roll back out that way. There are several other things you can try.

MR. LAYNOR: All right. Thank you. That's all I have.

CHAIRMAN HALL: Mr. Berven, I guess my only question is, were you -- did you participate in the critical design review?

THE WITNESS: No, I did not.

CHAIRMAN HALL: Have you read the report?

THE WITNESS: Yes.

CHAIRMAN HALL: Do you agree with the recommendations?

THE WITNESS: Yes.

CHAIRMANHALL: All right. Well, thank you very much. We appreciate your time.

THE WITNESS: I had one more comment here.

CHAIRMAN HALL: Surely.

THE WITNESS: Based on something that was said earlier this morning about ten to the minus ninth and extremely improbable. My understanding, not being a systems expert but having worked with a whole bunch of them, ten to the minus ninth is an extremely improbable event that does not happen during the life of the fleet.

Basically, that's a billion hours. If your typical 737 at this point has got 65,000 hours in 30 years, it's going to take 500 years to get a billion hours.

So basically, a ten to the minus ninth event is allowed to be catastrophic, because it never happens in the lifetime of the fleet.

CHAIRMAN HALL: So the point -- you're just clarifying that?

THE WITNESS: Yes, that's just a clarification.

CHAIRMAN HALL: All right. You're dismissed, sir. Thank you.

THE WITNESS: Thank you.

(Witness excused.)

CHAIRMAN HALL: We're not moving very rapidly, Mr. Haueter.

(General laughter.)

CHAIRMAN HALL: Mr. Berven gave us several lengthy descriptions of the same flight, and I guess we're now going to have some more?

MR. HAUETER: Yes, they should be shorter.

CHAIRMAN HALL: Okay. Well, let's take a break and come back at 4:15.

(Whereupon, a recess was taken.)

CHAIRMAN HALL: We will reconvene this Board of Inquiry, and our next witness, witness number 10, is Mr. Robert Stuver -- Stuever. Sorry, Mr. Stuever. He is the Program Manager of the OV-10 Flight Test-Wake Vortex Studies. And he comes to us from NASA-Langley in Langley, Virginia.

Thank you for being here today, Mr. Stuever.

(Witness testimony continues on the next page.)

ROBERT STUEVER, PROGRAM MANAGER, OV-10 FLIGHT TEST-WAKE
VORTEX STUDIES, NASA-LANGLEY, LANGLEY, VIRGINIA

Whereupon,

ROBERT STUEVER,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows:

THE WITNESS: Thank you for the opportunity to let me work today while my colleagues are on furlough, too.

(General laughter.)

CHAIRMAN HALL: We don't have to pay you, do we?

(General laughter.)

MR. SCHLEEDE: Mr. Stuever, give us your full name and business address, please?

THE WITNESS: Robert A. Stuever, Mail Stop **247**, NASA-Langley Research Center, Hampton, Virginia 23681.

MR. SCHLEEDE: Thank you. And what is your position at NASA?

THE WITNESS: My position is as an Aerospace Research Engineer in the Flight Dynamics and Control Division at Langley.

MR. SCHLEEDE: How long have you worked for NASA?

THE WITNESS: I've worked for NASA for five years.

MR. SCHLEEDE: Could you give us a brief description of your education and background?

THE WITNESS: Yeah. I have got a bachelors and a master's degree in aeronautical engineering from Wichita State University. I've worked at NASA for five years in the Flight Dynamics Control Division. Prior to reorganization about a year ago, I was in the Flight Applications Division.

I have been involved on the wake turbulence program at NASA-Langley, as well as some other flight research programs that we've had over the last five years.

Currently, my duties are as a group leader for a team of researchers studying wake turbulence hazards in the terminal area for terminal area activities for the purposes of looking at airport capacity issues and wake spacing criterion.

MR. SCHLEEDE: Thank you very much. Mr. Jacky.

MR. JACKY: Good afternoon, Mr. Stuever.

THE WITNESS: Good afternoon.

MR. JACKY: I would like to ask you first about you said you mentioned you work in the wake turbulence program at NASA-Langley. Could you give us a description of what that entails, please?

THE WITNESS: Well, it entails a lot of things. It's a very broad program that NASA is conducting jointly with the FAA for the purpose of looking at ways to increase airport capacity at major airports around the country. Primarily looking at ways to perhaps alter the spacing restrictions in instrument meteorological conditions as they pertain for wake vortex hazards.

My particular group is a team we call the hazard definition and assessment team. We're coupled in with another team at Langley that is looking at developing sensors and systems that would be able to predict wake vortex behavior in the terminal area environment and be able basically to space aircraft according to whether wakes are staying in the approach corridors and how strong those wakes are and so forth.

My particular team is looking at validating models and validating hazard criteria in terms of aircraft that would actually encounter wakes on the approach corridors and determining if it is, in fact, safe and satisfactory for an airplane to do that. Satisfactory in the sense that a pilot would not be inclined perhaps to maybe make a go around or do something that would disrupt the flow of traffic into the terminal area environment.

I might point out when I talk about wakes in the approach corridors and aircraft encountering them safely, really the best example to use is something like you might have a day where a wake from a leer jet might stay in the approach corridor and you wanted to send like a 747 behind it. I mean, that's an example of something that might be acceptable.

MR. JACKY: How long has this program been in place?

THE WITNESS: Well, the joint program with the FAA has been in place, I believe, about two years. We initiated the program shortly after I got to Langley, which was five years ago. In terms of a flight research project that would help us validate vortex encounter models that would then be put into -- well, we would have a systems group at Langley work on developing the actual system that would take these models and convert them into something that the FAA and the air traffic control system could use. But in terms of the joint program, I'm going to guess it was two to three years ago that we put the big program together.

MR. JACKY: Is there a program completion date at this time?

THE WITNESS: Yes. What we're targeting right now is the test of what we call an aircraft vortex spacing system or AVOSS system. Somewhere in the 1998, '99 time frame, and that would be a prototype system that we would test at major airports with the idea that if that test is successful, somewhere around the year 2000, we would start implementing that system nationwide.

MR. JACKY: Can you briefly describe that system? Is that a ground base type of system?

THE WITNESS: Yes, it would be a ground base system. At its best, it would be a system of sensors that would be able to measure -- actually, I'm sorry. That would be able to detect, track, and measure wake vortices in the approach corridors.

Well, at best, that's what it would be. Coupled with some predictive algorithms that would be able to tell you say at 20 minutes from now, given this weather state, this is what the wake is going to do. When the airplane that is now being marshalled into the approach corridors, when he gets to this particular point, this is what the wake of the preceding airplane might do and this is what the weather state is going to be like, that would drive the transport and decay of that wake.

So, yes, it would be a ground base system in terms of a deplorable sensor and a predictive algorithm deployed along with that.

MR. JACKY: And as part of the hazard -- I believe you said hazard definition team, what are your functions within this program?

THE WITNESS: Well, there's three functions. My particular function, as the team leader, I've got roughly five to six people working on this project. Although, some of them are also working on other things, as well.

Basically, we're addressing this particular research task in three ways. One, determining what's the metric for what would be an acceptable terminal area operation? In other words, you have to have some way of defining what a wake vortex hazard is based on something that's already acceptable to a pilot, to the air traffic control and so forth.

The second one, which is really our major effort now, it involves a lot of flight test work that we're doing now. We've done a lot of work in the wind tunnels. We're developing flight simulations and we've got some analysis work going on. And that is with respect to validating how you model the interaction of a wake vortex with an aircraft. Not how you model the vortex itself and the decay of the vortex, which is being done by the other team developing the AVOSS, but how you model the interaction of the aircraft in the wake.

The third thing that we're doing within the team is once you have these valid models, once you have a metric, how do you apply it to the fleet to develop wake hazards for all the aircraft in the fleet, under all the different categories.

MR. JACKY: Thank you. You said that you're doing a lot of flight testing. And you also have said that you're program manager for the OV-10 aircraft. Is this the aircraft that you'll be using for these flight tests?

THE WITNESS: That's one of the aircraft.

MR. JACKY: And what would be the other aircraft that you would be using?

THE WITNESS: Well, the OV-10 is one of the aircraft that we're using to make wake missions and we're also using it to make weather measurements. Initially, when we put the aircraft together as a research platform, we had intended to use that airplane as an encounter airplane. Meaning, we were going to develop a simulator of it, a simulation model of it, and validate our air models with that particular airplanes.

About -- I'm going to say about a year and a half ago, we decided to go with our 737-100 model that we have at Langley as our encounter aircraft for a number of reasons. One being that we already had a validated baseline simulation of that aircraft. Two, it more ideally represented an aircraft of the transport fleet. And number three, it was available at the time that we needed it.

So the 737 is our encounter aircraft. The OV-10 is another airplane. We are using an aircraft out of Wallops as a wake generator for our first series of tests and that's the C-130 at Wallops.

MR. JACKY: Okay. If I can direct your attention to Exhibit No. 13X-H, page 4, please.

THE WITNESS: You said hotel?

MR. JACKY: Yes, sir. And we also have an overhead slide of this page.

THE WITNESS: Oh, okay.

MR. JACKY:

(Slide shown.)

CHAIRMAN HALL: Are we going to get some help with the lights, please?

MR. JACKY: You can just -- if you want, you can either use that or turn around and hold the mike.

THE WITNESS: Can you hear me?

CHAIRMAN HALL: Yeah.

MR. JACKY: What I would like for you to do is to kind of step us around the airplane and just show us and describe to us how you utilize the OV-10 as a meteorological measuring airplane platform.

THE WITNESS: Okay. Well, basically, this is the OV-10. It's around 11,000 pound airplane, twin turbo prop, high wing and high tail, 40 foot span on the wing. Basically, we've completely -- well, we've completely modified the airplane to make it into a research platform, primarily to take measurements of wake turbulence and to take measurements of meteorological parameters.

In terms of the question that was asked regarding meteorological parameters, things that we can measure with this aircraft are temperature -- we've got a temperature probe out on the wing. Actually, we've got two of them. One goes to a standard central air data computer. We've got it mounted with an aircraft hygrometer to measure the dew point or in layman's terms would be the relative humidity in the atmosphere.

As you notice, we've got three booms that come off the aircraft. And the three booms are for the purpose of wake measurements instead of weather measurements. But what I want to point out is that at the tip of these booms, we have sensors out here that will help us measure how the air relative to the aircraft is behaving to help us make atmospheric turbulence measurements.

And finally, we have positional information in the form of an anersia navigation unit, coupled with the global positioning system receiver that we can then use to back out our winds at altitude.

MR. JACKY: Thank you. For the wake vortex flight tests that were accomplished in Atlantic City last month, could you please explain what your participation and the OV-10's participation in the program was?

THE WITNESS: Yes. We were asked to come up and collect data that would help verify some of the assumptions that were used in the Boeing wake vortex encounter simulations.

MR. JACKY: How many flights or missions did you participate in?

THE WITNESS: We flew three missions. Two at the time the 737 was flying, and then we flew an independent mission with just the 727.

MR. JACKY: Could you briefly describe what sort of things were you doing during the flight test?

THE WITNESS: Two things actually. The initial request came up that there was an interest in making measurements of the 727 wake, again for verification of some of the assumptions in the simulator. So part of what we did was to fly behind the 727, and this is what the 37 and the -- well, actually just the 37 out of the area -- and making penetrations through the wake at various downstream distances to basically characterize the properties of the wake using the flow centers on the booms as a primary measurement.

The second thing we did -- and actually we did this on all three flights. One flight was dedicated completely to it, and that was to make weather measurements in the area that the 37 was operating.

Essentially, weather measurements within a block of altitude that we thought the wake would be -- the wake from the 727 would be behaving within, to get a measurement of temperature at dew point profiles, atmospheric turbulence, and winds --

MR. JACKY: Generally speaking, could you give us a characterization of how weather plays in the effect of wake strength indicated?

THE WITNESS: Yes. One of the major flight test areas that -- in fact, we're embroiled in it now. And if it weren't for the furlough, we'd probably be out flying today, doing another one. But one of the major flight test areas we're working on right now is the validation of a wake decay model that one of our -- one of my colleagues at Langley has developed and we're in the midst of doing a flight test program to go out and validate this wake decay model, which is -- it's a decay model built around the assumption and the observation from several years of having done wake measurements in ground base facilities, that the atmosphere, especially things like atmospheric turbulence and the stability of the atmosphere in terms of temperature dew point, et cetera, play a significant role in the way that a wake decays.

MR. JACKY: Now, I understand that you brought along a video today for some of the portions of the flight tests that you participated in.

THE WITNESS: Yes, I did.

MR. JACKY: Could you maybe -- do you need to set it up at all or talk a little bit about what we're about to see?

THE WITNESS: It should be -- yeah, what the -- the video tape is of the first -- in fact, it was the first wake encounter flight that we ever did, and it was actually -- it's the first day that we came up and had an opportunity to fly behind the 727 in Atlantic City.

CHAIRMAN HALL: Mr. Stuever, before you go, the Chairman wants to say something, that I want to be sure that the public is aware of. We wanted to have this test for some period of time. I greatly appreciation NASA providing this OV-10. I appreciate the FAA letting us use their 727. And I appreciate Boeing's assistance. But I want a specifically acknowledge Mr. Seth Schofield as the CEO of USAir.

We spent, what, about six or seven months, Tom, trying to find the 737. Because Mr. Laynor and others felt -- we all felt that this was an extremely important test. When I visited with Mr. Schofield and explained our dilemma to him, he was able to arrange for a USAir 737 our of service, to be used for these tests.

And, General, I hope that you will let him know again, which I have said publicly before, how much we appreciate this. Because I do think not only is this test important to this investigation, it does help advance knowledge in this field and is something that hopefully will make a contribution to flight safety.

Thank you, Mr. Stuever, for letting me say that. Yes, Mr. Purvis?

MR. PURVIS: Just a quick question. I'm wondering if it can be -- these lights that are shining on the screen and this one that's behind the screen that shines at us can be dimmed? This witness and the next couple have --

CHAIRMAN HALL: The TV lights -- in fact, I keep hoping that all the TV cameras will leave, because those lights are about killing me, but --

(General laughter.)

CHAIRMAN HALL: If we could turn them off for this one video -- if I'm turning my back on the audience, it's not because I'm not interested. It's just those lights after a while get your attention. Is that a problem with the TV, because I think we have a video that we are providing you of what you're going to see anyway.

Thank you, sir.

THE WITNESS: I just wanted to have you put this slide up here because --

CHAIRMAN HALL: Let me just say one more thing and then I'll be out of the way here, because I feel strongly about the cooperation we've gotten from the parties on this investigation. Mr. Laynor reminded me that Boeing had 28 people up there assisting in this test. And we appreciate everything that everyone has done to help with this investigation, but I did want to make those points.

THE WITNESS: I wanted to put this slide back up. It's just a precurse of what you're going to see is footage from a video camera that we had in the tail of the aircraft. So what you're going to be looking at is just kind of an over-the-wing shot that we have.

Okay. We're ready for the video.

(Video played.)

THE WITNESS: Okay. These are basically just penetrations straight through the wake of the 727, and we've already made one penetration from the left side to the right side, and we're getting set up to go back through the wake. We started at approximately two miles back with the penetrations. I'm going to guess this is about two and a half miles. You can see the interception there.

What we're trying to do is essentially fly the aircraft as best as we can and hit both cores. And with the three booms that we have on the aircraft and the three separate instrument packages on those booms, get a pretty good cut of what the flow fields should look like.

As Mr. Berven pointed out, you can kind of see some of the oscillation in the wake here. At least through this part of it. And, again, this is -- a lot of this is driven by an atmospheric turbulence. There also is a kind of a self-destructing mechanic in the wake that you typically don't see for several miles back when you've got conditions that -- in which you don't have a lot of turbulence in the atmosphere. But a lot of this is -- as you can see, it's very hard to model.

I will back up what Mr. Berven said It's really not that bad of a ride. It's not a loaded maneuver. It's just a maneuver in the roll. And, in fact, it does smell like orcopus oil. That was not wake induced, by the way.

(General laughter.)

THE WITNESS: I'll let it go one more time through the wake and then we can turn it off. I believe on this one, this is the very first one we did. I believe we followed it back to, I'm going to guess, seven or eight miles. I would have to look at my notes.

Okay.

MR. JACKY: Have you ever used the OV-10 as a wake penetration aircraft before?

THE WITNESS: No, not before this test.

MR. JACKY: Was there anything in flying in the wake vortex tests up in Atlantic City that would have helped you for some of the ongoing projects that you're running right now?

THE WITNESS: Oh, yeah. The data from the 37. The weather data that was collected at the time the 37 flights were conducted. The data that we collected -- I mean, it's all going to be very useful. In fact, it was -- technically, we were very excited about supporting this.

MR. JACKY: Have you been able to make any sort of assessment of the data that you've collected so far?

THE WITNESS: No. Unfortunately, you caught us right at the beginning of a very -- well, I'm going to say a three-month test program that we were just starting. We're at the point where we have the data basically digitized and to put into engineering units, but we have not gotten to the point where we corrected it to where it's ready for release. But I don't see that being too far in the future.

MR. JACKY: So, therefore, you haven't made any sort of assessment as to the strength of the vortices or anything?

THE WITNESS: No, not yet.

MR. JACKY: Then you wouldn't have been able to make any sort of comparison back to the time of the accident or the data from there?

THE WITNESS: No, sir.

MR. JACKY: You mentioned that you had a 737-100 that you're using for part of your tests. Is that going to be used as a wake penetrating airplane or is it generating?

THE WITNESS: Yes.

MR. JACKY: What will be the wake generating airplane for your tests?

THE WITNESS: The aircraft we'll use as the wake generator is the Wallop C-130.

MR. JACKY: And you said that those tests are ongoing now or will be in the future?

THE WITNESS: That series is supposed to start -- keeping our fingers crossed for the folks in Congress. It's supposed to start the day after the Thanksgiving break.

MR. JACKY: You mentioned wind tunnel tests.

Have you done any sort of -- or could you describe the wake vortex tests that you've done in wind tunnel work?

THE WITNESS: Yes. I'll try to do it very briefly. It's kind of -- maybe difficult to explain. At NASA-Langley, we have -- I should say we had, because it closed about three weeks ago. We had a wind tunnel facility there that was -- they called it the full-scale wind tunnel.

It's a low speed wind tunnel that has a test section, that's roughly the size of this ballroom. It's about three times as high, but it's roughly the size of this ballroom. During World War II, it was big enough to put the fighter -- the complete fighter aircraft in there for dry cleanup.

In that tunnel, we have the capability to free flight scale models under -- obviously, under pilot control. And we initiated a series of tests about two years ago to look at the feasibility of actually flying wake vortex encounters in that tune.

For the first series of tests that we did, we took a business jet configuration that we had and we took a wing that we also had that was built for another test, and essentially put the wing in the forward part of the test section to act as a wake generating airplane and flew the business jet back behind that wing as an encounter aircraft.

That test proved successful. So as part of our ongoing program in terms of validating wake encounter models for transport aircraft and based on the fact that we were planning to fly our own 37-100 configuration in flight tests, we went ahead and built a free flight model of the -100. And, in fact, that was the last test that was ever conducted in that tunnel.

We finished in, I believe, the second week of October. We did wake encounters in that tunnel. Basically, we flew behind aircraft simulating an aircraft the size of the 37 and then another aircraft simulating -- or a wing simulated an aircraft that was twice the size of the 37. And the way you model the wake in the tunnel in terms of downstream distance or wake decay, is essentially you just change the lifting characteristics of the forward wing by changing its angle of attack.

So we could vary the strength of the vortex that the aircraft was penetrating to get a good assessment of, for instance, what kind of control power was needed, what kind of encounter trajectories you might see hitting various types of vortices and so forth.

MR. JACKY: Would you be able to characterize the type of intercepts that you -- were you just trying to fly the 37 into the wake or were you trying to very precisely put the 37 in the wake or --

THE WITNESS: Yes. We attempted to do two things. One thing was to fly precise encounters based on approaching the wake from different positions; from the side, from underneath, from on top, from the middle, and so forth. And we flew several passes for each trajectory for each different vortex strength and got a matrix of test points based on those encounters.

Then we also flew some control power studies to look at really how much control power you would need to fly the model in a controllable fashion at different points with respect to the vortex. And by the way, we did mark the wake with a similar smoke system, so that you could actually see the wake in the tunnel.

And it's a lot like what Mr. Berven was talking about. We would essentially fly the aircraft, put the wing tip in a core, and we would put the core near the nacelles. We would put it right on the fuse1 lodge and basically fly around the wake and take that on a control power assessment.

MR. JACKY: Was there any particular encounter that gave you a large upset or what encounter did give you the large upset?

THE WITNESS: Well, the worst upsets we had were obviously when we had the big wing in there at its maximum lift off efficient or maximum vortex strength. I mean, we kind of expected that.

With respect to what we did -- I mean, tying this into what we're going to do with our own flight tests and what we did at Atlantic City, for the configuration where we had a like-size vortex generator, we got encounters, we got model upsets, but we had no trouble recovering from them.

MR. JACKY: And in which axis of the airplane was the largest deviation?

THE WITNESS: Roll.

MR. JACKY: Roll. Did you see any sort of yaw or heading?

THE WITNESS: I can't answer that. I can't answer that. I don't know. I didn't actually fly the maneuvers.

MR. JACKY: You mentioned the data that you collected during the wake vortex flight test. Do you have any sort of an estimate as to when you might be complete or completing converting the data?

THE WITNESS: From which test?

MR. JACKY: From the Atlantic City.

THE WITNESS: Oh, okay. The long hold on that is with respect doing our video processing. One thing I didn't point out on that slide that is on the exhibit, we have video cameras that are underneath each wing tip. And the reason that we put those video cameras on underneath each wing tip was to record stereoscopic images of either a vortex smoke trail below us. Or in the case of when we do our 737 experiments, we're going to use those cameras to record the position of the 37 with respect to the wake,

The long hold in terms of our production is the video. So, I mean, we're guessing that's going to be about the end of January for that. Right now, like I said, we have the actual what I call the PCM or the basic numerical data digitized, and we're looking at some time in the December-January time frame to get that out.

MR. JACKY: And would you be willing to share that information with us?

THE WITNESS: Oh, certainly.

MR. JACKY: I want to thank you for your help on the flight test. I have no further questions.

CHAIRMAN HALL: Does the Technical Panel have other questions of this witness?

(No response.)

CHAIRMAN HALL: If not, we'll move to the parties. I see Boeing Commercial Group. Anyone else? If not, we'll move to the Boeing -- Mr. Purvis, with Boeing.

MR. PURVIS: Thank you, Mr. Chairman. Mr. Stuever. It's kind of just a -- I'm not sure that I got the answer or heard the response to Mr. Jacky's question. The data that is being provided from the OV-10, I think some of the parties are anxiously awaiting that. Do you know physically when we're going to have that in hand from the testing? Do you supply it to the NTSB and maybe they supply it to us?

THE WITNESS: The original request, as I understood it, were estimates of vortex strength, which is -- 1 mean, based on the fact that there is a few of us that are running this flight test that we are very heavily involved in right now. It's going to take us quite a while to do it. I have gotten a request both from Mr. Jacky and I've also spoken with Mr. Kerrigan about just releasing the data as it is.

As far as I'm concerned, the only thing we have to do to it is correct it and basically just give it a once over. So I'm going to say -- well, I'm going to say maybe by Christmas at the latest, you can have the numerical stuff.

MR. PURVIS: Thank you very much.

THE WITNESS: That doesn't have anything -- it doesn't have any estimate of wake strength or -- I mean, we won't actually have done anything with it. It's essentially very similar to the data that I saw in the Boeing exhibit.

MR. PURVIS: Thank you. That's all I have.

CHAIRMAN HALL: USAir, General?

GENERAL ARMSTRONG: Thank you, Mr. Chairman. Can you hear me now?

CHAIRMAN HALL: Yes.

GENERAL ARMSTRONG: You indicated that you were making some substitutions of a 737-100 for the OV-10 because it was more representative of some of the things that you wanted to examine. Can you give us an idea of the relative weight comparisons of those two airplanes, approximation?

THE WITNESS: Excuse me. Did you say weight?

GENERAL ARMSTRONG: Weight, yes.

THE WITNESS: Our 37 is approximately 85,000 pounds. The OV-10 is 11,000.

GENERAL ARMSTRONG: Thank you.

CHAIRMAN HALL: Other questions from the parties?

(No response.)

CHAIRMAN HALL: If not, we'll move to Mr. Clark.

MR. CLARK: Thank you. Mr. Stuever, the -- can you describe the OV-10 compared to -- how does it compare to general aviation type airplanes, say, in the King Air class, the Citation class?

THE WITNESS: I would put it in the King Air class, with the exception that it's a high-wing aircraft.

MR. CLARK: It's a high wing and you said it weighed about 11,000 pounds?

THE WITNESS: Roughly 11,000.

MR. CLARK: Are there any special characteristics about it for its roll authority? It runs very effective, more effective than the general aviation type airplanes?

THE WITNESS: I don't know.

MR. CLARK: When you were making these tests, my understanding is you flew from behind the 727 from two to four miles.

THE WITNESS: Yes. Excuse me. Two to four?

MR. CLARK: Two to four?

THE WITNESS: Two to six or seven or eight. I mean, it kind of depended on when the wake broke up.

MR. CLARK: In those tests, were you on the airplane?

THE WITNESS: Yes.

MR. CLARK: It appeared from the video that some of the onset rates were very sudden. Is that a fair assessment from your perspective?

THE WITNESS: Yes.

MR. CLARK: But you also said that it was recoverable each and every time. Is that transferrable to an airplane like the King Air, in your estimation?

THE WITNESS: I can't answer that. I don't know. I don't know what the roll control power of the King Air is.

MR. CLARK: But do you have enough data now to see what kind of roll power it takes to rest a roll rate and possibly go back and look at a King Air to see if it has the proper roll authority?

THE WITNESS: Yes, if you knew what the weight characteristics were.

MR. CLARK: What were the maximum roll angles that you saw during your testing?

THE WITNESS: With the OV-10, the pilot report, which is another exhibit, I believe, but 60 degrees.

MR. CLARK: Okay. So the airplane was getting up to 60 degrees. Was the pilot resisting or taking corrective action immediately during those encounters?

THE WITNESS: Yes, because we were flying -- trying to fly a trajectory between -- so that we hit both cores.

MR. CLARK: So the pilot could lead with the ailerons trying to minimize the roll and even with that, still ended up at 60 degrees?

THE WITNESS: Yes.

MR. CLARK: How far behind the 727 were you when you would typically encounter 60 degrees?

THE WITNESS: I can't say at this point. I don't know. And a lot of it depends on the vortex, as well, as to what trajectory you're taking and exactly where you hit it.

MR. CLARK: But without having all of the data reduced at this time, do you have any observations on whether the encounter was more severe at two miles, four miles, six miles, or eight miles?

THE WITNESS: Just from observation -- again, the pilot reported -- I mean, this is his report based on how he was flying the maneuver and so forth. I was kind of in the back talking on the tape and watching the data on the display and so forth. But based on what he said, it was kind of imperceivable as to how severe the upset was at the various separation distances. But then he also made the comment that, again, it depends on how you hit the vortex as to how severe it was.

MR. CLARK: If you hit the vortex in a certain way at each one of those miles, then his perception was the -- he couldn't tell a significant difference or a difference between the two.

THE WITNESS: Right. You had to reduce the data to be able to identify if there are differences. That's correct.

MR. CLARK: The project that you're working on at NASA, that's with the FAA also.

THE WITNESS: That's correct.

MR. CLARK: You're working in concert with the FAA. And it has to deal with -- that project is to try to establish aircraft separation limits based on wake vortex encounters.

THE WITNESS: That's correct.

MR. CLARK: Or establish procedures to avoid the encounters altogether. Do you have any thoughts from your observations on this flight test at this time of airplane in the class of an OV-10 or a King Air about the separation requirements? Any observations that you have in that area?

THE WITNESS: Only the observation in the sense that a lot of the spacings as they're set up now, are partially -- I mean, the success that they've had with the spacings right now, we think are partially successful, because the wakes have actually left the approach corridors for one reason or another.

I mean, I don't think that there's a documented case in the United States of a hazardous wake encounter when aircraft are flying under instrument meteorological conditions and they're being spaced by the controllers at those distances.

I can't tell you right now, because part of this system relies on being able to predict where the wake is and how strong it is. And again, whether an aircraft will encounter it or not -- I mean, based on what we flew, I don't know if I would want to encounter that wake at 100 feet off the ground, the way we did.

MR. CLARK: Or, for example, if you were at night four miles behind --

THE WITNESS: Right.

MR. CLARK: -- you don't want to encounter that wake in that type of airplane?

THE WITNESS: Right, based on what we saw.

MR. CLARK: And you heard Mr. Berven's statement that he was talking about a class of airplanes of a 737 behind a 727, and he felt comfortable that that was no big deal.

THE WITNESS: Yeah.

MR. CLARK: I guess, the question -- I guess, from what I hear from you, is that it's a bigger deal to have that same encounter with a dissimilar class of airplanes, such as the OV-10 behind the 737?

THE WITNESS: Oh, yes.

MR. CLARK: You also mentioned that you're going to have future tests where you're going to be flying behind a C-130.

THE WITNESS: That's correct.

MR. CLARK: Do you have -- is there data available from the tower flybys, for example, on the C-130?

THE WITNESS: Meaning something like the Idaho Falls data?

MR. CLARK: Yes.

THE WITNESS: Not to my knowledge.

MR. CLARK: And also, do you have any observations or comments about the influence of the propellers on the C-130 and how that may effect the wake vortex development?

THE WITNESS: We've had a lot of discussion about that. And, quite frankly, in going up and having flown several missions behind that aircraft, we haven't noticed any significant -- I mean, once the wake rolls up far enough downstream, it's rolled up into the two cores and you get very nice cores far downstream with that aircraft. And we haven't -- I mean, we specifically looked for that.

Well, I guess, I should say until we look at our actual flow field measurements, we can make the assumption that the wake looks pretty good. I mean, it looks as good as we need it.

MR. CLARK: But at this point -- I guess, when you do your testing, you may be able to see if the propeller might have an effect on the decay rate and that will be factored into your modeling?

THE WITNESS: Right.

MR. CLARK: Okay. Thank you.

CHAIRMAN HALL: Mr. Marx?

MR. MARX: No questions.

CHAIRMAN HALL: Mr. Schleede?

MR. SCHLEEDE: No questions.

CHAIRMAN HALL: Mr. Laynor?

MR. LAYNOR: Just one or two, Mr. Stuever. I know that NASA has a great deal of data about vortex, vortices's strength as obtained from tower tests, both NASA and the FAA. How much data exist regarding the strength of vortices at altitudes, out of ground effect?

THE WITNESS: Not much. The things that we're measuring right now are -- well, to my knowledge, other than some tests that my old branch had did on behind the C-5 back in the early '70s, and they may have also done one behind a 747, ours are the only set that I know of that we're currently measuring.

MR. LAYNOR: Did they actually involve instrumentation to measure the strength of the vortex or was it based on the response of a certain kind of airplane?

THE WITNESS: No, they were measured with a probe.

MR. LAYNOR: Is the activity that you're engaged in right now going to include any more of those kinds of tests?

THE WITNESS: I'm sorry?

MR. LAYNOR: Is the project that you're involved with right now intend to examine vortices at altitude and the behavior in any detail?

THE WITNESS: The purpose of validating the -- well, we call it the out-of-ground effect model, which is the model at altitude. Is to provide us with a validated model that we can use as an interim model in our aircraft vortex spacing system prototype. We have a program with another group that's working on this AVOSS system. They have developed ground-based LIDARS that actually measure and track vortices in ground effect.

The idea is that by the time they get all their data that they need to develop their vortex decay models in ground effect and they have these sensors developed to such a point where they can actually deploy them in the field or around the airports, the ground effect measurements and the ground effect models will be the ones that will be used in the final AVOSS system.

The purpose of doing the out-of-ground effect model is to kind of an interim solution that we can use in our AVOSS prototypes. To my knowledge, this particular test is the only one that we're planning to do out-of-ground effect.

MR. LAYNOR: Okay. Thank you, sir.

CHAIRMAN HALL: Mr. Stuever, were you born at the time the 737 was originally certified?

(General laughter.)

CHAIRMAN HALL: I don't want to get into your age or anything, but I just was wondering.

THE WITNESS: That's a good question, because when we were thinking about making a simulator for the ov-10, I got a hold of some simulation and stability and control documents and the dates were right around the day I was born is when this airplane was designed.

CHAIRMAN HALL: Well, I'm certainly impressed with your credentials. On your program that you're undertaking for the FAA that I assume you're familiar with the recommendations the NTSB has made in the wake vortex area.

THE WITNESS: Regarding the classification --

CHAIRMAN HALL: The separation, yes.

THE WITNESS: With the 57?

CHAIRMAN HALL: Mm-hmm.

THE WITNESS: Yes.

CHAIRMAN HALL: And I guess you have all the material that Volpe had done in the '70s and '80s on the tower flyby tests and that sort of information?

THE WITNESS: Yes, my colleagues do.

CHAIRMAN HALL: While increasing airport capacity is important, how are you going to factor or will it be the FAA's responsibility to factor safety into this equation?

THE WITNESS: Well, I mean, it's kind of a joint thing. When we look at this in terms of the hazard definition and when I spoke about defining a metric, that metric is kind of something -- I mean, it has to be something that's agreed upon by the FAA, by NASA, by the airplane operators, by the manufacturers. I mean, it's really a very big effort and, in fact, it's something that we need to get started on right away in terms of how you define this, in terms of having a safe operation.

I mean, it's nothing -- 1 don't know who will have the ultimate responsibility for it. That's the best answer I can give you, but it's something that we all are going to have agree upon and define together.

CHAIRMAN HALL: And it's yet to be defined?

THE WITNESS: Yes, sir.

CHAIRMAN HALL: I guess my last question is the weather in Pittsburgh on the particular day that the USAir flight that we're discussing, I think was very clear. Winds were very calm.

THE WITNESS: That's my understanding.

CHAIRMAN HALL: How do you take a test on a day that's not similar at an altitude of 15,000 feet versus 6,000 with different weather conditions and how do you then factor that? I'm sure NASA is able to do that, but I'm interested in how do you come up with some better understanding of what the vortices might have been under those types of atmospheric or weather, whatever the right word is, conditions, so that you have a kind of apples to apples situation in looking at it?

THE WITNESS: Well, you've given us a lot of credit so far in terms of having the techniques. Part of doing this out-of-ground effect decay test that we're currently involved in, is to validate a model of wake decay out-of-ground effect knowing what the meteorological conditions are. In order to correlate -- I mean, if you wanted to have a simulation of the accident conditions -- well, first of all, it's going to be very hard to do.

I mean, it's very hard to repeat the weather. But in order to be able to verify what the conditions were in terms of the wake and its strength and so forth, you need to have either a measurement of the wake at some downstream distance and/or a measurement of the weather coupled with a validated decay model that has weather terms involved in it. And right now, we're at the point of actually flying the flight series that we hope -- well, that we plan to use as the validation for the out-of-ground effect wake model.

CHAIRMAN HALL: Now, Mr. Laynor tells me what we flew a number of these at 6,000 feet. Is that correct? And in pretty stable air? I should have asked the expert when he was up here. I apologize. Well, I just -- that's one of those things that I think the layman is interested in in just trying to understand what type of situation that particular plane encountered on that day.

Well, we really appreciate your testimony. Is there anything else that you would like to add?

THE WITNESS: No.

CHAIRMAN HALL: Okay. And we hope you will get back to work soon, just speaking as one taxpayer. But we'll send you back to furlough, then.

(General laughter.)

THE WITNESS: Thank you.

CHAIRMAN HALL: You're excused.

(Witness excused.)

CHAIRMAN HALL: Very well. The next witness is Mr. Michael Carriker. He's a Senior Engineering Project Pilot on the 737 for the Boeing Commercial Airplane Group in Seattle, Washington.

(Witness testimony continues on the next page.)

MICHAEL CARRIKER, SENIOR ENGINEERING PROJECT PILOT, 737
BOEING, SEATTLE, WASHINGTON

Whereupon,

MICHAEL CARRIKER,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows:

THE WITNESS: I was nine years old when they certified the 737.

(General laughter.)

CHAIRMAN HALL: That gives me more comfort.

(General laughter.)

MR. SCHLEEDE: Mr. Carriker, please give us your full name and business address?

THE WITNESS: Michael Carriker. I'm with the Boeing Commercial Airplane Group, Seattle, Washington, 98124.

MR. SCHLEEDE: Your position at Boeing?

THE WITNESS: I'm the Senior Engineering Project Pilot for the 737.

MR. SCHLEEDE: Would you briefly describe what your duties and responsibilities are in that position?

THE WITNESS: I'm involved in the development of airplane's systems, all the systems on the airplane. I work on new airplane projects. I work on continuing improvement of the current airplane projects. I work on accident investigations and other duties. I fly all the other Boeing aircraft on flight tests.

MR. SCHLEEDE: Give us a brief description of your education and other background?

THE WITNESS: I have a bachelor's degree in science and aeronautic engineering from Wichita State University. I had 12 years in the Navy. I flew A-7s and F-18s. I'm a graduate of the Navy Test Pilot School. I instructed there. And I've worked for the Boeing Company for five years.

I have type ratings in all current Boeing production airplanes, and I'm an instructor, a flight crew instructor on the 737 and the 777. I have about 5,000 total flight hours.

MR. SCHLEEDE: Thank you very much. Mr. Jacky.

MR. JACKY: Good afternoon, Mr. Carriker.

THE WITNESS: Mr. Jacky.

MR. JACKY: As part of your job function, how much time in part of your duty is flying?

THE WITNESS: I fly about 300 hours a year and work about 2200 or so, a seventh of it.

MR. JACKY: How much of it is devoted to the 737?

THE WITNESS: About half of that. Half of that 300 hours.

MR. JACKY: And have you flown -- been able to fly all the derivatives of the 737?

THE WITNESS: I've flown the 300, 400, and 500. I have two flights on the 737-200, and I've never flown a -100 version.

MR. JACKY: Before we get into talking about the flight test, I would like to direct your attention to Exhibit 9X-1, please. This is an article that's been excerpted from the Boeing Airliner magazine, the October-December issue of 1995. I was wondering if you might be able to give us some background as far as what precipitated this article?

THE WITNESS: I think during these -- during the accident investigation process, I was a member of the cockpit voice recorder team. I was an ex-officio member of the performance group. And I am member of the human performance group.

I can to a realization that a lot of people did not understand how and why airplanes fly and that we have events that occur in fleet service that on the offset, if you just read the data, don't see to be as critical as the write up.

For example, an airplane had a yaw damper failure -- I mean, a three degree hardover hit. An airplane rolled to 11 degrees angle bank on the flight data recorder. The crew was on the flight controls within about one second and actually stopped the original bank angle at five degrees. Then they oscillated and ended up -- when they found the solution, they ended up at 11 degrees angle bank.

The crew declared it an emergency. Thought that if they hadn't put in immediate control inputs, the airplane would have rolled on its back, and they declared it an emergency and landed.

So from the data that I read and the crew report that I got that we also read, the two did not seem to intermix very well. So we thought at the Boeing Company that we would write an article that stays out there and the crews could read, and it might help explain how and why this system works, what are the actual effects of it. It would stop -- hopefully, stop rumors, put actual information out there and get it to the crews.

So myself and Marty Ingham and Al Nader, we sat down and spun out this article and talked about aerodynamics, some human factors points, and what you might expect, to help preload crews. We also know that if you give crews good sound information and training, that they use it very well.

MR. JACKY: You mentioned rumors. Could you describe what some of the rumors that you've been hearing about?

THE WITNESS: It's just that the people are -- we had different airlines that had different events. We had crews that were doing things like turning off systems prior to landing, just in case, and things like that. We thought that that was not appropriate action, but it was what they had heard, somebody had told them.

So we thought if we got some straight information out there, maybe these things would slow down.

MR. JACKY: The incident that you're discussing, would you characterize that as being any sort of an unsafe condition?

THE WITNESS: No, it's a certified -- it's one of the failures that we look at. You go up and we -- for a yaw damper hardover. We go up with a fault injection box. We put the fault in, the rudder slams over to three degrees, at the maximum rate available. We watch it recover, and it gives the same data that crews do when that happens in flight, which is ten or 11 degrees. We look at ten or 11 degrees. We know the event is coming. You preplan for it. And you say, okay, this is a nominal event. And, therefore, we don't have to protect against it.

If the yaw damper fails in this mode, you reach up and you turn it off and then you fly away.

MR. JACKY: Is there a concern within the company that there might be some sort of inappropriate reaction to an onset like this?

THE WITNESS: I don't think it's inappropriate. The crews always take appropriate action. They always do what they're trained to do in those events. But the reports back, as they get back, seem to be of an increased magnitude in concern and more concern that we -- than it would seem like the straight numbers would indicate.

MR. JACKY: Have you heard any feedback or any feedback from airline crews on this article?

THE WITNESS: I've heard feedback from several airlines, and they appreciated the effort. They appreciated the explanation of lateral directional stability, the explanations of startle events, and a readout of what happens when this event occurs.

There's more than 5,000 copies out there now.

MR. JACKY: Has Boeing sent them to basically every 737 operator?

THE WITNESS: We sent them to everybody -- I don't know the exact circulation of the airline of our magazine. But they all got them in the copy of the magazine. And then there's also been 5,000 extra copies printed to hand out either currently or in the future.

MR. JACKY: Does Boeing have any other methods for getting information back to crews about kind of recurrency or updates or reminders about certain events?

THE WITNESS: Yes, through our Flight Training Department.

MR. JACKY: So they have a regular type of publication or something that they put out?

THE WITNESS: Yes, the FSOPs. Yes, they have mediums by which -- where they assimilate information and they get those back to the flight crew, back to all the operators, and then the operators do what they want with them.

MR. JACKY: So if there would be some sort of recurrent event or something, would someone make a decision and say, we need to remind crews about this?

THE WITNESS: Yes. And also, there's through the airplane operation's manual. We make changes to the operation's manual via bulletins, if something specifically needs to be told, and that's another process you can go through.

MR. JACKY: Okay. I would like to move on to talking about the simulator calibration flight test that was held in Seattle with the USAir 737-300. We had some testimony from Mr. Berven as far as his observations as far as the results of the tests. I was wondering if you might be able to tell us some of your reactions or impressions.

THE WITNESS: I've got to agree with Mr. Berven. I mean, we sat there and we saw the exact same data, the air speeds, all alike. We actually did a few more events than he accounted for. We did cross control events where we put a step rudder input in and then a fixed step aileron we put in and then added up those and see what the result of those things are.

On request of USAir, we did a leading edge slide extension to show that the leading edge slats come out symmetrically. So we did that. We also defined the full rudder travel at speeds below the cross-over points. We used asymmetric thrusts to add the extra yawing moment, actually rolling moment, rather, so we could use the full rudder. So we could define what full rudder was at those slower speeds.

MR. JACKY: Can you remember what those full rudder positions were at the various speeds?

THE WITNESS: No. I can look it up, but I can't remember them right off.

MR. JACKY: Okay. Could you make some sort of comparison of the events that were flown on the airplane back to the engineering simulator, the 300 simulator?

THE WITNESS: We can -- the proof of match, although, Mr. Kerrigan would be the better person to talk about the proof of match. We went out there and we tested the one airplane. We tested the one USAir airplane -- with its trims, with its aileron trims and with its engine trims. And now our simulator matches that airplane.

We might go out on a different airplane and get two or three knots different speeds based on lots and lots of different factors. So we had that in the simulator. We found out that the rudder traveled another two degrees more than what our simulator had calculated and there's reasons why that is.

So we went back in and increased the throw of the rudder hinge moment of the rudder. We went in and we did -- technically evaluated that versus the steady heading side slip to look over the cross-over point and found a difference of four or five knots. I did a qualitative evaluations on things like engine failures, right after takeoff, using the airplane to do a side slip cross control with the land, wing down, top rudder. And then we did the full rudder inputs and qualitatively, there was not any difference between the old model and the new model.

Now, there may have been a degree here or two degrees there or something, but you couldn't pick it out of the data.

MR. JACKY: But you did notice the two degree difference in the simulator?

THE WITNESS: Yes. It came out the difference at that one specific test condition about four knots difference in increase in the changeover speed.

MR. JACKY: Which would mean then that if you were decelerating from 190 knots, you would reach it at a . 4 knots higher?

THE WITNESS: In the cab, I thought it went from the region of the high 7Os, 178, 170, into a region of 183, 184 speed for the cross-over point.

MR. JACKY: When you're in a situation like that in a side slip and you do decrease below whatever the cross-over air speed is, do you regain the control once you -- and you start to accelerate, do you regain the control as soon as you reach or you go past that point, whatever the air speed that you lost that?

THE WITNESS: There's an anersia term in there and a rate term. So once you overcome that, if you're very slow and you decelerate very slowly and you only go in theory one knot below the magic number, you pick up a very small rate. You don't have to go very slightly above that. You would have to go one knot back -- actually a two knot increase to counteract that. It's fairly close in there.

If you two or three knots slow, then you have to pick up three or four knots on the other side of the number to balance it out.

MR. JACKY: You mentioned or we were talking about the two degree difference in the rudder and you mentioned, if I remember correctly, that it would be applicable in only that one air speed type condition or at one portion of the flight envelope.

THE WITNESS: Well, again, that's a better question to a person who does simulator proof of match and does the simulator calculations. Whether or not they go all back through the envelope and they change the rudder hinge moment from 340 knots down to a 100 knots, I don't know.

MR. JACKY: Okay. But what I wanted to ask you was as a pilot, is that difference -- or where in the flying envelope are you going to notice that difference? Where is it going to be applicable to you?

THE WITNESS: You never would.

MR. JACKY: How about at rudder blow down at higher speeds?

THE WITNESS: The idea of the concept here is that you're talking about going along at a high speed, you wouldn't just step on full rudder. There is no maneuver that ever asks you to do that in the normal flying envelope. So if you have an engine failure or an idea when you might use a full rudder, an engine failure right at takeoff, an ABCG at full thrust and low gross weight, you might -- when you hit that, there is probably -- there is a difference in the theoretical amount of rudder pedal you have to put in, but it's probably something like the difference between three and a half inches and three and three-quarters inches. Along the line, and you would never know that as a pilot.

MR. JACKY: I asked Mr. Berven this question. I'll ask you the same thing. When you're flying at 190 knots and one degree of flap extension, approximately how much rudder would you be using while maneuvering?

THE WITNESS: Zero.

MR. JACKY: Zero. And in flying the 300 in general, are there any forces within the flight envelope that you would be actively using rudders?

THE WITNESS: A lot of Boeing's design goals is to fly an airplane with your feet on the floor. So we have balance lateral forces with the resulting adverse yaw. You don't need to do that. So really the only time that you need to use the rudder pedal input is for steering on the takeoff roll, if you have an engine failure, or if you want to do a side slip landing and to line the fuse1 lodge with the runway.

MR. JACKY: Were you present yesterday for Anne Evans' testimony?

THE WITNESS: Yes.

MR. JACKY: Were you able to get a good look at the chart of the information that she had from the rudder --

THE WITNESS: Yes, generally. I couldn't read the specific numbers, but you could see they were bigger right at zero and plus or minus one.

MR. JACKY: Does that surprise you?

THE WITNESS: No, you see that all the time on flight data recorders.

MR. JACKY: So in your flying the 737, you've never had the -- besides in something like a steading heading side slip, you've never had to put in full rudder?

THE WITNESS: No, not in the normal flight maneuver.

MR. JACKY: Okay. As part of your training, are you given any sort of training for recovery from control system hardovers?

THE WITNESS: No.

MR. JACKY: All three axis control?

THE WITNESS: That's correct. We don't -- in the Boeing flight crew training for the 737, we don't address auto pilot failures, because they have been shown to result within the certification limits, so you don't have to specifically train for that event. And since it never had, I guess, a rudder surface hardover or a lateral control surface hardover or a pitch control surface full throw, we don't train for events that don't occur.

MR. JACKY: To what maximum control position would you train to in as far as recovery from if you had a hardover or a jam?

THE WITNESS: Now, we don't -- there's no specific training for jam. And the Boeing flight training syllabus, we go with a stabilizer jam. That's one of the maneuvers that we train to fly and teach a person in runway trims and things like that, to stop them. Use the trim to fly the airplane. But we don't -- there's no discussion of a lateral flight control system jam or a directional flight control system jam.

It's different, of course, for certification.

MR. JACKY: Now, I would like to talk about the wake vortex tests that were flown in Atlantic City.

You were the pilot in command of the 737?

THE WITNESS: Yes.

MR. JACKY: I would like for you to give us sort of your characterization of the testing and some of the things that you saw while performing the test?

THE WITNESS: One --

MR. JACKY: Well, first let me ask you, how many flights were you participating in?

THE WITNESS: Every one.

MR. JACKY: And do you remember how many?

THE WITNESS: I'm sorry?

MR. JACKY: Do you remember a number of how many flights?

THE WITNESS: Eight, I think. Eight and we drew one of them out for bad weather out of those flights.

MR. JACKY: I'm sorry. Go ahead.

THE WITNESS: I found the wakes to be very, very -- like Mr. Berven said, I found them to be fascinating, what they would do in the sky. They would trail back. They would break up. They would -- we developed a lot of different names for them; pigtails, double Us, just to try to describe what the wake did. It was very interesting from that standpoint just to sit there and watch what the wakes did.

They are not frozen ropes in the sky. They're not just this straight line in the sky. It seems like in all the manuals that I've read, they would always depict the wake vortex as an expanding thing, like a funnel shape, especially in the ground pictures that you see. You always see them expanding out and they don't expand.

They stay at this three, four, five foot diameter core all the way back until they burst. Four or five or six miles back behind the airplane, which is something unusual. They flow left, right, up and down, inside maybe a 15 foot diameter tube on a stable day.

What one wake does set to have no bearing on what the other wake does. The events, to me, were not startling, because we had only planned on doing this for six months. But the outcome of the wake encounter was an unpredictable event by -- what I mean is, you think you've got it all set up, you think you've got it and this is what's going to happen and it doesn't. You think that you're not going to have a roll and you get a bigger roll. You think you're going to have a bigger roll and you get a smaller roll off.

It is possible to quickly hit the same wake twice, because the wake is not fixed in space. You could possibly get a left roll and the fact that the wake vortex is actually on your left side at that point in time, if you cross over, it means that you roll right back into the wake.

Then again, you could have a left wake and the wake is bent to the right slightly in front of you and it gets you clear quickly. It's a bit stronger than I would have expected. I would have said before briefs that it was in the 20 to 25 degree region, and it was probably 25 to 30. So it's not any monumental amount.

When the fuse1 lodge -- as Mr. Cash presented yesterday morning, it's only when the fuse1 lodge hits the core that you get the thump noise. It's not when it hits the wing or the tail or any part else. It's when the fuse1 lodge has just been right at the core in that time period. I also remember that the core is where you get the fastest roll, the biggest roll acceleration.

As Mr. Berven said, we did take one right down the engine and it had no effect on the engine. It had an audio noise, you smelled it, but the engine operating characteristics were just right down the line.

One thing interesting that it did is it actually lifted the windshield wiper perpendicular off the wind screen and then it popped back with a rather subtle clicking noise. And we're pursuing -- I would like to see pursued to see if that event is the clickety click noise that we hear on the cockpit voice recorder. That's tough to tag, because it's only when I -- I don't think you can hear -- you won't hear it on the audio tape, unless I've said, okay, there was the click, and we have to find that and have to back it up and find that tape time. Go back, get the CDR out, find that exact same tape time. It's a huge process to get that out.

The flow direction around the fuse1 lodge was such that on occasion, we would get the angle attack, the stickshaker to fire, which means that the local flow at the side of the fuse1 lodge has changed from one to two degrees up into where the stickshaker fires, which is about 27 degrees angle of attack. I could check on that stickshaker.

At three nautical miles behind the wake, the vortex, to stay in there, the wake -- the vortex had the strength to roll the 737 at 35 degrees per second, which is about 12 times the nominal auto pilot rate. How do we know that? Because we have data where we sat in the core with full aileron displacement, zero rudder displacement, and very little bank angle change, and that condition outside the core resulted in a 35 degree per second roll rate.

As you heard Robert say, the wake vortex can be formed at five, six, seven miles behind it. Although, we never went back there. And I would agree with the decay. We did a box the wake test, where we tried to find the relative strength of the wake day per day, to say well, Tuesday was like Wednesday and Wednesday was different than Thursday. And in that test, we found out that putting a wing tip in the core at two nautical miles was almost the same as three nautical miles and three nautical miles was almost the same as four nautical miles.

So if you got put in one of those position and opened up your eyes, you wouldn't know, but you could probably tell the difference between two and four nautical miles. When it was 25 or 30 degrees a wheel at three miles, it was probably 30 to 35 degrees at two miles, and 25 degrees at four miles. There's a little bit of difference, but not very much.

MR. JACKY: I understand that you brought along a video tape also.

THE WITNESS: Yes, I did.

MR. JACKY: Do you need to set up the video?

THE WITNESS: Yes. And I think I would also have the house lights down, because there's some of the points I want to look at that are a subset of the whole video. I mean, it's a small inset picture. So we can actually see hand position.

CHAIRMAN HALL: Can we get all these lights off again? Was everybody able to see back there on the last one? Did we have enough lights out and it was contrast and everything was okay? Fine.

THE WITNESS: One thing about it, I don't have any nice picture to show of the 737, but we had seven video cameras installed on the airplane. There was one on the top of the tail looking forward down over the fuse1 lodge. There was one in the cockpit looking down into the cockpit where you can see the pilot and the copilot -- the pilot and first officer.

You can one out on the wind screen looking straight out of the cockpit. There was one on each wing tip looking straight forward and one in the fuse1 lodge looking down each wing.

Now, we're using these to position the wake vortex exactly in space. That's the only way you can record where the wake vortex was.

(Video played.)

THE WITNESS: It may appear that the 727 is climbing. That's because actually the wake is descending. The first of these two are wake stability characteristics. In the first, you can see how it moves and flows. One wake is higher than the other. And how uniform air flows affect the wake. You can see it lifting there. In the 727, it was actually level the whole time.

If you can turn the audio up -- that was when it went over part of the Delaware Bay. And whatever reason why, it just lifted up the whole wake and then it just drops right back down again.

This next one, some more of the wake stability characteristics. You can see how it flows and moves. Even in the -- and even in smooth conditions. Notice, right when the airplane goes through it, that the wake bursts and we get a plus or minus -- still get a plus or minus 20 degree roll.

You can see it just blowing up right there when we go through. The next one is a standard auto pilot turn. It's Captain Jim Gibbs from USAir in the right seat. And also, you notice at the very beginning, we have an inadvertent hit of a wake turbulence when we're just turning around and you can see how it just kind of shakes the whole cockpit. That's engaging the auto pilot there.

Then you see how much the wheel deflects. That's the auto pilot limit. The auto pilot limit is 24 degrees of wheel throw when the flaps are out of their position. And there, I was getting chastised by the flight engineers for not performing the test correctly.

The next one is an auto pilot wake encounter. It's with Les Berven of the FAA. It's coming in from the left side. The first thing you see is the outside view, and you get about a plus or minus 20 degrees of roll. This is the camera looking straight out of the airplane.

This is the same view from the inside. You can see how the auto pilot commands the wheel. You can see the wheel moves a lot quicker when the auto pilot needs to.

The next one is where the wake is descending in the three degree path, i.e., the 727 was coming out of the sky at about 1100 feet per minute and the resulting 60 degree roll happened. So we just hit the right wake, the right core, excuse me.

Now, that is hands off. It's just hitting the core and letting the airplane fly and then I recovered. Now, you see the outside picture of it. This is taken from the T-33 chase airplane. You can see how the other wing tip disturbed that wake. If you notice, that other core is actually a correcting moment.

The next one is when we did the cockpit voice recorder flight for Mr. Cash, and this is just another -- I didn't know they were going to play a video. The first hit is the -- oh, excuse me. I'm sorry. This is the fin and the core, if I'm not mistaken there.

This is myself. You'll notice that my right hand is almost vertical and you can see that it goes against the roll stop and that the airplane isn't rolling. The camera gets precluded because of the oil and the smoke. I had my feet off of the rudder pedals so that the data reduction would be easier.

The last one is a CVR flight. If you listen to it -- I really need the audio up on the very first pass here.

(Audio turned up.)

THE WITNESS: And that's that.

MR. JACKY: Were the test conditions and trying to fly through the wake, were they fairly repeatable?

THE WITNESS: Yes, within the bounds of what we tried to do. We were tasked to -- it was easy to hit the three degree wake. That's easy to set up. We were tasked to do two degree, five degree, and ten degree intercepts, and that task was not easy. We had to know the heading of the 27.

So we took some special precautions to do that. I would say our two degree task was that we probably didn't hit it any less than two, but it wasn't any more three or four and our five degree task probably went from four to six or seven. The ten degree task was easier. It was easier to take that bigger cut.

MR. JACKY: Could you tell us what type of upsets you would see in each axis?

THE WITNESS: In each axis, there is -- as Mr. Berven said, there is basically a roll upset. And it has been said before, it's a function of how you hit the wake and how you happen to hit the combination of the wake. There's also a little bit of a vertical G bobble, a plus or minus .l and .15 Gs, and very little lateral accelerations.

MR. JACKY: How about in the pitch axis?

THE WITNESS: Very little pitch attitude change. Just a pure heaving moment.

MR. JACKY: Were you able during any of the encounters to look at the yaw damper indicator in the cockpit?

THE WITNESS: Yes, and it was -- as a matter of fact, we had to turn it off. We turned the yaw damper off, because, again, to make the data reduction easier, we wanted to get the rudder motion out of the computation. So we did these events. We would cross from left to right with the yaw damper on, cross right to left with the yam damper off, so that we could make those calculations easier.

MR. JACKY: And when you left the yaw damper on, could you see that it was moving --

THE WITNESS: Yes.

MR. JACKY: -- as you went through there?

THE WITNESS: Oh, yes. That's the specific reason why we turned it off, because it was working all the time.

MR. JACKY: When you had the yaw damper off, obviously, you didn't have any sort of indication in the cockpit as far as what the rudder was doing. But could you feel any sensation that the rudder was moving?

THE WITNESS: No.

MR. JACKY: Did you feel that when you -- during the encounters that you had with the auto pilot on, that the auto pilot was able to correct for any upset that you found?

THE WITNESS: Yes. The auto pilot would react and it would -- even as fast as the auto pilot rate is, which is some place around 50 degrees per second, it was still slightly behind. It would dampen out the motions. As the first motion would come in, it would put in an opposing motion and then it would have to take it right back out as it crossed the other wake. It was actually a probe rolling moment at that point in time until it takes it back out.

MR. JACKY: But it was reacting to each --

THE WITNESS: Yes.

MR. JACKY: -- individual wake?

THE WITNESS: Yes, to each wake, each individual wake.

MR. JACKY: As you went through the wake, did you notice any sort of large heading change or yaw?

THE WITNESS: No. We specifically were looking for that. We only had one or two or maybe three instances where we had a lateral acceleration and/or a heading change that you could actually feel.

You had a little bit of a rolling moment that was just a little bit -- was little bit of lateral G, but there wasn't any unknown lateral acceleration in there that we hadn't seen before.

MR. JACKY: Do you feel that there were any sort of geometries or encounters through the wake that would give you a large heading change?

THE WITNESS: A large heading change?

MR. JACKY: Yeah, that you didn't fly?

THE WITNESS: No.

MR. JACKY: No. During the encounters, could you give us an assessment about -- if you weren't trying to stay in the vortices or keep the wing tip in the vortices or keep the tail in, approximately how long do you feel like you were in the effect of the vortices?

THE WITNESS: Well, on the two degree crossing rate, I'd say two seconds on the nominal one.

We also hit one where we only had one wake core, but because of the way the wake was oscillating in front of us, we also stayed in one wake core for two seconds plus.

MR. JACKY: Okay. And could you think of any way that you would -- if you weren't purposely trying to fly through the cores or in the wake effect, that you would keep in the wake effect?

THE WITNESS: No. There is a possibility that one, you could come into a core and like I stated a little bit before, it could roll you up and roll you to the left. And the fact that the wake is actually coming from there -- it's bending in and coming in your left side, you could roll back into that. But that's about it.

You could get tossed into the other wake, but the other wake is a correcting moment. So you may bounce around in there a couple of times and get three seconds, four seconds, but you would have to set the wake structure up to do that. Now, we didn't have any of those. Didn't inadvertently hit that ever.

MR. JACKY: And at any time during any of the encounters, did you feel like you were losing control or about to lose control of the airplane?

THE WITNESS: No.

MR. JACKY: Did you have any encounters that would have startled you or surprised you?

THE WITNESS: Not for the fact that myself was in there. Like I said, we had been planning on doing this now for months. Had all the time preparation and practicing in the simulator, saw the smoke, entered the wake, along that line. And the resulting 20 degrees angle of bank was within a couple of percent, 10 percent of the predicted value.

So, no, it wasn't. I mean, the very first time you hit the wake, you didn't quite know. But after that, it went down.

MR. JACKY: Would you characterize any of the encounters that you had as being disorienting to you?

THE WITNESS: No, they're not disorientated. Sometimes you're behind on the flight controls. You don't quite know what to do with the flight controls. If the task was to maintain wings level throughout the event, then you're a little bit behind, because the rolling moment influenced on the airplane changes so fast, that you can't keep up with it. So you're kind of -- I'll just keep what I got here. The engineers can worry about it later.

MR. JACKY: If you weren't able to see the vortices as marked by the smoke, do you think any of the encounters would have been disorienting?

THE WITNESS: I don't know about disorientating, but I know that they would be -- in reports that I've received, especially through things like the Aviation Safety Reporting System, where they have a third of all uncontrolled airplane events are attributed to wake turbulence, I would see how it is possible to conceive that a crew when they hit one of these events and they put in full control motion and nothing happens at that point in time, because they are in a wake core, that they may have a momentary point where they're going, well, I put in full left wheel and the airplane didn't instantaneously react to that event and then it does a second later or two seconds later as you come out of the wake vortex.

MR. JACKY: So would that mean that they might overreact to the encounter?

THE WITNESS: I don't know. I think that's a -- tasking my human performance group knowledge and I don't know really how to answer that question. I've only begun to start to approximate these things and calibrate myself into crews that have had 6,000, 7,000 hours of routine flying and they hit these event in the dark of the night at the end of their fourth day flight -- fourth flight of the day.

Something along that line. And that's what we're using these other reports and these feedback reports, so that you can -- just like we calibrate a strain gage. If you're in flight test and you have an event that rolls to 20 degrees, well, data shows that it is possible that airline crews are going to report that event as 40 degrees in that kind of excitement. Then they have to add that into your knowledge of is this acceptable, is this not acceptable, does this take exceptional pilot skill, and things like that.

MR. JACKY: Do you have a definition for exceptional pilot skill?

THE WITNESS: I have some in electronics. I have developed some very much ones for flight management computer operations. But exceptional pilot skills, what I do is I've taken the people that I've trained in the 737 and seen what their skills are. I fly with line crews once a year to try to get an idea of what they are. I read the SRS reports and things like that to try to build up a database of what is acceptable.

Like I said, we certify the yaw damper -- I didn't certify. The yaw damper hardover is certified as an event that is satisfactory, except where we've had two of them and the crew has declared emergencies and landed. So that kind of skews your calibration of what's acceptable and what's not acceptable.

MR. JACKY: Was the wake encounters that you had in the flight tests, were they comparable to what the simulations were in the M-CAB?

THE WITNESS: Yes, they are. With the limitation of the M-CAB, as a bounding to it, they are very good. I think that the M-CAB motion is a bit more abrupt than the nominal wake encounter that we have. And in comparison to that, I thought that the VMS simulator that we did in NASA-Ames a was a bit -- just a bit on the milder side. And we fed it the same set of data.

It's kind of a basis on a nominal event. The accelerations are a little bit smoother in the VMS than they were in the airplane. In our M-CAB they're more abrupt.

MR. JACKY: What would account for the difference between the VMS and the M-CAB simulator?

THE WITNESS: In the M-CAB, we try to drive -

- since we want to get these higher rates, we have very little throw. We drive the rates very quickly at the very beginning to try to get it up, because you only have two feet to go. So you use it up fairly quickly.

Although, I've said that difference, that's a qualitative opinion. I've been asked that a lot. Are these good? And they are both good representations of the wake vortex.

MR. JACKY: I have no other questions.

CHAIRMAN HALL: Does the Technical Panel have other questions?

(No response.)

CHAIRMAN HALL: No. Questions from the parties? I see the hand of Boeing Airline Group, Airline Pilots Association. Anyone else? Very well. The Airline Pilots Association, Captain.

CAPTAIN LeGROW: Thank you, Mr. Chairman. Good afternoon, Mr. Carriker.

THE WITNESS: Good afternoon.

CAPTAIN LeGROW: Just a couple of questions. First of all, the Exhibit 9X-India, this is from the Boeing Airliner. Is that the name of the publication?

THE WITNESS: That's correct.

CAPTAIN LeGROW: There was some conversations and questions in how this is distributed. Is this document distributed to flight crews for the various airlines or just to the managements of the flight crews, of the airlines?

THE WITNESS: I don't know that answer. I think that probably is dependent upon the airline.

CAPTAIN LeGROW: But Boeing -- I guess my question is does Boeing have a way to distribute it to the line pilots throughout the country?

THE WITNESS: I don't know that.

CHAIRMAN HALL: Mr. Purvis?

MR. PURVIS: I know a little bit about that, in that it is sent to the airline, not to the pilots. And the distribution is about 40,000 copies.

CHAIRMAN HALL: I assume you have no objection if it's copied.

MR. PURVIS: No, in the front, it has the right to do that, just so long as it's attributed.

CHAIRMAN HALL: Very well.

THE WITNESS: We don't even know that -- we can send an operation's manual change and it only goes to the airline. It doesn't necessarily even go to the pilots.

CAPTAIN LeGROW: Thank you. You told us that you've been with Boeing for five years. Is that correct?

THE WITNESS: Yes. Six years come next month.

CAPTAIN LeGROW: Six years. Of your 5,000 hours total flying time, how much of that would be in the 737?

THE WITNESS: I have 1400 hours in the 737.

CAPTAIN LeGROW: Fourteen hundred hours. Have you throughout your career ever flown for a scheduled airline operation with carrying passengers?

THE WITNESS: No. Oh, carrying passengers or a scheduled airline?

CAPTAIN LeGROW: A scheduled airline carrying passengers?

THE WITNESS: No, I have not.

CAPTAIN LeGROW: You talked about early in your testimony about rudder hardovers. And I believe you made the statement, correct me if I'm wrong, that there had never been a rudder hardover, full rudder hardover in the 737?

THE WITNESS: That's correct.

CAPTAIN LeGROW: You talked about exceptional piloting skills or pilot skills. Could you define more specifically exceptional pilot skills? Is that correct? Is that the term you used?

THE WITNESS: I think that was Mr. Jacky's term. And then when he asked me that question, I said that -- I can't remember what I said. I could ask the court reporter.

CAPTAIN LeGROW: Well, what is your definition of the --

THE WITNESS: It's -- my exceptional piloting skills. I know the people who operate the 737, and I know that they don't always include U.S. flag carriers. So in our exceptional pilots skills, you go to -- for the Boeing Company, you go to what I would think is not the lowest common denominator, but down there some place. Because I know that we have -- there are a lot of ab initio crews that come in, and it's the first airplane they've ever flown, is the 737.

So that's the basis that I take in that event to try to predict, because that's one of my jobs. Is to have a failure in the simulator and ascertain whether or not it is acceptable or unacceptable and then to promote that data. It's not my opinion personally. It is the Boeing pilot's opinion, and then we present out opinion to the FAA, and either concur or they don't concur.

CAPTAIN LeGROW: I'm a little unclear on who the Boeing pilots are.

THE WITNESS: There's the Boeing engineering pilots, the Boeing production pilots, and the Boeing flight crew training pilots. They'll all be used to evaluate scenarios.

CAPTAIN LeGROW: You are an instructor for Boeing; is that correct?

THE WITNESS: Yes. I am also an engineering pilot.

CAPTAIN LeGROW: Would you say, in your opinion, the average U.S. flag carrier pilot, would he be considered an exceptional pilot, having exceptional pilot skills?

THE WITNESS: No.

CAPTAIN LeGROW: He would be below?

THE WITNESS: No. He has average pilot skills.

CAPTAIN LeGROW: But he would not have exceptional pilot skills?

THE WITNESS: Some of them would.

CAPTAIN LeGROW: And that's determined by the pilots at Boeing.

(General laughter.)

CAPTAIN LeGROW: I have no further questions.

THE WITNESS: I would like to respond to that. That's an FAA definition. And we have to operate by the FAA definition. If we go in and there's something that happens in the airplane, in the cab or the simulator that we simulate, and it takes a skill level that is not thought to be there and that is based upon training. We know the FAA syllabus for training. We know the Boeing recommended flight crew training syllabus.

In those type of events and the skills and then we look at it. Then you make a valued judgment based on people's opinions, not just mine, but possibly 20 other pilots. And they say, is this acceptable, is this not acceptable. And then that determination is made.

Then usually these things are done hand in hand with the FAA. When we go to do pilot tasking skills, we have a rapporteur of about 50 pilots that we bring in, and they are not Boeing engineering pilots. As a matter of fact, the FAA will not allow Boeing engineering pilots to do some of these big assessments.

We have pilots come up from our production flight crew and we bring pilots in from the outside to ascertain the answers to these questions when they get down to the tough questions. Sometimes, it's basically obvious that you cannot -- that it's unacceptable.

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

CHAIRMAN HALL: Thank you, Captain. Other questions from the parties? Mr. -- I'm sorry. Mr. Purvis, of course, Boeing Commercial Airplane Group.

MR. PURVIS: Thank you, Mr. Chairman. Mr. Carriker. Back to your experience, are you, in fact doing initial operating experience with Cathay?

THE WITNESS: Yes, for a month, I'm going to be one of the four instructors for Cathay Pacific's initial operating experience on the 777 flying out of Hong Kong, Sidney, Bancock, Manilla.

MR. PURVIS: You indicated earlier that you were an instructor for Boeing 37 and 77 airplanes. Are you also instructing on the line for the 77?

THE WITNESS: Instructing on the line for the 777.

MR. PURVIS: For the 777.

THE WITNESS: Yes.

MR. PURVIS: Onto the Atlantic City tests and those that preceded it in Seattle, you indicated eight flights. Does that include the Seattle, do you remember?

THE WITNESS: No, I believe we had eight flights in the Atlantic City area.

MR. PURVIS: In all of those flights, were you the pilot in command?

THE WITNESS: Yes.

MR. PURVIS: Regarding some of the things that we saw in the video, first of all, does -- how far back does that wake persist?

THE WITNESS: We only went b&c-- it persist -- the farthest back point that we were was four nautical miles, and it was still formed at four nautical miles.

MR. PURVIS: So it would be beyond four nautical miles?

THE WITNESS: Yes. Robert stated that it was back to six, seven, and eight nautical.

MR. PURVIS: On the video, you showed first an auto pilot engaged roll up 20 to 30 degrees. And then later, one not on auto pilot rolling beyond 60 degrees. Those are numbers -- especially the 60 is -- higher than Mr. Berven testified to. Was Mr. Berven present on those flights?

THE WITNESS: No, he was not.

MR. PURVIS: There is -- what sort of wheel input does it take to maintain wings level on wake encounters?

THE WITNESS: I guess, you have to define wake encounter.

MR. PURVIS: Well, a wake turbulence. What force of full -- of wheel, is it full wheel to maintain wings level?

THE WITNESS: I guess, again, you have to define what the task is here. If you're talking about staying in the core, that's full authority. If you cross it at 90 degrees, you don't need any wheel input.

MR. PURVIS: At say three nautical miles and you encounter it.

THE WITNESS: If it's on a three degree descent and you want to encounter it, you would probably end up with almost full wheel. At least at a point, about 60 or 70 percent of the wheel.

MR. PURVIS: I should have clarified. To keep the tail in the wake.

THE WITNESS: Oh, to keep the tail in the wake, it's full wheel -- sorry -- at three nautical miles. It was interesting to note that it was equal and opposite to the rolling moment -- available rolling moment of the 37.

MR. PURVIS: You indicated that when you heard the thump, that it meant the fuse1 lodge was in the center of the wake. Is that correct?

THE WITNESS: Yes.

MR. PURVIS: At that point, can you talk about the roll accelerations that you experienced?

THE WITNESS: The standard wake vortex theories says that that's the largest moment, because the velocity at the center of the core is zero, and it increases linearly out to the maximum value, which is about two to three feet. And then it decays at one over R square squared. So if you put the center of gravity right down the middle of the core, you're going to get the biggest rolling moment available, because your other wing tip is just barely in the correcting moment of the other wake.

MR. PURVIS: And that's when we've heard the thump?

THE WITNESS: Yes.

MR. PURVIS: Are those roll accelerations beyond the auto pilot rate that most pilots are accustomed to?

THE WITNESS: Well, yeah. Yes, because the normal auto pilot roll rate is -- although, in the old airplanes it's four degrees per second and in the new airplanes it's a function of bank angle ramping up to four degrees per second. If you have a 25 degree bank angle selected and the maximum roll rate is three degrees a second for the auto pilot and this roll ace1 is -- or this roll -- steady state roll rate is not exactly a direct comparison, is 35 degrees per second.

MR. PURVIS: On the wake tests that you did, how many wakes do you estimate that you personally flew through during the tests?

THE WITNESS: About zoo.

MR. PURVIS: On most of these encounters, did you have a chance to anticipate and prepare for the wake encounter?

THE WITNESS: Yes. As a matter of fact, we had very specific tasking, to hit an exact spot in the wake.

MR. PURVIS: So when you were doing these encounters, could you see the wake before you hit it?

THE WITNESS: Yes, otherwise, we couldn't do the test.

MR. PURVIS: Could you always correctly anticipate what it was going to do to you when you finally hit it?

THE WITNESS: No, not with -- you could come within about 15 or 20 percent. If you thought it was going to roll 20 to 25 degrees, it may have rolled only 15. And if you thought it was going to roll 15 or 20, it may have rolled 30.

MR. PURVIS: On other parts of the test when you were maneuvering, were there occasions when the smoke generator was turned off and that you actually encountered the 27 wake?

THE WITNESS: Yes, because we're always in the four nautical -- we're trying to stay four nautical miles behind the -- three to four nautical miles behind the 27.

MR. PURVIS: So were you or any of the other crew members surprised when you encountered these wakes?

THE WITNESS: Yes, because you couldn't see them coming. So there was elements. You were surprised and all of a sudden you were shaking. As it showed in the video there, all of a sudden you just bounced.

MR. PURVIS: That was the one we saw in the video.

THE WITNESS: Yes.

MR. PURVIS: Did you find that your wake encounters had the potential to be confusing?

THE WITNESS: Not to me.

MR. PURVIS: To other pilots, possibly?

THE WITNESS: I think so, because in pilot reports, like I said, one-third of all uncontrolled airplane actions are related to wake turbulence events.

MR. PURVIS: How would you expect that that confusion would occur? What would cause it?

THE WITNESS: An initial rapid roll acceleration that cues the pilot that in a few seconds things could be not very good, and as you hit the other side, it corrects it. So by the time you think that -- this is spatulation. This is what the performance, human performance group is looking into, is how crews react to these kind of events.

MR. PURVIS: Would any of the noises that had occurred be an issue?

THE WITNESS: Any sort of noise that you hear during an event is another input into what the pilot has to think about what's going on. So it's another sensory input that you have to think about.

MR. PURVIS: You indicated earlier that you had been involved with three groups; the human performance group, the performance group itself, and the CDR group. Is that correct?

THE WITNESS: That's correct.

MR. PURVIS: During that investigation, have you interviewed the crews and studied events involving some of these unexpected upsets?

THE WITNESS: Yes. All the ones that come into the company that we have and they come into the performance, human performance group, we would look at and try to match up crew comments with the terms off the flight data recorder.

MR. PURVIS: In your work doing this, have you found crews can get startled or do get startled by wake turbulence or other unexpected events?

THE WITNESS: Yes.

MR. PURVIS: Is there a chance that they might misperceive or over perceive the extent of the upset?

THE WITNESS: I suppose in the way you word it, there is a chance that could happen, but it would vary per airplane crew and per event and per phase of flight. I think if you're flying along at 35,000 feet and everything's been fine for the past 16 hours, you may have a bigger event than if you're on takeoff and you know that there's a 747 departed three miles in front of you.

MR. PURVIS: Do they ever feel threatened by this encounter or surprised?

THE WITNESS: We have quotes from pilots that said that it was going to roll on its back and with the exact same roll acceleration terms.

MR. PURVIS: Going on to the updated simulator at Boeing. Have you flown the updated one now that we've put in the corrections?

THE WITNESS: Yes.

MR. PURVIS: How many occasions?

THE WITNESS: Twice.

MR. PURVIS: And it's been when the aircraft is simulated for flight at flaps one and 190 knots?

THE WITNESS: You could ask the simulator match people, but that's where the point that we specifically evaluated the airplane for and we specifically updated the simulator for.

MR. PURVIS: And have you then put in a full rudder input in the simulator at that point?

THE WITNESS: Yes.

MR. PURVIS: At that point, is the 737 controllable after the input is made?

THE WITNESS: Again, you have to remember -- if you remember what Mr. Berven said about the time constraints, what the time is. If you ascertain how much roll control input the crew uses and how fast he puts it in and what he does with the angle of attack, what he does with his foreign aft column, you can get variations on an answer. But if you just come along at 190 knots and you step on full rudder pedal, you wait two solid seconds and then apply full wheel -- not 60 percent, not 70 percent, but full wheel. Then the resulting roll angle is in the mid 20s before you recover. And if you don't have the task of keeping exactly 190 knots and exactly the tasked altitude, you vary off altitude by several hundred feet and you would probably pick up seven or eight knots.

MR. PURVIS: Is it recoverable at that point?

THE WITNESS: Yes, because it was not -- yes.

MR. PURVIS: Out of control?

THE WITNESS: Yes.

MR. PURVIS: Can you define again controllable and recoverable?

THE WITNESS: Do I have to?

(General laughter.)

THE WITNESS: A controllable airplane, I define it -- I define an uncontrollable airplane, in my terms, as an airplane that impacts the ground. I define an airplane that you can recover as one that's controllable. I guess, an example is if you have an engine failure after takeoff. If you don't do something about that, you will have a crash.

So is it controllable? Yes. Is it recoverable? Yes. Is it uncontrollable? Well, it is if I don't do something about it. So the FAA has come -- as Mr. Berven explained, in the spins. You have to put a boundary upon the exceedence, and that comes from the one that we use, the one that I've been using. It's from the auto pilot section, where you're allowed to have 60 degrees angle of bank. If you exceed 60 degrees angle of bank at any point during the maneuver, then you have to prohibit that maneuver. You cannot allow that occurrence to happen.

The prime example on the 737 is the auto pilot system. You have to have both auto pilots up and running with their full monitoring system, because if one auto pilot goes down -- and it's not just the auto pilot. It could be the symbol generator in an EFIS airplane. It could be an anersia navigation unit. You have to turn the other auto pilot off, because with the four second criteria, the airplane rolls with a roll auto pilot hardover to about 50 degrees. But in the recovery, you exceed -- in the one test that they did, they exceeded 60 degrees angle bank.

So, therefore, from now on in the 737, you have to turn the auto pilot off when you don't have a monitoring device on top of it.

MR. PURVIS: No more questions. Thank you.

CHAIRMAN HALL: Questions -- well, that's encouraging. Mr. Wurzel with the IAM.

MR. WURZEL: I have one question, Mr. Carriker. Good afternoon.

THE WITNESS: Good afternoon.

MR. WURZEL: If you say that most airline pilots have only average pilot skills, not exceptional, do you think that the 737 aircraft is so critical that it has to be flown by only average pilots or by above-average pilots?

THE WITNESS: Well, I dug myself a hole,

didn't I? You have to take -- what you do is your take the normal pilot out there and you assign his skill level, which is far and above the average skill level of the worldwide fleet, and you assign that value of normal. That's it. And that's normal. There are some better pilots out there. There are some not better pilots out there. So that's the task we have.

The average U.S. pilot, the average U.S. carrier pilot trained through the FAA system has above-average skills compared to I would think probably the worldwide fleet of airplanes. And that is based on -- because a lot of people are flying this airplane. Like I said, this ab initio airplanes. It's the first airplane they've ever flown.

So you can't have 5,000 hours of experience in flying the airplane the same day you stepped into it for the first time. So the average U.S. airline pilot has average skill.

CHAIRMAN HALL: Other questions? Captain.

CAPTAIN LeGROW: Thank you, Mr. Chairman. I have just one follow-up question. You said that in your duties as an accident investigator in this accident, you served on three groups. Is that correct?

THE WITNESS: Two groups and in the

performance group, I provided simulating and piloting.

CAPTAIN LeGROW: You said that you had interviewed some pilots that had been involved in events in the 737 during the course of this investigation?

THE WITNESS: I did one phone interview. I did one by correspondence interview. And I read the flight data recorders, and I read the crew reports.

CAPTAIN LeGROW: And this was in connection with your duties in this accident as a -- on which group would that be? Would that be the human performance group?

THE WITNESS: Yes.

CAPTAIN LeGROW: And your assessment of the pilots that you interviewed, was that the consensus of the entire group?

THE WITNESS: I don't think -- the question was not posed to me as the consensus of the group. I thought the question was posed to me as to my judgment.

CAPTAIN LeGROW: And my question is was that the consensus of the entire group or your judgment only?

THE WITNESS: The consensus if the group will be published in the group's final report.

CAPTAIN LeGROW: Thank you. I have no further questions, Mr. Chairman.

CHAIRMAN HALL: Very well. Mr. Clark.

MR. CLARK: We've talked earlier about the changeover point, where we changed from dominate wheel authority to the dominate pedal authority. And at one point, I thought that was 190 knots and then I heard you talk about a changeover point that raised from 179 to 183, and I wasn't tracking that. Can you help me out with those?

THE WITNESS: Yes. I got in the cab and I did it and I thought the value was in the low 180s. It would be afterwards. In the airplane that we flew, it was 190 knots to one side and it was in the high 170s to the other side. Now, I can't explain that one.

I know that Mr. Kerrigan just didn't like me mentioning that. You take another airplane out there the next day with a different center of gravity with ailerons that are rigged slightly different, so you have more effective ailerons, and you take an airplane out there where you match the end ones, but one of them has a brand new engine on one side and one's got a 10,000 hour core on the other side, and then you have 300 pounds of asymmetrical thrust with equivalent end ones, you're going to get slightly different speeds, but they're going to be in the range of three, four, five knots.

MR. CLARK: Well, Mr. Kerrigan has either probably a half hour or until tomorrow morning to bone up on that one. You also talked about an area that in the recovery process, it wasn't clear to me that if you got one knot below the changeover point, you would start an excursion. And then you said you had to go at one knot above to recover or if you got five knots below, you had to go five knots above. Could you elaborate on that?

THE WITNESS: Well, there's an anersia term in there and a weight term that you have to overcome. So the static point -- it's the difference between statics and dynamics. If you have a dynamic situation, you have to stop a rate, you need a bigger force to stop a rate than you do to just stay put. So that's the part and that's one of the hardest thing for the simulator to calculate, are all those anersia terms.

MR. CLARK: Then in that, if you were, for example, one knot low but your reaction was somewhat delayed, you may have to go to a greater speed than one knot above to recover?

THE WITNESS: I think in a general term, yes, because if you allowed that rate to develop -- although, you might just go to a steady rate. I've never even thought about that. If you go one knot slow, you probably just go to a steady state rate. It wouldn't be an increasing rate.

MR. CLARK: In the data that was recovered for the simulator calibration, are you satisfied with those tests? Are there any more tests that need to be done in that area?

THE WITNESS: I would like to see -- personally, I would like to take another airplane out there and do the exact same test to verify that you do get the exact same speeds, along that line. I would also like to do it on a 737-500 and a 737-400 to get an idea of what the tail moment -- the different tail moment is. Because I've done them in a 737-500 and the speed is in the mid 170s, because of, I think, the different tail arm length.

MR. CLARK: The tail arm is the length of the --

THE WITNESS: The difference between the center of gravity and the center of pressure on the vertical tail.

MR. CLARK: Now, we've been talking a lot about 190 knots. I think you stated that in a normal course of operation, you would never have a need to use full rudder in that situation. If you have an engine failure, typically how much pedal would you need or how much rudder would you need?

THE WITNESS: At 190 knots?

MR. CLARK: Yes.

THE WITNESS: I would say about a quarter; although, that's a pretty good -- I mean, that's an estimate. I've never been in that configuration to do it. All I know is if it passed through there -- of course, it depends on what the -- the thing is, at a 190 knots, you don't have a full takeoff power on the engine normally. So they have to take that moment out.

So if you're coming down there flying 190 knots, your level of flight is about a quarter of a rudder pedal. But if you're on takeoff and you get full thrust on that engine, it's some other different value, somewhat greater, but --

MR. CLARK: That's 190 knots and it's well above any type of VMC speed?

THE WITNESS: Oh, yes. VMC is -- you could ask Mr. Berven, he probably knows VMC better than I do.

MR. CLARK: So basically we're looking at probably a small pedal in the normal course of operation at these speeds?

THE WITNESS: Yes.

MR. CLARK: Would you -- you said something about a two foot throw on the end cap simulator and was comparing that to the VMS simulator. Could you describe a little bit about -- a little bit more about the VMS simulator? What does this two foot throw mean?

THE WITNESS: The vertical motion simulator is -- our large motion simulator is located at NASA-Ames. There's some rough numbers. I don't know the exact travel, but it can move approximately up and down, plus or minus 35, 30 feet and left and right 30 feet on a center box. It's a huge apparatus. so you can sustain a lot -- you can sustain higher accelerations for a longer period of time, because you have the displacement to move.

Our multi-purpose cab is a standard six degree of freedom cab simulation, with about plus or minus 30 degrees in roll and pitch and about 30 degrees in yaw. Plus only two feet of travel in heave and lateral and longitudinal acceleration. So you get what you get in two feet. No matter how hard you drive it, you still have to stop after two feet. Whereas, the vertical motion simulator can drive for 70 feet. You can sustain that a lot longer.

MR. CLARK: In other words if simulators have -- you gain some feet back from the accelerations --

THE WITNESS: That's correct.

MR. CLARK: -- but not for long in any direction?

THE WITNESS: Not for long. Even in the world's best one there is -- in Boeing time, we can match the flight data recorder up to Boeing time about 135, 136. And if we drive it really hard, we can match it almost to 137. The vertical motion simulator with all its ability match it up to about 139.

MR. CLARK: These times are the --

THE WITNESS: These are Boeing accident times in seconds.

MR. CLARK: Related to the Pittsburgh accident?

THE WITNESS: To the Pittsburgh accident.

MR. CLARK: Both, I believe you and Mr. Berven said that normally in this 190 knot range, you operate without rudder input, commanded rudder input from the pilot. Typically, is it likely that somebody would get on the rudder pedals in a wake vortex encounter -- when you were doing your encounters, would it be likely that somebody would get on the rudder pedals in that situation?

THE WITNESS: I don't know about likely. It is a -- I've seen data where they do and I've seen data where they don't. So is it likely? I don't know. We don't know why. There's a wake turbulence event of the 737 landing behind the 757 at Denver and the crew uses half available rudder. And there are other wake turbulence events where they don't touch the rudder, so.

MR. CLARK: Is there anything that you felt in the wake vortex encounters that would prompt a full rudder input in your estimation?

THE WITNESS: No.

MR. CLARK: Anything in the -- you were in the VMS simulator, the M-CAB simulation that went through the motions of Pittsburgh. Are there any visual cues or motion cues recognizing the limitation and the motions that you feel would prompt somebody to put in full rudder?

THE WITNESS: Not in the classic sense. In the classic sense, the only time you use the rudder pedal is when you have a definitive yawing moment, i.e., an engine failure or something like that. Or you have a very -- you have a high rolling moment is the other case that we find out that pilots use rudders.

So from the classic sense of using the directional controls to control the direction of the airplane, no.

MR. CLARK: But even in the sense of the rolling direction, the cue would be to put in right rudder, for example?

THE WITNESS: That is a question that I hope the human performance group gathers data upon and can provide the data for the NTSB to come up with the analysis.

MR. CLARK: In one of your comments, you were talking about sticking the tail into the vortex core at about 190 knots. I believe you said it took full wheel and opposite rudder. I think you said it --

THE WITNESS: Zero rudder.

MR. CLARK: Did you just say "rudder?"

THE WITNESS: Yes.

MR. CLARK: Okay. I understood that when you were in the -- trying to hold in the core, I thought you made a comment about equal and opposite for the tail in the wake.

THE WITNESS: No. Oh, yes. Equal and opposite for the rolling moment to correct, to keep the wings level, but I didn't use rudder.

MR. CLARK: Just the wheel.

THE WITNESS: Just the wheel.

MR. CLARK: Oh, okay.

THE WITNESS: Initially, every now and then, I started to use the rudder, but then you would translate left or right out of the full effect of the core and then I would be left with either putting -- I had already taken out some wheels and have a little bit of rudder in. So that you're left with the problem of either taking the rudder out and putting the wheel back in or leaving the rudder there and just playing with the wheel.

So finally, to keep the engineers happy, I put my feet on the floor and just tried it with wheel off. If I couldn't hold it, I couldn't hold it. If I could, I could.

MR. CLARK: I'm sure Mr. Jacky and Mr. Kerrigan will appreciate that very much.

THE WITNESS: Yeah.

MR. CLARK: I have no further questions.

CHAIRMAN HALL: Mr. Marx.

MR. MARX: Yes. I may have missed this in the video tape, but the encounter in which there was a 60 degree roll, what altitude was that at?

THE WITNESS: Six thousand feet.

MR. MARX: Six thousand feet. What was the configuration of auto pilot? Was that on or off?

THE WITNESS: No, that is a hands-off event. It's just putting the airplane -- making sure the airplane hits square in the middle of the wake hands off and let it roll.

MR. MARX: Could you account for why there was a difference between a maximum of 60 degrees and your event, one event compared to Mr. Berven's 30 degrees max?

THE WITNESS: I think that -- well, Mr. Berven didn't fly under these conditions for one thing. He wasn't on board the airplane the day we flew in those conditions, at least at the two nautical mile point. So he wasn't there.

The 30 degree bank, it's not much of a -- I don't think it's as technical as it sounds. If you can find a way to hit the wake vortex and situate yourself such that you stay in it longer and then the rolling moment has a bigger effect. So when the vortex is in this three degree descent, instead of crossing it through and getting some of the vertical, you actually just get almost pure rolling moment out of it. And it's tilted slightly. So you cross it at a little different angle, a little broader angle.

Also, if you look in the tape, another time we had the vortex was coming down and then it kind of leveled out and then went down again. And if you just hit it at this part where it's level, now what you've really done is hit the original part of a wake -- of an instantaneous start of the wake vortex.

So it's just a function of an event that you can have that allows you to stay in the core longer.

MR. MARX: Has there been any consideration made to the density of the air and how strong the vortex would be if it is at different altitude?

THE WITNESS: That's out of my expertise.

MR. MARX: Thank you.

CHAIRMAN HALL: Mr. Schleede?

MR. SCHLEEDE: No questions.

CHAIRMAN HALL: Mr. Laynor?

MR. LAYNOR: No questions.

CHAIRMAN HALL: Well, let's see. Do I have any questions? Mr. Carriker, I guess I do have a question about this article. I guess this was written in the interest of providing 737 line pilots information on the 737 directional control system. I guess there may be some -- well, some conversation in the community of the people that fly that, because of the tension on these two accidents. Is this information, you think, every 737 line pilot would find beneficial and should have?

THE WITNESS: I'd like to think so. I put a lot of effort into writing the article and researching and making sure that the numbers and the perceptions are correct and got approved by aerodynamics people and mechanical systems people and human factors people to get that information out there.

I guess another reason I should have stated that we gave an airline a brief about yaw dampers and what happens when they fire. The first time they had one of these events, it was a fairly big happening. And after the crew had the brief and another one happened, it was if the yaw damper failed, turn it off, continue on to the next point.

CHAIRMAN HALL: General, does USAir get this magazine and would this be something you would distribute to your line pilots on the 737? How many pilots do you have that fly that, do you know offhand? I know in Pittsburgh we mentioned that number, but I can't remember what it was.

GENERAL ARMSTRONG: Yes, sir. We did receive the article. We did, in fact, reproduce the article and distribute it to all 2700 people.

CHAIRMAN HALL: Well, good. The Airline Pilots Association would have to make their own decision, but if you look at it and think it's something that's appropriate, I would encourage you to get it out. And internationally, this American passengers fly this plane worldwide. I assume that this information goes out internationally, as well.

Well, I applaud your efforts in putting this together. On page 6 of this exhibit, which is page 29 of the article, you get into -- you say apparent uncommanded yaw or roll not caused by yaw damper malfunction. And then you list some non-normal events; wake turbulence, adverse weather, flight control malfunctions, split throttles, engine power loss, auto pilot malfunctions. Any other malfunctions of the rudder are not here. Is that because there would not be any or you all don't have the experience with --

THE WITNESS: It's because you could possibly have almost the same indications and not be the same fault. So we didn't want to tell people -- to give people the idea that every time you roll, you had a yaw damper malfunction. You may have hit a wake. You may have hit just a regular turbulence in a thunderstorm activity.

Flight control malfunctions are such if things like asymmetric flaps or asymmetric slads, whether you get a rolling moment split throttles, there's a possibility that on the auto throttles, one throttle can come up and the other one doesn't. And that's a heck of a rolling moment. Engine power loss is pretty easy and auto pilot malfunctions and we talked about those.

CHAIRMAN HALL: Well, I found the article very interesting and I hope it gets wide distribution. I guess you have, what, how many hours on the 737?

THE WITNESS: About 1400.

CHAIRMAN HALL: Fourteen hundred. And Mr. Berven had what, 5,000?

MR. BERVEN: My total flight time is 7,000. About 3500 hours are in engineering testing. And my total time in the 737 --

CHAIRMAN HALL: I apologize. I'm causing problems here.

MR. BERVEN: I said my total flight time is **7,000.** About 3500 hours are in engineering testing. And my time, total time in the 737 is about 450 to 500 hours.

CHAIRMAN HALL: Well, we got a lot of experience here and you have participated with us in this investigation, as you mentioned, representing Boeing on two of the groups. In this public setting, is there anything else that you think we should be doing in this investigation or other tests that should be run or other things, suggestions you would have or comments for us?

THE WITNESS: I would like to see the continued activity and a broadening of the scope of the human performance group. We're at a bit of an impasse because we're only allowed to look at this event. And they're bringing up -- there's NASA studies, FAA studies, university studies involving all these different parameters, and we have not assimilated, incorporated, analyzed, or even brought forth from a team -- and I am a member of the team -- brought forth to highlight sections, paragraphs, and present that data to the NTSB for the NTSB's analysis.

CHAIRMAN HALL: And finally -- I meant to ask Mr. Berven this question -- we made a decision to extend some taxpayer dollars in terms of this test. We also were fortunate that USAir and Boeing contributed to this test. But we, FAA and the National Transportation Safety Board, dipped into our emergency fund. Do you think that that wake vortex test that we took at Atlantic City will advance the knowledge in this area? I guess, did we spend the money properly, in your opinion?

THE WITNESS: Yes. I honestly believe we did. We've solved a couple of key problems with the unknown points on the cockpit voice recorder. We now have the absolute best chance of having a very valid simulation. From that simulation, we hope from the performance group to know where the flight controls went and to aid us in trying to recognize what happened.

I think it gave experience to John Cox and Jim Gibbs and Les on what it is to flight test an airplane, how the airplane can be flown, and not have to fly it in the airline environment. And to broadening all around through the members of the NTSB that were there and observed the flight test, and members of the FAA, members of ALPA and USAir to see, one, how all these people can work together and successfully complete a program in a very quick time. And, two, gather as a group all this information and to start processing it and using it.

CHAIRMAN HALL: Well, I'm sure -- I'll be sure Administrator Henson hears that. I don't know Mr. Cox and Mr. Berven may have different opinions, but we'll find out from them. Well, thank you very much for your time and your participation.

Unless there are other questions, we will excuse you.

(Witness excused.)

CHAIRMAN HALL: We need to get to Mr. Cox today, that's for sure, because -- right? Captain Cox. I apologize, Captain, I'm sorry. I'll get in trouble real quick that way. But I guess we ought to take a break and then come back and have Captain Cox. Is that everybody's pleasure?

So we'll come back here in 15 minutes. At ten minutes to the hour.

(Whereupon, a brief recess was taken.)

CHAIRMAN HALL: We will reconvene this Board of Inquiry. Captain Cox, I want to give you of all individuals, a special welcome up here, because I am the eighth chairman of the National Transportation Safety Board and some have described me -- well, some have described me -- some of my detractors have described me in other ways, but I have been described as an average chairman of the National Transportation Safety Board.

(General laughter.)

CHAIRMAN HALL: And it's nice to -- I believe you're here as an average pilot. Is that correct?

CAPTAIN COX: Yes, sir. That's what they tell me.

(General laughter.)

CHAIRMAN HALL: Well, we'll get together and celebrate after this is over.

(General laughter.)

(Witness testimony continues on the next page.)

JOHN COX, CAPTAIN 737, USAir, AIRLINE PILOTS
ASSOCIATION, PITTSBURGH, PENNSYLVANIA

Whereupon,

JOHN COX,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows:

CHAIRMAN HALL: Who's handling this one?

MR. SCHLEEDE: I've got to --

CHAIRMAN HALL: Oh, he's not been sworn? I'm sorry.

MR. SCHLEEDE: Yes, I'm sorry. He's sworn. I just want to qualify him for the record.

CHAIRMAN HALL: Okay.

MR. SCHLEEDE: Captain Cox, your full name and business address, please?

THE WITNESS: My name is John M. Cox. My business address is One Thorn Run Center, Corapolis, Pennsylvania.

MR. SCHLEEDE: And your position with USAir?

THE WITNESS: I'm a 737 Captain.

MR. SCHLEEDE: Could you briefly describe your experience bringing you up to that position?

THE WITNESS: Yes, sir. I've been a licensed pilot for 25 years. I've flown professionally for 22 years. I've been with USAir for 16 years. I hold an Airline Transport Pilot certificate with three jet type ratings, including the Boeing 737. I have something in excess of 12,000 hours flight experience, and of which something over 8,000 hours in the 737.

MR. SCHLEEDE: And you're working on the investigation of the USAir accident.

THE WITNESS: Yes, sir.

MR. SCHLEEDE: In what capacity?

THE WITNESS: I'm with the systems group. I've also done work with the performance group and participated in the wake vortices flight tests in Atlantic City and the simulator validation tests in Seattle.

MR. SCHLEEDE: Have you worked any other investigations with the NTSB?

THE WITNESS: Yes, sir, several.

MR. SCHLEEDE: Thank you. Mr. Jacky.

MR. JACKY: Good evening, Captain Cox.

THE WITNESS: Good evening, Mr. Jacky.

MR. JACKY: You mentioned that you're a pilot for USAir on the 737-300. Are you rated and do you fly in the other derivatives of the 37?

THE WITNESS: I'm currently flying actively the 737-300 and 400. We fly that as one type of aircraft at USAir. I also have experience in the 737-

200.

MR. JACKY: But you're not actively flying?

THE WITNESS: No, sir. We currently fly that as a separate type aircraft. But I flew it both as a first officer and a captain on the 200 version.

MR. JACKY: Okay. And you have no experience in the 500?

THE WITNESS: No, sir.

MR. JACKY: Does USAir fly the -500 airplane?

THE WITNESS: No, sir, we do not.

MR. JACKY: I guess, first off, if we could turn to Exhibit 9X-1, please. Again, this is the article that's taken from the Airliner manager. I was wondering if I could get your assessment of this article, whether or not you feel it is a good article. Have you read the article?

THE WITNESS: Yes, I have.

MR. JACKY: Could you give me a characterization of the article?

THE WITNESS: I think that it's -- overall, it's a pretty good article. I did notice what I would characterize as some carefully chosen verbiage. In that way, that I think it's technically correct, and I applaud the Chairman for his efforts to insure its distribution. I know it was being distributed pretty well around USAir. But it's sort of information with the interest in the lateral control system in the 737 is something that I would think is advantageous to all the line pilots.

Within the Airline Pilots Association, we have also tried to distribute this sort of information. So, it's an educational process that I think is good.

MR. JACKY: Have you had any discussions with other pilots within ALPA and USAir on this article?

THE WITNESS: A few, a few people.

MR. JACKY: And any comments or thoughts from --

THE WITNESS: Pretty much the same as mine. That some of the verbiage was chosen a bit carefully, but overall it's pretty good. It explains some things pretty well. And it's a well-researched article. So in that regard, I think it's good.

MR. JACKY: Does USAir have any sort of method for getting information like this to -- I know you said that USAir has distributed the article to the pilots. Are there any other ways that they get information to you?

THE WITNESS: Well, there are several

different ways. One of the company distributions is a magazine called, "Safety on Line." It's about a monthly publication from the Safety Department. There's also specific aircraft issues that come up on the 737. There's a publication ALPA publishes, approximately a monthly magazine and safety articles and airplane specific information. Our articles probably constitute 60, 70 percent of that magazine.

So on an average month, USAir pilots are getting quite a bit of material on current information. And about once a quarter, we also get a publication from the company called "Flight Crew View." And that oftentimes has reprints of flight safety foundation articles and other industry publications that are applicable to line operations.

MR. JACKY: Are the articles sort of meant to be refreshers to your training or are they just giving new information to you or what are the purpose of the articles?

THE WITNESS: Well, I think it varies from article to article. Oftentimes, they are the events in research that has come up in the industry. It's serving to re-emphasize training that we've already had on a variety of subjects. Sometimes as a refresher, sometimes as new material is brought forward. And sometimes, as is topical for the season. As an example, in the late spring, you get the thunderstorm articles and then as deicing season approaches, you'll get the deicing articles. So it's a big seasonal in what's going on in the industry.

MR. JACKY: I asked the other two pilots this question. I'll go ahead and ask you. At a flaps 190 airplane configuration, normally how much rudder would you expect to use while maneuvering?

THE WITNESS: In normal line flying, zero.

MR. JACKY: Zero. And per USAir operating procedures, what would be the normal air speed range that you would use while operating under flaps one configuration?

THE WITNESS: Well, we would operate normally between 210 and 190 knots with flaps one under the current system.

MR. JACKY: And then would you -- then at what point would you start going to more flaps or slow down or --

THE WITNESS: If you were slowing below 190 -- and I would probably need to clarify that. Previous till about two months ago -- and that's an approximate figure -- depending on the gross weight of the airplane, that zero flap or flaps one maneuvering speed could have been lower than that. So at times -- you know, six months ago or for longer, we could have had the airplane operating at a lower speed with the flap setting of one, but that would have been normal. At 190 knots, flaps one would have been a normal setting for us.

MR. JACKY: You mentioned when you were talking about this, you said that's the current procedure. Does that indicate by use of that word, that there's some thought about changing that?

THE WITNESS: Well, there has been a change. We have now gone to a less weight restricted, more categorical, if you want to call it that, speeds of 210 and 190 as a range for the flaps one setting. And that's on a much broader scale where we would previously -- on the previous system, we would incrementally adjust it for every 1,000 pounds of weight or so.

MR. JACKY: So then you're just -- you're basically -- or would that mean that you're using that now all the way across the band of weights then?

THE WITNESS: Well, there are some weights in there where the speed goes up further, but they are at the heavier weights.

MR. JACKY: Okay. What was the reason or the basis behind that change?

THE WITNESS: I'm not absolutely sure. I know that there was some thought. This process was used some years ago. The speed schedule was used some years ago. And the engineering folks came up with the idea of flying the airplane at the slower speeds, I think in an effort for fuel conservation. But they were Boeing approved -- it was a Boeing approved procedure. And then USAir, as I say three or four months ago, decided to go back to the newer speed schedule.

MR. JACKY: In the course of your flying experience in the 300, what would you believe would be about the maximum amount of rudder that you've ever had to use?

THE WITNESS: Well, it would vary. I mean, there are training scenarios where we've used it all. In a simulator with an engine out event, heavy weight conditions, where you need just about all the rudder. As far as with a non-instrumented airplane in line operations -- for example, in cross wind landings, I really don't know that I could characterize in degrees how much you use. You use what you need, if that makes sense, as you align the airplane with the runway.

MR. JACKY: So how many of your -- within the 737 fleet at USAir, how many of those airplanes have some sort of indication of where the rudder is at in the cockpit?

THE WITNESS: None.

MR. JACKY: None. And that can be said for the 200 and the 500 also? Or, I'm sorry, the 200 and the 400?

THE WITNESS: Yes, sir, that's true. The only indication of any consideration with the rudder is the yaw damper indicator on the forward panel.

MR. JACKY: Okay. And just for clarification, could you tell us how big and where on the cockpit panel the yaw indicator is?

THE WITNESS: It's approximately the diameter of a quarter and it's fairly far up on the forward panel underneath the glare shield almost.

MR. JACKY: And does it give you -- is it a gage? Does it tell you exactly where the yaw -- where the rudder is and the yaw damper position in degrees? Or how does --

THE WITNESS: It's only -- it's a white needle with an indices that the center moves, tracks left and right in relation to the yaw damper. And it's not marked in degrees. It's just -- if you had to describe it, the only definition you could use is needles widths. That's the only measurement you could use.

MR. JACKY: Could you give us a characterization of your participation in the simulator calibration flight tests, please?

THE WITNESS: I was on the aircraft first as an observer. When Mr. Berven and Mr. Carriker flew, we were in the back of the aircraft with the videos and the flight test engineers. Then Captain Gibbs and I exchanged flight crew duties on the second flight. He flew a portion of the flight and I flew a portion of it.

MR. JACKY: In the course of your flying with USAir, have you had the opportunity to perform the type of maneuvers that were performed during those simulator validation flight tests?

THE WITNESS: In some respects, part of my history with USAir, I was a simulator instructor, an aircraft instructor check pilot, check airmen, and also an acceptance test pilot. So in doing some of the acceptance test work on the different aircraft -- not the 737, I have had some experience in this type of work before, but not quite to the extremes and not in this airplane, but it's similar in nature.

MR. JACKY: Did you perform any of the steady heading side slip maneuvers?

THE WITNESS: On the 737 in Seattle, yes, sir.

MR. JACKY: Yes.

THE WITNESS: Yes, sir.

MR. JACKY: Which of the two flights was that on?

THE WITNESS: The second one.

MR. JACKY: Did you perform any of those maneuvers were you in Atlantic City?

THE WITNESS: Yes, sir.

MR. JACKY: Could you give us your impressions of -- there's been -- I'm sorry. There's been a lot of talk about the lateral stability and the control and the cross-over point and whatever. Could you give us your impressions of what you saw there?

THE WITNESS: The thing that I think probably stuck with me the most was at speeds right around 190 knots, in a full rudder condition, the airplane would start to roll and did. It had insufficient lateral control to stop it. As you accelerated back, you had to go several knots above that, before the lateral control system could again over power the rudder.

It surprised me a little bit, because once the roll started, it was pronounced. It's something that you could definitely see. I was a bit surprised at that. I didn't expect the cross-over points, quite frankly, to be quite that high. I was -- 1 had never taken the airplane before into that regime of flight.

So from a line pilot perspective, I think that I would have expected more padding under the maneuvering speeds that we were flying in the case of a full hardover rudder than in the cases as we observed it.

MR. JACKY: Would you have any sort of assessment as far as the -- we talked about the two degree offset in the rudder at the full rudder blow down condition. Would you have any sort of assessment of that?

THE WITNESS: My opinion is that after flying the M-CAB simulator in Seattle and then also having flown the flight simulator at USAir, that the aircraft exhibited the cross-over point at a higher speed than the simulators. So in that regard, I was pleased to hear that they're going to update the simulator model to more accurately represent the airplane.

MR. JACKY: Do you think that the airplane that was used in the flight test was fairly representative of 300?

THE WITNESS: Yes, sir. I would guess that I've flown every 737-300 and 400 that we have, which is, I think, some 235 airplanes. And it was what I would call very definitely an average airplane. It was rigged pretty well, which is normal for a USAir airplane, and it flew, I would characterize it, as average. Average or better.

MR. JACKY: Could you tell us about your participation in the wake vortex test?

THE WITNESS: Yes, sir. Once again, on the first couple of flights, my function was that as an observer in the back of the aircraft with the engineers and the video monitors. On four of the flights, I believe, I participated as a flight crew member flying the aircraft. I flew several of the wake turbulence or the wake vortex encounters from a variety of the test condition.

MR. JACKY: Could you characterize for us the behavior of the wake vortices?

THE WITNESS: It was consistent with pretty much things that we see on the line. Operating in and out of the east coast, which is where USAir is a predominant airline, we go into high density airports with great frequency.

I mean, on a three-day trip, three or four-day trip, it's normal to come across wake vortex of traffic. The word routine is probably not descriptive, but it's certainly not unusual. And this was -- it was consistent with the experiences that I've had previously.

Now, the only difference was I've never before tried to find the center of a core and stay there. So the control inputs necessary to do that were larger than what I -- certainly larger than what I had seen in previous line experience. But where Mr. Carriker referenced hitting a vortex two or three times, I've experienced that, both with the auto pilot on and off where I was hand flying the airplane.

The Atlantic City test was no different. It's not that disruptive a condition.

MR. JACKY: Two of the earlier witnesses were talking about the amount of time that you would spend within the effect of the wake vortices. Could you give us your characterization of that?

THE WITNESS: In normal line operations, it's a couple of seconds. I mean, you're in and out of it. The one or two times that I had experienced what I'd call repetitious encounters, which I now understand to be the same core as it maneuvered around with us holding a track over the ground as going back through it. That whole thing is lasting just a couple of seconds per encounter and then you're gone.

One of the things is it's very difficult to stay in the core. The aerodynamics are such that it wants to spit you out and away from the center of the core quite quickly. So if you're not deliberately trying to stay there, it's going to move the airplane away from the center of the core.

MR. JACKY: During the flight test in Atlantic City, what were some of the representative or maximum amounts of roll angles or upsets that you saw?

THE WITNESS: Depending on the test condition, with any kind of pilot intervention, they were, I'd call it, in the mid 20s. A good bit of the time you spent looking outside because you're trying to align the airplane visually with the core and you glance back inside as you went through it, and I don't recall seeing anything much above 20, 25 degrees. I'd certainly characterize it as normal.

For example, an auto pilot will oftentimes make a 30 degree bank, and this would be what I would call within the realms of normal for passenger service. Now, the video describes 60 degrees of bank, and I was a cockpit crew member when some of those tests were done. Those were set up quite carefully to examine the airplane's free response.

So we would set the airplane up to hit the maximum portion of the core and remain there as long as it could with no pilot intervention at all. Literally we were sitting there with our feet on the floor and our hands up to let the airplane have maximum time to respond until it dampened out and then we'd set up the next test.

So the 60 degrees is what I would characterize as a special test condition, that's not representative of line flying.

MR. JACKY: And during your experience with wake encounters and line flying, if you can remember, what would be like the maximum amount of roll rate or roll -- I'm sorry -- roll that you would see in any of those encounters?

THE WITNESS: I don't recall seeing any much over -- about the same amount, 20, 25 degrees. And that's very usual. Typically, more often than not, what we'll hit them is at a fairly acute angle. So you'd get just one or two pretty good bumps and not a lot of roll.

On the cases where you're going in behind a lot of traffic, is the cases where I've -- the strongest memories are of encountering the roll. And even then, it's 20, 25 degrees. Not much more than that.

MR. JACKY: And during the flightest in Atlantic City, did you notice any encounters that resulted in a large yawing moment or heading change?

THE WITNESS: No, actually, we did several tests with both the yaw damper operative and switched off. We had the vertical fin in the vortex. We put several parts of the airplane carefully in the vortex, looking for yaw, and it was less than I had expected it to be, because I had -- particularly with the fin only in the core and with the yaw damper off, I had expected a fair amount of yaw and it wasn't there.

MR. JACKY: When you were flying through the wake during the flight tests in Altantic City, did you happen to notice if the yaw damper was active?

THE WITNESS: It was active. Yes, sir, it was active, but I don't know that I could characterize it in magnitude. I was sort of busy doing other things, but it was moving. Yes.

MR. JACKY: During your experiences as a line pilot, have you had any sort of wake encounter that would result in a large heading or a yaw change or yaw moment?

THE WITNESS: No.

MR. JACKY: Let me ask you, when you are doing line flying and you have a wake encounter, what are the sort of cues or what tells you that you just had a wake encounter?

THE WITNESS: There's an abrupt movement in the airplane that was -- that the pilot didn't put in. The airplane is flying along in a steady state, if you want to call it that, even in light choppy air. And then the airplane begins a roll that was not instigated by the crew or the auto pilot and there's usually little bit of vertical moment with it. And it has a distinctive characteristic, a fingerprint, if you want to call it that, that you come to know pretty quickly as that was the wake of another airplane.

MR. JACKY: Over the past several days or past two days, we've had a lot of conversation about some of these uncommanded roll events that have been happening in the industry. Do you see any way that what you term as being a wake encounter, could that have been some sort of roll upset with the auto pilot or something?

THE WITNESS: I think that in some cases, that's probably true. One of the things that after the accident in Pittsburgh everybody began to look and had some concern surrounding the 73. And as the education came out and the people and USAir put out a lot of information saying that if there is anything unusual in roll or whatever, to make sure that you go ahead and get reports, and that way that the diagnostics could be applied to it.

So what we found pretty quickly was that reports that two years ago would have been written off as well that was probably a wake turbulence encounter, now generated paperwork and became the -- the term as uncommanded roll event. So I think some of them are maybe wake encounters. But some of them, based on the information that I've got, I don't think are.

So I think that we've got a very sensitive pilot group that are reporting events in an effort to try to do what they can to assist this investigation and also the issue of the 737 uncommanded roll events.

MR. JACKY: But you haven't had one of these blue water or uncommanded roll events while you were flying the airplane?

THE WITNESS: The airplane is a -- the airplane has an FMC in it, that the airplane spends quite a bit of time flying in. So I've had the auto pilot do things to me that I didn't expect. And oftentimes, you write that off to you -- or lateral navigation, making adjustments.

So if you want to characterize that as uncommanded roll, I've seen it, because I've had the airplane surprise me when it rolled in an area that I didn't initially expect it to. But with the amount of experience that our 737 crews have, you rapidly learn what's FMC induced. And if you -- as you watch the airplane, it will settle down and go on about its way.

So in that respect, I've had the airplane do it. But as far as anything of significant magnitude, no sir.

MR. JACKY: You were talking about some of the wake encounters that you had while acting as line pilot. Were you hand flying the airplane any time during these encounters?

THE WITNESS: I've had them with the auto pilot on and when I've been hand flying.

MR. JACKY: And when you've had these wake encounters, have there been any times that you have been startled or surprised?

THE WITNESS: In a line operation, you never know they're coming. So as far as -- I don't know if it's surprise, because it rapidly goes to identifying what it is and going on. You have no idea that it's coming and it startled the turn that -- it doesn't cause a reflex action or grave concern, but it's unexpected. I guess, is a better term for it.

MR. JACKY: During any of the wake encounters you've had while line flying or during the flight tests in Atlantic City, did you have any encounters that you thought were disorienting?

THE WITNESS: No, sir. As a matter of fact, one of the things when we're flying and the tests in Atlantic City, when you flew into the core, you lost all outside visual reference. So you would transition from flying the airplane visually to having to fly it by instruments and then back visually again.

There was clearly no disorienting cues to me at all in regard to which way the airplane wanted to roll or what control should be applied to counter that roll.

MR. JACKY: As a line pilot, have you had any sort of training as far as wake vortices, both encounter and recovery from?

THE WITNESS: No, sir. As I say, they're pretty common. It's something you learn early in your flight training experience. So, I mean, you deal with it as a student pilot forward. So particularly with a jet transport airplane, the experiences is clearly all you need.

MR. JACKY: Did you see anything either of the two flight tests that would, you believe, help train or help better train pilots?

THE WITNESS: I'm very hopeful that the tests will help rewrite some of the books on wake vortices and how pilots are trained with them, because I think that there's a lot of information. They are not, as Mr. Carriker made reference to, the steady state 300 feet a minute diverging cores in the sky that he described quite accurately. And that's what's in the book. They are not that.

They move both horizontally and vertically. They'll come together. They'll burst open. They will snake, for lack of a better term, both -- particularly vertically. And at one point, we had the opportunity to have the FAA 727 fly over in Atlantic City and you could actually hear them. We were out near the runway. And you hear the vortices as they blew over towards us. There's quite a bit of energy there. And I think that if those videos can be brought forward, particularly for pilots of light aircraft, that they need to be respected, particularly in a small airplane. But I think that there's a lot of education and a lot of research that I hope NASA and others will do.

MR. JACKY: Would you be able to characterize any sort of difference in the way that the 300 would react to a wake encounter as opposed to a 400? Are there any differences?

THE WITNESS: Probably not. The airplanes fly very, very similarly. Probably not. I don't know that I could characterize the two as having any difference.

MR. JACKY: Would you say that the airplane that was used for the purposes of flight tests had more rudder used on it over a shorter period of time than any average airplane in the USAir flight?

THE WITNESS: In flight, yes, sir. Now, maneuvering the airplane around on the ground, particularly before flight -- every flight, the controls get a full lock-to-lock control check prior to flight, and that's done before every leg. And an average 737 probably makes in the neighborhood of six legs, maybe seven a day.

So the controls get a pretty good full deflection workout. But in flight, you don't use that amount of rudder.

MR. JACKY: During the flight tests, did you see anything that would lead you to believe that any of your training simulators needed to be changed?

THE WITNESS: The simulators pretty closely represent the airplane. I did notice and as has been previously stated here, I did notice that the aircraft has what I'll call a higher cross-over speed than demonstrated in the simulator. So in that one area, in my opinion, there could be some modification made to more accurately represent the airplane.

Also, from what I understand that Boeing has made that adjustment in the M-CAB. I would certainly hope that they would get that correction out to the industry.

MR. JACKY: Did you get a chance to fly through the vortices as modeled on the M-CAB?

THE WITNESS: No, sir.

MR. JACKY: I believe I have no further questions.

CHAIRMAN HALL: Other members of the Technical Panel? Mr. Haueter?

MR. HAUETER: Just a couple here quickly. You mentioned that flying in the east coast, the number of flights you do, that you're fairly used to vortex encounters.

THE WITNESS: We see a lot of them.

MR. HAUETER: Would you think that experience would cause you to delay getting on the controls?

THE WITNESS: No, sir. It's virtually instinctive. When the airplane starts to move and do something you didn't want it to do or expect it to do, you're on the controls quite quickly, and it's instinctive.

MR. HAUETER: On the steady heading side slip data and the cross-over point, as an average pilot, if you hit a dynamic rudder input, do you think you could -- based on, well, I guess prior experience, recover the aircraft?

THE WITNESS: I think it would very much depend on where you got it. At the higher speeds, if you're well above a cross-over point, I think the airplane -- you could probably control it. I think if you were right at that speed or below it, I'm not as nearly as confident or even sure that that's possible.

The airplane roll rate, it appeared to me, seemed to be significant. As the roll in degrees, the bank angle would increase, the problems would get worse. As the airplane would have more and more difficulty holding altitude and it resulted lift loss and so forth. So things would deteriorate quite quickly from a flight crew perspective.

MR. HAUETER: Do you believe your training to date would prepare you for such an event?

THE WITNESS: Here again, if this happened at 250 knots, I think that it would be a very bad roll rate. It would be very uncomfortable. We would stabilize the airplane and look at each other and try to figure out what we're going to do next to try get the thing on the ground or how we could resolve it after we diagnosed it.

If you were at cross-over speed or below, I think the problem solving window would be pretty short, and I don't know that you could get to satisfactory answer before you would run out of time.

MR. HAUETER: Do you have aerobatics training in your background?

THE WITNESS: I have a limited amount aerobatics's training. Primarily when I was doing work on my commercial license, there was an aerobatics -- a limited amount of aerobatics there, but it's too many years ago. We're talking quite a few years.

MR. HAUETER: Based on your experiences on this test and working on the investigation, do you believe there should be more unusual attitude training to look in areas like this?

THE WITNESS: Training is something the pilots are always thinking you should get more, because you can never have enough. In this particular area, I think that it will provide some help in certain areas, but I'm not sure -- 1 think it needs to be very carefully crafted.

I've been through the United Airlines unusual attitude training. And I think that it has some merit in some areas. But in the case we're talking about here with a deflected flight control and not having full authority on all three axis of flight, I think you've got apples and oranges.

MR. HAUETER: One last question, have you ever had a yaw damper failure in any of your flights or went hardover?

THE WITNESS: I've had a yaw damper, but it was passive.

MR. HAUETER: How was that?

THE WITNESS: It just ceased to function.

MR. HAUETER: Okay. It didn't increase.

THE WITNESS: It didn't hardover. It just ceased the function.

MR. HAUETER: Thank you very much.

THE WITNESS: Yes, sir.

CHAIRMAN HALL: Questions from the parties? I see the Boeing Commercial Airplane Group, the Airline Pilots Association. Anyone else? If not, the Boeing Commercial Airplane Group, Mr. Purvis.

MR. PURVIS: Thank you, Mr. Chairman. Good afternoon -- good evening, Mr. Cox -- Captain Cox. Sorry.

THE WITNESS: Good evening, Mr. Purvis.

MR. PURVIS: You were just talking about your feeling on crews getting unusual attitude training. Some of these courses are now being offered by United and others. And I think you said you had taken the United course. Is that correct?

THE WITNESS: Yes, sir. I was invited at United to evaluate the course.

MR. PURVIS: Do you know in that course why United and the other airlines are providing training that shows or demonstrates how to respond to an upset, especially from a wake vortex?

THE WITNESS: I wasn't aware that it was specifically for a wake vortex. That's certainly not anything that I saw. There were specifically designed flight maneuvers that I would characterize as expanded from what we normally see in line operations. But they were expanded in a variety of areas. For example, we did full stall in the simulator. We don't see that in the line operation. But there was nothing specifically geared for a wake vortex encounter.

MR. PURVIS: Do you personally believe that it's a good idea to collect and study crew's responses to -- and I'll use your word -- unexpected upsets, including wake turbulence upsets or wake vortex upset?

THE WITNESS: I would -- anything that regards study of flight crew performance in pretty much any arena, fatigue for being one, startled, as you characterized it, would be another. I mean, there's a multitude of research that I would like to see done for flight crews in an effort to generally improve and better understand the working environment where I work.

MR. PURVIS: That would include then upsets?

THE WITNESS: Yes, sir.

MR. PURVIS: Have you personally evaluated crew's reported reaction in which unsuspecting crews were startled by wake encounters?

THE WITNESS: I'm sorry. Could you rephrase it? I'm not sure I understand what you're asking mean.

MR. PURVIS: In your work or in part of the accident investigation that you've participated in, have you been able to evaluate crew reports where there were reported reactions from the crew in which the crew was startled by wake encounters, by an unsuspecting crew, in particular?

THE WITNESS: I think your question is have I interviewed and evaluated crews that have unexpectedly encountered a wake vortex and evaluated the actions of that.

MR. PURVIS: Either crew interviews or crew reports?

THE WITNESS: Yes, sir, I had done that. And what I have found that typically the responses are -- the trend of responses is correct. The magnitude that they report is sometimes amplified. But in general, if for example, they say the airplane rolled right, and when you look, the airplane rolled right. So as I say, the trend of information is correct. I have seen, on occasions, sometimes when the magnitude has been amplified a bit.

MR. PURVIS: In the reports?

THE WITNESS: Yes, sir.

MR. PURVIS: During your just concluded testimony, you said that you would get right on the controls during a wake encounter?

THE WITNESS: Yes, sir.

MR. PURVIS: What sort of a delay would you consider to be normal?

THE WITNESS: I don't know that I can characterize that, because, as I say, it's virtually instinctive. When the airplane starts to move in an area in a way that either myself or the first officer didn't command, you get right on it. It's instinctive.

You reach for the airplane to find out what's going on.

MR. PURVIS: So, no delay?

THE WITNESS: I don't know. We're all human. There is a delay involved, but it would be in my estimation, quite short.

MR. PURVIS: Thank you. That's all the test -- or all the questions I have.

CHAIRMAN HALL: Thank you, Mr. Purvis. Captain.

CAPTAIN LeGROW: Thank you, Mr. Chairman. Good evening, Captain Cox.

THE WITNESS: Good evening.

CAPTAIN LeGROW: You testified that you're a captain with USAir. However, you represent the Airline Pilots Association in this accident. Could you explain to us the position you hold with the Airline Pilots Association?

THE WITNESS: Yes, sir. I am the chairman of the Central Safety Committee at USAir, which is the top level at USAir of a group of pilot volunteers that deal with safety issues from the line. So I've become a focal point for the flow of information, safety information and concerns that the pilots would bring forward.

I interface with the company safety office on a regular basis. In addition, I'm part of the accident investigation team at USAir. And for ALPA National, I'm the technical coordinator for the 737 airplane and have been for about four years now.

CAPTAIN LeGROW: Thank you. Has the Airline Pilots Association provided you with any training or education in your endeavors?

THE WITNESS: Yes, sir. They initially sent me to the ALPA Basic Accident School, which is a requirement for participation in the ALPA accident team. In addition, I've been to the University of Southern California, through several courses there, including their accident investigation course.

In addition, ALPA has also qualified me, through the International Federation of Airline Pilots, to assist and investigate accidents worldwide.

CAPTAIN LeGROW: Do you belong to any other safety associations industry wide?

THE WITNESS: Yes, sir. I'm a member of the International Association of Air Safety Investigators.

CAPTAIN LeGROW: You said that you interact with the company in your duties with the Airline Pilots

Association. Exactly how does that interaction take place and with whom do you interact?

THE WITNESS: I interact with probably my counterpart, Captain George Snyder, who is the Director of Corporate Safety, Quality Assurance. I also frequently interact with General Armstrong, who is the Vice President of Corporate Safety and Regulatory Compliance. And also on operational issues, Captain John Murphy, who is our Senior Director of Flight Operations, and also with senior management from time to time. It's a very close working relationship between the airline pilots and USAir on safety issues.

It's a very open-door policy. So I interact with an awful lot of people in a variety of departments in dealing with safety issues. But it's a very open exchange of information in both directions.

CAPTAIN LeGROW: Thank you. I believe that Mr. Jacky asked you some questions about the Boeing Airliner article that was offered as an exhibit. And you said that ALPA and the company write articles. Do you personally or have you personally written articles to be distributed to the pilots of USAir?

THE WITNESS: Yes, sir. I generally produce one article a month for the ALPA publication on some issue of safety. And over the course of this 14 month investigation, I have had several articles on the 737 and the progress of this investigation.

CAPTAIN LeGROW: On your duties on the wake vortices tests, how many of the test flights did you actually participate on either airplane?

THE WITNESS: I believe there were eight test flights total. I was on six of them. There were two flights in Atlantic City. There were only two flights in Atlantic City that I was not on the airplane.

CAPTAIN LeGROW: How would you characterize -- and I think this question was asked before, but I really wasn't sure of the answer. But how would you characterize those wake vortices events or how did you characterize them?

THE WITNESS: They were about what I had expected based on my experience from line operations. It was something that a line pilot sees on a relatively normal basis. And the magnitude was consistent with my experience.

CAPTAIN LeGROW: On a normal month of flying, how many hours is a line pilot flying?

THE WITNESS: Block hours, we're actually away from the gate probably ion the neighborhood of 70.

CAPTAIN LeGROW: In that 70 hours a month, how many, on the average -- how many times would the average, average pilot anticipate encountering a wake vortices?

THE WITNESS: It's easier for me to characterize it sort of by trip, because it's the way you tend to remember things. I would expect one any where between two or three times on a three or four day trip to come across some form of a wake vortex going in and out, as I say. It's more often in and out of the high density airports. You know, Boston, New York, Pittsburgh.

CAPTAIN LeGROW: In your 25 year career, Captain Cox, have you ever encountered a wake vortices under normal line operation that would be in the vicinity of 60 or more degree bank?

THE WITNESS: No, sir, I have not. Not anywhere close.

CAPTAIN LeGROW: Mr. Purvis asked you some questions on the interviewing of some pilots. Could you elaborate a little bit on exactly how that takes place? Is that with your duties as the accident investigator on this accident or as your duties as Central Safety Chairman?

THE WITNESS: It's been as my duty as Central Safety Chairman. It is -- it's not at all unusual if a pilot has an event that in addition to contacting the company, that he will call ALPA safety. So we get a pretty early contact with the flight crew members. It's a good exchange. It's very low key. So we get a lot of information that we can then assemble and help in determining what actually went on on that flight.

So it's very routine. It's something I've been doing for seven or eight years now.

CAPTAIN LeGROW: Thank you, Mr. Chairman. I have no further questions.

CHAIRMAN HALL: Thank you, Captain. Any other questions from the parties?

(No response.)

CHAIRMAN HALL: Seeing none, we'll move to Mr. Clark.

MR. CLARK: Captain Cox, with the experience that you've had in the wake vortex flight testing, do you think the separation standards in existence are adequate for a 73 behind a 727?

THE WITNESS: Yes, sir, I do. As was characterized by Mr. Carriker, I found the difference in magnitude not real discernable between two miles and three miles or between three and four, but between four and two, you could tell it. So I think however the number of three miles came up, that it's probably a pretty good standard.

MR. CLARK: You said that in a one-week period, you may encounter vortices three to four times?

THE WITNESS: On a three or four-day trip, that's what I would characterize as an average trip.

MR. CLARK: What would be the nature of the encounter, what kind of airplane typically would you be following?

THE WITNESS: It could be anything. Where we operated. It could be anything from a 747 to a leer jet.

MR. CLARK: So in these three to four encounters a week, does it seem reasonable that those three or four times, you're operating at 300 or 400 feet below the flight path of the airplane ahead of you?

THE WITNESS: It would depend -- I mean, because oftentimes for example -- let me give you an example of New York. If we're landing in LaGuardia, there is a departure path from Kennedy. So you have airplanes crossing in a variety of directions and different altitudes.

So it's hard for me to characterize being exactly 300 feet below, because it's a pretty dynamic environment with the airplanes both descending and climbing at pretty good rates.

MR. CLARK: But your understanding of the motions of the wake vortex and what you saw at Atlantic City indicate that the vortices descend.

THE WITNESS: They do descend, yes, sir. Once they descend, though, if there's any kind of atmospheric heating, they snake pretty well, and that can be -- 1 don't know -- probably 50, 60, maybe a 100 feet. I don't know. It's hard for me to gage the magnitude of that snaking, but it was quite noticeable.

So maybe 200 feet under certain conditions and 400 feet others, they move.

MR. CLARK: So basically then if the FAA is operating on the premise that the flight path for all of these airplanes have to be equal or at least the trailing airplane should be at a higher flight path, then says operationally that three to four times a week, at least hit the vortices, the trailing airplane is below the flight path of the preceding airplane.

THE WITNESS: A preceding airplane, I don't know that it would be necessarily the one directly in front of you. Another airplane would be a better characterization of it.

MR. CLARK: Okay. Do you believe this encounter three to four times a week is typical of all of your counterparts?

THE WITNESS: Yes, sir, I would think it would be representative.

MR. CLARK: Mr. Jacky asked about flying at 190 knots and flaps one, asked if you would typically use the rudder in that environment, and I believe you said no.

THE WITNESS: No, sir.

MR. CLARK: Do you -- where would your feet be? On the floor or on the pedal?

THE WITNESS: It would depend. If I'm hand flying the airplane, I'll normally have my feet up on the rudder. If the auto pilot wants -- once I've engaged the auto pilot and assured it has engaged correctly and is not going to present a problem and it virtually never does, then I'll fly with my feet on the floor.

MR. CLARK: In your line operation, you said you've hit these vortices. I assume you've had some pretty good jolts?

THE WITNESS: Yes, sir.

MR. CLARK: In any of those, did you use the rudder while you were flying?

THE WITNESS: I don't ever remember coming up on a case where I've needed it. With swept wing jet airplanes in that sort of flight regime, I would apply a controlled wheel and if I wasn't getting a result that I was comfortable with or felt that I needed more roll, I would add rudder then. But it would be a stepped process, first control wheel, trying to get the airplane aligned with wherever I wanted it and illustratively wings level.

If the airplane wasn't going there, then I would add rudder in an effort to increase the rolling moment to oppose whatever roll of force was applied to the airplane.

MR. CLARK: Is the type of rudder you would input, would that be consistent with the phrase of stepping on the top rudder, top pedal?

THE WITNESS: I would be countering the direction of roll, both with control wheel and rudder, in that case.

MR. CLARK: You talked about in the flight control demonstration where you were using full rudder input and slowed below 190 knots and then you had to increase several knots above that to effect a recovery. Was that type of action intuitive in your estimation?

THE WITNESS: It was in a test regime. So we were very -- trying to carefully record those parameters. So instinctive in that environment, no, sir, because we were trying to do everything very deliberately in a research effort.

MR. CLARK: You talked about your encounters in the vortex flight test. I think basically you said there was nothing disorienting about the event. I believe you also participated in the M-CAB events in the VMS simulator.

THE WITNESS: Yes, sir. That's correct.

MR. CLARK: Was there any disorienting effects in those?

THE WITNESS: No, absolutely not. That's -- the cues were very clear to me about which way the airplane was trying to roll. And that's true of the M-CAB, the vertical motion simulator at NASA-Ames and in the flight tests. The cues were very clear.

MR. CLARK: What was the most powerful cue available to you?

THE WITNESS: Roll rate. And it's instantaneous -- it's simultaneous. There's the visual recognition of roll and then there's the lateral g feel as the airplane starts to roll and they come together. So I don't know that I can separate them.

MR. CLARK: Now, you commented about it surprised you that the cross-over speed was 190 knots and that you had not seen that in the simulator environment. My question is is that typically demonstrated for a line pilot operation, a line pilot --

THE WITNESS: No, sir.

MR. CLARK: So all of this was a result of the investigative process you were involved with --

THE WITNESS: Right, the flight test.

MR. CLARK: -- rather than anything going on in training today.

THE WITNESS: Right.

MR. CLARK: The typical line pilot would have no idea what the cross-over point is?

THE WITNESS: Before starting this test, Mr. Clark, I had no idea what the cross-over points were.

MR. CLARK: Thank you.

THE WITNESS: Yes, sir.

CHAIRMAN HALL: Mr. Marx?

MR. MARX: No questions.

CHAIRMAN HALL: Mr. Schleede?

MR. SCHLEEDE: Yes, one question. It might have been asked. During these encounters and on the line, have you ever noticed the thumps that we've heard referred to?

THE WITNESS: No, sir. The first time I had -- that I remember hearing the thumps was in the flight test, but you only hear them when you're virtually aligned with the vortex itself so that your entry angle is very low. You're almost parallel, I guess, and you hear it then. That's a bit unusual. It's my impression, it's a bit unusual to hit that close or that low an entry angle in normal line operations.

You almost are sliding in there slowly, intentionally.

MR. SCHLEEDE: So you've never heard them on the line?

THE WITNESS: No, sir, I have not.

MR. SCHLEEDE: During the wake tests, did you notice what Mr. Carriker mentioned about the wipers jumping?

THE WITNESS: Yes, sir, I saw that.

MR. SCHLEEDE: You did. Did you hear it?

THE WITNESS: I don't remember hearing it as much. Mr. Carriker commented. We talked about that a little bit, but I don't recall -- I don't have personal recollection of it.

MR. SCHLEEDE: Have you heard the voice recorder on the 427?

THE WITNESS: Yes, sir.

MR. SCHLEEDE: Thank you very much.

CHAIRMAN HALL: Mr. Laynor?

MR. LAYNOR: No questions.

CHAIRMAN HALL: Well, Captain, first let me thank you on behalf of the board for the excellent way in which you represent not only USAir, but the Airlines Pilot Association. Your participation in this investigation has just as Mr. Carriker, and I think anyone here would, I would think, be very impressed with the level of experience and expertise that you all are bringing in assisting us with this investigation.

I want to thank you. I'm going to ask you the same question I asked Mr. Carriker. Do you think this taxpayer dollars we spent to do this test was worthwhile?

THE WITNESS: Yes, sir, I do. Initially

going in, I was unclear about how much results we could really expect. In the end, the tests exceeded my expectations significantly. I not only think that it was -- we got our money's worth, I think we actually got a bargain.

CHAIRMAN HALL: Thank you. Were you in the part of the flight crew when you got the 60 degrees?

THE WITNESS: Yes, sir, I was.

CHAIRMAN HALL: Was that by turning into the vortex and it was descending? Is that what I understand?

THE WITNESS: Yes. Well, we did several of those. When you set the airplane up where it drifts in and we caught it just right, you could get that kind of result, assuming that we made no intervention at all and we just let the airplane rescind as it would with no pilot input. As I said, literally, we had our feet flat on the floor and our hands straight up to assure the engineers that we weren't in some way affecting the airplane. So it was what -- it's termed a free response.

CHAIRMAN HALL: Did we recreate that type of upset, if that's the proper word, with the vertical motion simulator?

THE WITNESS: No, sir, we did not.

CHAIRMAN HALL: What was the -- well, what was the worst angle we went on that?

MR. JACKY: The information that was used in the vertical motion simulator was from the flight data recorder.

CHAIRMAN HALL: At Pittsburgh?

MR. JACKY: Yes.

CHAIRMAN HALL: A similar profile. Are we going to be reprogramming that, as well, or are we just going to reprogram the 737, the engineering simulator?

MR. JACKY: At the present time, we plan to model both or resimulate the wake vortices themselves, as well as the 37, but on the Boeing engineering simulator.

CHAIRMAN HALL: Captain, let me ask you a question, because you represent a very important population of people. Every party to this investigation is important. But you represent the individuals responsible for flying this plane. Is there any information that you're aware of that has been withheld by any of the parties to this investigation that this Chairman and this Board of Inquiry should know about?

THE WITNESS: No, sir. Absolutely on the contrary. It has been my experience with this investigation that the flow of information between the parties and between the board -- to the board and back from the board has exceeded that of anything that I have ever seen before.

As the process has gone on month after month, the dedication and the commitment to solve this accident has been quite apparent in the willingness of all the parties to share information and work in a cooperative manner. So quite the contrary, sir.

CHAIRMAN HALL: Well, I'm pleased to hear that, because I'm aware that there is concern in the pilot community. And I want the pilot community, as well as the American public, to know that we're doing everything we can in this investigation.

THE WITNESS: The --

CHAIRMAN HALL: On that -- I'm sorry.

THE WITNESS: Well, I was only -- as I mentioned earlier, I write an article on a monthly basis. And that I have attempted, and I think to some degree successfully, to convey that message to the pilots at USAir and also across the seven carriers that are represented by the Airline Pilots Association, that the level of cooperation in this investigation is unprecedented, I think.

CHAIRMAN HALL: Well, let me ask you then finally the same question I've asked a number of witnesses, intended to ask them all. And that is, is there anything in this investigation that you think we should be doing that we're not doing?

THE WITNESS: As a member of an active group, the systems group is still quite active and under the leadership of Mr. Phillips. We are -- we've got the methodology in place to continue to evaluate the next step in this investigation. I think the process is fundamentally sound. I think it has proved itself over a difficult 14 month period, and I think that we're on the right track, particularly within the systems group.

That's really all I can speak to from personal experience.

CHAIRMAN HALL: Well, I appreciate your testimony. Mr. Haueter is putting together another "to do" list. Tomorrow before we finish, we want to get -- if you can have a copy of that, like you did in Pittsburgh, with our to do list printed up, then we would like to follow that.

Captain, thank you very much. For an average pilot, you certainly do well.

(General laughter.)

CHAIRMAN HALL: I feel a lot better flying back and forth to Chattanooga now that I've met a USAir average pilot.

THE WITNESS: Thank you.

CHAIRMAN HALL: Well, thank you. Thank you very much for your testimony.

(Witness excused.)

CHAIRMAN HALL: We have three witnesses left to cover. What the Chairman would propose and I would appreciate it if any of the parties or the audience if there are people that have an interest in these hearings and have left, if you would please try to let them know that in the morning, we will begin at 8:30 rather than at 9:00, to see if we can't -- we have some long-winded fellows from Boeing, I think, to get through --

(General laughter.)

CHAIRMAN HALL: -- but hopefully we can get through by lunchtime. I know some people have planes and things to catch, but we'll start promptly in the morning at 8:30 and hear our last three witnesses.

(Whereupon, at 8:00 p.m., the hearing was adjourned. To be reconvened on Friday, November 17, 1995, at 8:30 a.m.)

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