

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:

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1 P R O C E E D I N G S

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

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

8 (Witness testimony continues on the next
9 page.)

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5 WALTER WALZ, CUSTOMER SERVICE REPRESENTATIVE, PARKER

6 HANNIFIN, IRVINE, CALIFORNIA

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8 Whereupon,

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WALTER WALZ,

10 was called as a witness by and on behalf of the NTSB,

11 and, after having been duly sworn, was examined and

12 testified on his oath as follows:

13

MR. SCHLEEDE: Mr. Walz, could you please

14 give us your full name and business address for the

15 record?

16

THE WITNESS: Walter James Walz, Parker

17

Bertea Aerospace, Irvine, California.

18

MR. SCHLEEDE: What is your position at

19

Parker?

20

THE WITNESS: Presently, I am retired, but I

21

was manager of technical integrity.

22

MR. SCHLEEDE: Would you give us a brief

23

description of your background and experience that

24

qualified you for your position at Parker?

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

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

5 THE WITNESS: The aerospace industry.

6 MR. SCHLEEDE: Thank you. Mr. Phillips.

7 MR. PHILLIPS: Good morning.

8 THE WITNESS: Good morning.

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

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

13 (Laughter)

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

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

24 MR. PHILLIPS: Okay. And that was in the

1 customer --

2 THE WITNESS: Service.

3 MR. PHILLIPS: Customer services division.

4 THE WITNESS: Yes, customer support.

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

7 THE WITNESS: Yes.

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

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

15 MR. PHILLIPS: Coordinate the test activities
16 then?

17 THE WITNESS: Absolutely.

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

20 THE WITNESS: Yes, I have.

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

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

1 for 427.

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

4 THE WITNESS: Yes, I was.

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

7 THE WITNESS: A new warranty, yes.

8 MR. PHILLIPS: What is that warranty?

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

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

16 THE WITNESS: That's correct.

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

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

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

24 THE WITNESS: We would warranty them; that's

1 correct.

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

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

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

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

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

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

1 the database.

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

5 THE WITNESS: Yes, that's correct today.

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

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

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

17 THE WITNESS: That's correct.

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

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

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

24 THE WITNESS: We've been trying to find out

1 what the official requirement is and we get many
2 answers. Ten years we feel is safe and so we keep them
3 ten, and I think that they're kept longer than that.

4 MR. PHILLIPS: Would that be an FAA
5 requirement?

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

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

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

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

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

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

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

1 wrong.

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

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

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

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

13 MR. PHILLIPS: And why do you do that?

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

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

18 THE WITNESS: That's correct.

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

21 THE WITNESS: No, we don't.

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

24 THE WITNESS: I think maybe over the years,

1 we've made a few setups where we've done that, but it's
2 been years ago.

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

7 THE WITNESS: No. No, we are not.

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

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

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

19 THE WITNESS: Not yet, it isn't.

20 MR. PHILLIPS: Not yet. Do you mean that
21 it's not got to the level where it's important enough
22 -

23 THE WITNESS: That's correct.

24 MR. PHILLIPS: -- to the FAA?

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

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

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

10 MR. PHILLIPS: Okay. So if you work on 25 to
11 30 percent, then the rest are being modified or
12 repaired? I won't say modified. They're being
13 repaired by people other than Parker?

14 THE WITNESS: That's correct.

15 MR. PHILLIPS: And who are those people?

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

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

21 THE WITNESS: I would assume the FAA.

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

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

3 MR. PHILLIPS: The operators.

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

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

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

12 MR. PHILLIPS: The operators.

13 THE WITNESS: The operators, we do.

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

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

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

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

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

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

6 MR. PHILLIPS: Okay. We'll dig one up here.
7 Specifically, I believe the -- well, we'll get the
8 recommendation here. I believe we're talking about
9 recommendation 20, 21, and 22, on page 46 of Exhibit
10 9X-A.

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

18 We build the units. We write the procedures.

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

22 MR. PHILLIPS: To make a point clear here,
23 were the -- was the main rudder PCU that was involved
24 in the USAir 427 accident, to the best of your

1 knowledge, was that ever worked on or repaired by
2 anyone other than Parker?

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

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

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

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

12 THE WITNESS: Yes, we do.

13 MR. PHILLIPS: And why is that?

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

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

21 THE WITNESS: Same thing.

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

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

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

10 THE WITNESS: That's correct.

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

14 THE WITNESS: Not to my knowledge.

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

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

21 MR. PHILLIPS: Are you looking for wear?

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

24 MR. PHILLIPS: Are there a group of

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

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

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

8 THE WITNESS: No, it does not.

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

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

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

18 THE WITNESS: Yes.

19 MR. PHILLIPS: The compliance stat~~for~~
20 completion of the program, for the modification
21 program, was set over a number of years. Are you aware
22 of that?

23 THE WITNESS: Yes, I am.

24 MR. PHILLIPS: Are you aware of how many

1 years?

2 THE WITNESS: Five -- pardon?

3 MR. PHILLIPS: How many years?

4 THE WITNESS: Five years.

5 MR. PHILLIPS: Five years?

6 THE WITNESS: Yes.

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

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

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

15 THE WITNESS: I believe the FAA did.

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

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

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

24 THE WITNESS: Well, they could have, but I

1 think that they take into consideration the number of
2 units and the capacity available to do the work. So I
3 would say that that's given some consideration.

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

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

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

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

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

18 THE WITNESS: No, I don't.

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

21 (No response.)

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

24 (No response.)

1 CHAIRMAN HALL: I see no ~~ands~~. And we'll
2 move to Mr. Clark.

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

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

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

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

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

24 THE WITNESS: Pardon me?

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

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

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

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

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

21 THE WITNESS: Yes, it does.

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

24 THE WITNESS: John, I don't have those

1 numbers.

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

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

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

11 THE WITNESS: Yes, it would have.

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

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

22 MR. CLARK: What we're referring to then is
23 the servo valve itself had been repaired by other
24 facilities. You delivered the part to the airlines,

1 the servo valve. And then subsequently, the servo
2 valve had been repaired by other facilities and then
3 the part was returned back to you. In your service --
4 in your receiving test, you found that it had a
5 potential to over travel.

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

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

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

21 MR. CLARK: Improper torque values --

22 THE WITNESS: That's correct.

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

24 THE WITNESS: Not on the end cap. On a nut

1 that locates a spring guide down inside.

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

6 THE WITNESS: There is. Yes, sir.

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

12 THE WITNESS: We certainly would.

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

16 THE WITNESS: Yes, it is.

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

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

22 MR. CLARK: Coming back to the questioning
23 that started, as we've kind of jumped into the middle.
24 My question was on the mechanics, I was not referring

1 to the mechanics that work at the Parker facility that
2 receive these parts in need of repair. I'm talking
3 about the mechanics that make the original
4 determination that the part needs to be repaired.

5 THE WITNESS: Oh.

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

9 THE WITNESS: Most common cause is external
10 leakage.

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

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

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

19 THE WITNESS: We do. You bet.

20 MR. CLARK: Is that routine or --

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

1 MR. CLARK: Is that reported in your
2 documentation?

3 THE WITNESS: Yes, it is.

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

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

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

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

24 MR. CLARK: Now, this leaking we're talking

1 about is an external leak.

2 THE WITNESS: Yes.

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

6 THE WITNESS: Dripping out, right.

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

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

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

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

23 MR. CLARK: On your incoming test would you
24 be able -- would that test disclose that a unit had a

1 sticking servo valve? One of the valves may be
2 sticking?

3 THE WITNESS: Yes, it would.

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

6 THE WITNESS: Yes.

7 (Lengthy pause.)

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

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

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

18 THE WITNESS: That's correct.

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

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

24 MR. CLARK: But you would have records that

1 may indicate that?

2 THE WITNESS: We would have records, yes.

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

5 THE WITNESS: Yes.

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

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

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

13 THE WITNESS: Hysteresis is a test that's run,
14 yes.

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

18 THE WITNESS: They check that.

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

23 THE WITNESS: Are you talking ADr are you
24 talking just normal routine repair and overhaul?

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

3 THE WITNESS: That's correct.

4 MR. CLARK: Now.

5 THE WITNESS: Now.

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

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

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

13 THE WITNESS: No, it does not.

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

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

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

24 THE WITNESS: John, I can't help you with

1 that. I'm sorry. I don't know.

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

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

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

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

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

17 THE WITNESS: It could be, yes.

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

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

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

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

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

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

13 MR. CLARK: Okay. Thank you.

14 CHAIRMAN HALL: Mr. Marx?

15 MR. MARX: Wally, congratulations on your
16 retirement.

17 THE WITNESS: Thank you.

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

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

24 MR. MARX: During this overhaul, would they

1 be taking some of the components apart and getting
2 inside the PCU at anytime?

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

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

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

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

18 THE WITNESS: What they would look for?

19 MR. MARX: Yes.

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

24 MR. MARX: Is there other types of things

1 that happen to the valves, such as erosion, that occur?

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

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

7 THE WITNESS: One would see that reasonably,
8 yes.

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

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

14 MR. MARX: Thank you.

15 CHAIRMAN HALL: Mr. Schleede.

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

21 THE WITNESS: Yes, I do.

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

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

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

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

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

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

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

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

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

21 CHAIRMAN HALL: Mr. Laynor has no questions.
22 I've got just a few questions, Wally. Again, thank
23 you. I appreciate the tour you provided me when I came
24 out to look at your facility. How large an

1 organization is Parker-Hannifin and what different
2 types of products does your company manufacture?

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

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

11 THE WITNESS: Service.

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

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

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

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

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

24 THE WITNESS: About 380.

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

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

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

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

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

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

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

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

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

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

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

5 THE WITNESS: There's some arrangement, yes.

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

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

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

13 THE WITNESS: Yes.

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

16 THE WITNESS: That's correct.

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

19 THE WITNESS: Many.

20 CHAIRMAN HALL: Many. At this same facility.

21 What is your procedures that you follow? You all have
22 the manufacture and then you service. Do you have a
23 tracking system so that you can feed back to the
24 manufacture if there are improvements that need to be

1 made in the unit?

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

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

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

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

14 THE WITNESS: It was in place before then.

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

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

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

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

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

4 THE WITNESS: Yes, sir.

5 CHAIRMAN HALL: I believe you were at the
6 sites.

7 THE WITNESS: Yes.

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

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

16 CHAIRMAN HALL: But no particular changes in
17 the procedures?

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

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

22 THE WITNESS: Yes, we did. Yes.

23 CHAIRMAN HALL: You've, I'm sure, have read
24 much more than I have in regard to this unit. I know

1 that you have a great -- a much greater deal of
2 technical knowledge than I do in regard to this unit.
3 Is there anything that we should be doing in this
4 investigation? We've talked about a silting test
5 yesterday. Is there anything that you all should be
6 doing at your company that you would recommend to us to
7 help us try to determine if there was any type of
8 malfunction of this particular unit?

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

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

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

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

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

20 CHAIRMAN HALL: Mm-hmm.

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

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

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

7 CHAIRMAN HALL: They have concentric valves
8 with them?

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

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

13 THE WITNESS: I'm sorry?

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

16 THE WITNESS: Oh, yes.

17 CHAIRMAN HALL: -- and you were here
18 yesterday?

19 THE WITNESS: Yes.

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

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

3 CHAIRMAN HALL: Did you assist them in their
4 work?

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

7 CHAIRMAN HALL: Okay. Any other questions?

8 (No response.)

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

13 THE WITNESS: Thank you.

14 (Witness excused.)

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

17 (Whereupon, a short recess was taken.)

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

23 (Witness testimony continues on the next
24 page.)

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

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24 Whereupon,

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

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

9 MR. SCHLEEDE: Thank you, Mr. Chairman. Mr.
10 McSweeney, please give us your full name and business
11 address?

12 THE WITNESS: Thomas E. McSweeney. My
13 business address is 800 Independence Avenue,
14 Washington, D.C.

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

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

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

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

24 MR. SCHLEEDE: Would you expand a little bit

1 as to who and what organizations are directly under
2 your authority?

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

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

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

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

20 MR. PHILLIPS: Thank you. Good morning.

21 THE WITNESS: Good morning.

22 MR. PHILLIPS: I would like to start out our
23 discussion this morning on the critical design review.

24 Were you responsible in any way for the formation or

1 the concept for the critical design review?

2 THE WITNESS: Yes, I was partially
3 responsible.

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

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

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

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

21 THE WITNESS: Yes, we did. We talked about
22 issues relative to bringing on board people who did not
23 have past experience with the 737. Our main objective
24 was to develop an effort that was not biased in any

1 way. We didn't want any piece of information tossed
2 out because somebody might have concluded prematurely
3 that well that wasn't important.

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

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

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

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

1 probabilities.

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

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

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

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

20 THE WITNESS: Not to my knowledge, no.

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

24 THE WITNESS: Well, the recommendation to the

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

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

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

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

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

24 We believe it's important to make that

1 information available.

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

6 THE WITNESS: I missed the first part of
7 that.

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

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

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

16 THE WITNESS: Yes.

17 MR. PHILLIPS: Yesterday we discussed with
18 Mr. Zielinski the concepts of failure analysis and
19 FMEAs. We had several terms. I would like to talk
20 about that just a little bit in terms of certification.

21 Again, yesterday we heard testimony that at the time
22 the 737 was certified was in the 1960 time period?

23 THE WITNESS: Correct.

24 MR. PHILLIPS: We're correctly looking at a

1 new generation of aircraft in the 737 series; the 600,
2 700, 800 series. Is that correct?

3 THE WITNESS: That's correct.

4 MR. PHILLIPS: Are we -- is the FAA planning
5 to certify those aircraft to the standards of the
6 1960's era requirements?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

22 It is really through the airworthiness
23 directive process that we, in essence, upgrade the
24 certification basis of the aircraft when it is deemed

1 necessary because of an unsafe condition.

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

5 THE WITNESS: Yes. Yes, it certainly does.

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

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

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

24 MR. PHILLIPS: What's motivated that change

1 in corporate thinking over the last three or four
2 years?

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

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

15 THE WITNESS: Yes, it is.

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

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

1 today.

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

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

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

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

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

20 THE WITNESS: It would be something that
21 certainly could be done if we had enough resources to
22 do it and we felt that it was a priority thing to do.
23 I think the key about looking back is saying to
24 yourself, do you have enough information that leads you

1 to believe that that's the best use of your resources.

2 Going back and recertifying aircraft to today's
3 standards.

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

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

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

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

1 to change regulations?

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

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

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

18 MR. PHILLIPS: Let me try it a little
19 differently. Thirteen O-nine specifically is a fairly
20 new -- has been revised recently to cover very specific
21 regulation. It talks about probability. If you wanted
22 to -- say you have 25.671, which is flight control's
23 definition. Would you want to generate advisory
24 circulars independent of -- well, let's back off that

1 question. I've lost my train of thought there.

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

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

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

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

1 I know the FAA will accept it.

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

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

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

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

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

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

1 FAA regulations.

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

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

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

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

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

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

24 CHAIRMAN HALL: Mr. Phillips, excuse me just

1 one moment. Mr. Laynor has a clarification question he
2 would like to ask.

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

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

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

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

19 CHAIRMAN HALL: Please proceed, Mr. Phillips.

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

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

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

14 THE WITNESS: Absolutely.

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

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

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

23 THE WITNESS: Yes, we do. In fact, I think
24 if my memory serves me correct, the advisory circular

1 is in final draft. That deals with the definition of
2 that and a couple of other terms that the CDR reports
3 asked for definitions on.

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

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

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

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

17 THE WITNESS: Well, I may not use the word
18 "require." Let me just use the words "what kind of
19 people do we normally hire," because there are really
20 no requirements. Most of the people, with very few
21 exceptions, that come to the aircraft certification
22 organization have years of experience. I would say
23 most of them, more than five years experience with the
24 industry. If they're engineers, they've worked with

1 one of the design organizations in the United States.
2 If they are inspectors, they've been either with a
3 manufacturer or with the Air Force.

4 It's very difficult for us to train a large
5 number of employees directly out of college. Really
6 what needs to have -- what needs to be seen by
7 everybody is both sides of every issue. If you've been
8 out there trying to deal with the engineering and
9 sciences in the design of products, you have one view.

10 The FAA, you have a slightly different view. Science
11 hasn't changed, but just kind of the view has changed.

12 We think the meriting of those two is really
13 the best kind of person for us. I would just point to
14 Mr. Cook, Werner Koch, in the example that he spent
15 many, many years in industry before he came to the FAA.

16 Those people are instantly full performance as far as
17 we're concerned.

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

22 THE WITNESS: Yes, it is.

23 MR. PHILLIPS: Is there oversight of an
24 engineer -- does the final decision for an

1 airworthiness directive or any kind of an action,
2 regulatory action by the FAA, lie on one person's
3 shoulders?

4 THE WITNESS: The major decisions usually do
5 not. There is consultation with more senior engineers.

6 In fact, we are instituting just this year a senior
7 engineer program within the FAA, with an associated
8 grade raise and everything that goes with it, to
9 encourage them to be facilitators of technical issues,
10 to be the ones that the junior engineers come to. The
11 supervisors also generally have years and years of
12 experience. There's consultation.

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

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

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

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

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

1 manufacturer says.

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

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

8 THE WITNESS: I don't really know.

9 MR. PHILLIPS: Is the lead airline concept
10 new?

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

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

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

23 MR. PHILLIPS: Yesterday, we heard testimony
24 from Mr. Newcombe. Do you -- are you a manager who

1 oversees Mr. Newcombe's work?

2 THE WITNESS: No.

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

5 THE WITNESS: Yes, I am.

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

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

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

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

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

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

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

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

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

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

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

19 We are also looking at in the long term
20 trying to do the same kind of large data retrieval with
21 transport airplanes. It's not just -- and we're going
22 beyond just the warranty stuff. There are several
23 databases out there that are being gathered to track
24 events. And we're really looking at trying to see if

1 in the long term we can design some kind of a computer
2 engine that just goes out and finds all of this data,
3 brings it all in, analyses it, and starts flagging what
4 needs to be done.

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

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

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

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

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

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

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

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

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

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

23 THE WITNESS: Well, certainly our request of
24 SAE is an openness to look at whether or not we should

1 change it. Like everything else that we do, we work
2 quite hard to not restrict design and not overly design
3 products. We think that the people who design the
4 products are better at it than we are.

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

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

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

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

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

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

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

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

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

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

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

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

23 We believe in the long run -- and there have
24 been some growing pains with ARAC, but we believe in

1 the long run, that this consultative open process
2 enables us to have better notices of proposed rule
3 making, better advisory circulars with everybody's
4 input, and actually in the long run saves resources.

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

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

10 THE WITNESS: Very much so.

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

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

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

23 We do have what we call a harmonization work
24 program between the U.S. FAA and the JAA with industry

1 involvement to bring those two regulations together.
2 The British, I believe, have four categories. It may
3 even be that the JARs have four categories under 1309.

4 But we are in the process of harmonizing those, so
5 that there is one set of standards that the industry
6 has to meet.

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

11 We have discovered that in the JARs, that comma, in
12 effect, is not there.

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

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

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

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

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

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

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

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

22 They must literally debate and reach an
23 agreement as to which one is right or maybe there is
24 some in between that's right. But we do not allow them

1 to simply just draw an envelope. That is not
2 harmonization. That's just simply trying to do your
3 job as quickly as you can.

4 There have been some changes in both
5 directions.

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

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

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

21 THE WITNESS: Well, the engineers and the
22 ACOs review the service difficulty reports that have
23 been submitted by the airlines and operators and users.
24 We also get reports under a regulation 21.3 of

1 significant events directly from the manufacturers that
2 are required to report specified events. In fact, the
3 airlines are required under Part 21 to report SDRs,
4 unspecified events.

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

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

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

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

23 THE WITNESS: SDRs is one I think is very
24 good. There is a cut-off point, as was mentioned

1 earlier. I don't know exactly what date it is. I know
2 we've -- I've seen electronically recovered data back
3 to 1980. So that's quite a ways back. I think the
4 ASRS reporting system is a very good reporting system.

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

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

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

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

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

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

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

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

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

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

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

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

21 THE WITNESS: Yes, I am.

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

24 THE WITNESS: Well, I support the critical

1 design review recommendation on that. I know it's
2 being evaluated by the ACL. I know there are some
3 thoughts to redesign parts of it. I certainly support
4 those efforts. The key is going to be whether it's
5 really going to make an improvement and whether that
6 improvement is necessary.

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

10 THE WITNESS: I do not believe that.

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

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

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

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

1 most, failure.

2 MR. PHILLIPS: No auto pilot vents that may
3 be misdiagnoses or anything?

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

13 MR. PHILLIPS: In your opinion, is it a
14 safety -- an auto pilot failure, is it a safety flight
15 critical issue?

16 THE WITNESS: No.

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

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

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

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

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

24 MR. PHILLIPS: It sounds like this is

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

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

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

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

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

13 MR. JACKY: Good morning, Mr. McSweeney.

14 THE WITNESS: Good morning.

15 MR. JACKY: I wanted to ask you a couple of
16 questions regarding certification of the 737. When the
17 737 was first certified back in 1965, 1966, were there
18 flight tests accomplished in order to -- or as part of
19 that certification?

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

24 CHAIRMAN HALL: Did I hear you correctly,

1 there's no one left with the FAA employed that was
2 there at the time of the certification?

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

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

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

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

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

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

17 THE WITNESS: I believe that's true.

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

24 THE WITNESS: Well, if we had a rule that

1 required or had the words in it normal, normal use or
2 normal operating environment, then I would say we would
3 -- if it was a control surface, we would look at what
4 we expected the normal use of that control to be.

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

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

15 THE WITNESS: Okay.

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

24 THE WITNESS: Yes. The FAA was taking

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

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

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

22 In fact, they had a meeting just yesterday.
23 The document that the working group has prepared
24 dealing with this recommendation and other

1 recommendations on flight data recorders that the board
2 has recommended that are issued to the FAA, is a part
3 of that package.

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

6 THE WITNESS: I don't believe there is.

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

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

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

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

1 condition.

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

4 THE WITNESS: Yes, they were.

5 CHAIRMAN HALL: Very well.

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

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

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

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

23 THE WITNESS: Yes.

24 MR. JACKY: How does that differ in length of

1 time to a regular ARAC committee?

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

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

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

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

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

23 CHAIRMAN HALL: Could you provide that for
24 the record?

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

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

7 THE WITNESS: Fine.

8 CHAIRMAN HALL: If that's no problem.

9 THE WITNESS: No problem.

10 CHAIRMAN HALL: I mean, when we --

11 THE WITNESS: I can give you ~~an~~ almost
12 tomorrow, I think.

13 CHAIRMAN HALL: That would be fine. Thank
14 you.

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

17 THE WITNESS: Yes, we have.

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

20 THE WITNESS: The discussion that I'm
21 familiar with -- and I'm sure the people on the working
22 group have had other discussions, because I would be
23 surprised if Boeing isn't a part of the working group.
24 The ones I recall dealt with the possibility of

1 installing a bracket up into the rudder area in the
2 horizontal -- vertical stabilizer area to measure cable
3 position as a substitute for pedal position in the
4 cockpit. Therefore, having cable position before the
5 PCU measured and then surface after being measured.

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

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

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

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

24 It was -- there have been extensive

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

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

7 THE WITNESS: As short as a year.

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

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

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

24 CHAIRMAN HALL: But it is technologically

1 feasible to do that?

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

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

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

12 CHAIRMAN HALL: Where did you get your
13 information?

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

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

21 THE WITNESS: Well, the time depends on it
22 seems quite significantly on an issue that has come up
23 as to whether the AFT laboratory has to be removed or
24 not. Times that we have been given and look reasonable

1 to us are anywhere from two to three days down time for
2 the airplane.

3 The Air Transport Association provided a
4 chart showing all the tasks necessary to accomplish it.

5 There are some 70 to 75 tasks, depending on whether
6 you take out the laboratory. That chart shows a time
7 frame of between two to three days.

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

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

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

24 I am also personally concerned about

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

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

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

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

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

22 CHAIRMAN HALL: Well, do you have any other -
23 - does the FAA have any other responses that we should
24 be doing to monitor the safety of this airplane, since

1 we have two accidents and we have yet to determine the
2 cause?

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

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

7 THE WITNESS: What? To monitor?

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

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

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

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

1 that.

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

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

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

1 And if this recommendation is not acceptable,
2 then we would sit -- certainly sit down and try to work
3 out something that would be in the interest of safety.

4 I know you and the airlines share the interest that we
5 at the board and the American public has in safety of
6 flight.

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

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

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

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

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

22 (General laughter.)

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

1 9X-A. There are three recommendations there; 20, 21,
2 and 22. And they address the issue of third party as
3 far as 36 approval to manufacture parts.

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

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

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

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

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

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

24 THE WITNESS: Oh, absolutely. Yeah, we

1 intend to do that.

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

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

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

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

1 small.

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

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

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

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

18 MR. PHILLIPS: Okay.

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

23 MR. PHILLIPS: So as a result of this work,
24 will the FAA attempt to verify that the parts that are

1 being manufactured for the 737 by third-party vendors
2 now, meet the requirements of these recommendations?

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

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

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

20 We have all that data. We have all that
21 data.

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

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

3 MR. PHILLIPS: Des that exist today?

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

6 MR. PHILLIPS: I have nothing else.

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

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

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

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

23 THE WITNESS: I would say in all cases, it
24 would be by assessing the consequences of a deviation

1 in that tolerance or whatever the process was. If a
2 deviation would result in a continued safe flight and
3 operation problem, then that would be a critical
4 element of that part.

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

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

9 MR. LAYNOR: Yes.

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

19 MR. LAYNOR: Okay. Thank you.

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

22 MR. HAUETER: Yes, I have a couple.
23 Concerning the modifications to the rudder power
24 control unit, do you know the status of those

1 modifications, the percentage that have been completed
2 or where that stands?

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

7 MR. HAUETER: That's correct.

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

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

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

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

22 THE WITNESS: Excuse me. I think I missed.

23 MR. HAUETER: What do you plan -- when Boeing
24 finishes their design work, is there plans to make that

1 an AD or how is that going to be handled, do you know?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

23 THE WITNESS: I've discussed it personally
24 with Mr. Don Rigglin.

1 MR. HAUETER: Was Mr. Riggin involved in the
2 original certification of the airplane?

3 THE WITNESS: No, he was not.

4 MR. HAUETER: When did he join?

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

8 CHAIRMAN HALL: Are there records still
9 available?

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

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

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

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

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

24 MR. HAUETER: Are you familiar with the study

1 heading side slip tests that were conducted as part of
2 the simulator validation?

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

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

13 THE WITNESS: Somewhat familiar.

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

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

20 MR. HAUETER: Correct.

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

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

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

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

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

23 MR. HAUETER: Thank you, sir.

24 CHAIRMAN HALL: Any other questions from the

1 Technical Panel?

2 (No response.)

3 CHAIRMAN HALL: If not, we'll move to the
4 parties. Any questions for this witness from the
5 parties? I see the hand of the Airlines Pilot
6 Association and I see the hand of Boeing. Anyone else?

7 Mr. Donner, you have no questions of your boss here?
8 No.

9 (General laughter.)

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

13 MR. PURVIS: Good morning.

14 THE WITNESS: Good morning.

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

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

24 MR. PURVIS: That's all I have.

1 CHAIRMAN HALL: Captain, Airline Pilots
2 Association?

3 CAPTAIN LeGROW: Thank you, Mr. Chairman.
4 Good morning, Mr. McSweeney.

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

7 CAPTAIN LeGROW: It's still morning.

8 THE WITNESS: Barely.

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

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

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

1 CAPTAIN LeGROW: Okay. I'll ask Mr. Berven.

2 Along that same line, as I understand it in 1967 -- I
3 guess there's nobody left in the FAA 28 years later?

4 THE WITNESS: Not that we know of.

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

8 THE WITNESS: That's probably a good
9 assumption.

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

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

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

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

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

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

8 THE WITNESS: I have no knowledge of that.

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

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

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

23 THE WITNESS: Extremely improbable means an
24 event would occur no more than once in the entire

1 lifetime of a fleet of aircraft. It doesn't say that
2 that event would occur in the very last year of
3 operation or the very last aircraft.

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

7 THE WITNESS: We would assess that event and
8 look at whether we needed to fix whatever it was that
9 caused that event. I mean, when we look at the
10 probability assessments, it's a way of dealing with
11 stuff that we kind of maybe don't know what might
12 happen. We're all human. We do the best job we can,
13 but we got to where we are with the level of safety --
14 this level of safety of 10 minus 9, or 10 minus 8, or
15 10 minus 5 for the probable events.

16 Once we see an event and we say, gee, that's
17 an event we don't like, we ought to correct that event.

18 We step back from the certification of the probability
19 and we deal with that event.

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

22 THE WITNESS: Right.

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

1 THE WITNESS: Right.

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

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

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

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

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

3 THE WITNESS: Right.

4 CAPTAIN LeGROW: -- it's my understanding
5 that -- or is it your understanding that the airplane
6 will be certified to the same standards as the 757 and
7 767 and 777 or will it be certified under the same
8 certification criteria of 1967 and the 100, 200, 300,
9 400, and 500?

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

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

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

22 THE WITNESS: Yeah, close. It's probably
23 more than that. If the certification took place in
24 '67, the cert basis was probably established when the

1 application was made in, I would guess, '62 or
2 someplace like that.

3 CAPTAIN LeGROW: Does the FAA consider latent
4 failures?

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

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

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

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

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

21 CAPTAIN LeGROW: You talked earlier about the
22 737 when it was certified. The full deflection of the
23 controls were not a criteria in the certification.
24 What guidance were flight crews given to this? In

1 other words, to rephrase that, were the flight crews --
2 did the flight crews know that that was not a criteria
3 in the certification of the airplane?

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

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

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

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

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

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

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

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

24 THE WITNESS: Okay.

1 CAPTAIN LeGROW: I think Mr. Haueter asked a
2 couple of questions. My question is, has the FAA, to
3 help satisfy this recommendation, considered mandating
4 Boeing to either increase the lateral control of the
5 737 or limit the yaw capabilities of the 737?

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

12 The rudder, as we mentioned earlier, is sized
13 for engine out to a great extent. You reduce the
14 rudder affectivity in any way and you've got a problem.

15 You've got to deal with engine out. If you increase
16 the roll authority -- if you go too far on the ailerons
17 and I'm not an aerodynamics expert, but it seems
18 logical to me that if you go too far up on the ailerons
19 or down on the ailerons, you could get flow separation.

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

1 the next accident.

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

4 THE WITNESS: Right. I understand that.

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

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

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

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

17 CAPTAIN LeGROW: Could you elaborate on
18 those, please?

19 THE WITNESS: Well, you're in an area where
20 I'm not, again, an expert in the piloting and the
21 performance. But there have been discussions about
22 different speeds for the flaps, raising the speeds.
23 The part of that that I am familiar with is the
24 structural part. And operating more frequently at a

1 higher flap speed will, in fact, cause the higher loads
2 on the flaps to occur more often, which affects the
3 fatigue life on the flaps.

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

12 We are discussing all of that internally
13 still.

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

24 Did they give you any indication of exactly

1 how many man hours that involved, from start to finish?

2 From the time the airplane got in the hanger until the
3 airplane went out, how many man hours it would take to
4 do this?

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

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

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

20 CHAIRMAN HALL: Thank you, Captain. I do
21 feel that I should point out that a statement that you
22 made, which I'm sure you were intending to be a
23 hypothetical statement. I don't want there to be any
24 misinterpretation by the audience, that there has been

1 a full rudder deflection on the plane twice in the last
2 five years.

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

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

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

16 (No response.)

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

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

23 THE WITNESS: It involves two to three days
24 of consecutive down time.

1 MR. DONNER: Thank you.

2 CHAIRMAN HALL: Mr. Clark.

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

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

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

19 THE WITNESS: Yes, it is a major impediment.

20 MR. CLARK: Who provided that data?

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

24 MR. CLARK: But the airline feeds their

1 information through ATA, Air Transport Association?

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

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

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

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

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

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

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

24 One of them was an urgent recommendation.

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

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

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

19 Please proceed.

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

22 THE WITNESS: Two to three.

23 MR. CLARK: Two to three, I'm sorry. We've
24 talked about possibilities and probabilities. Is it

1 possible that ATA inflated those figures to forward the
2 urgent nature of this recommendation, so they can take
3 the two to five years?

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

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

9 THE WITNESS: Right.

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

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

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

24 MR. CLARK: Is that discussion going on

1 within FAA today on this --

2 THE WITNESS: Yes, it is.

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

4 THE WITNESS: Yes, it is.

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

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

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

17 THE WITNESS: It is, yes.

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

21 THE WITNESS: Yes, there is.

22 MR. CLARK: -- it can be accomplished in a
23 series of overnights or that it is important enough to
24 implement these recommendations, even though the

1 airplanes may be on the ground for an extra day or two?

2 THE WITNESS: Yes, there is that possibility.

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

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

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

23 The airlines seem to think that really even
24 to do this on a C-check, it will require an extension

1 of the C-check. By how much, maybe we're in the area
2 of inflated numbers. I don't know. But if you extend
3 the C-check any amount, you reschedule every airplane
4 in the system, because they are all scheduled based
5 upon they're going to be in this place at this time and
6 then the C-check is due.

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

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

11 THE WITNESS: Yes.

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

14 THE WITNESS: Not intimately, no.

15 MR. CLARK: In one sense, and I may be mixing
16 apples and oranges, you commented earlier about the two
17 and a half years to implement part of the
18 recommendations for the existing fleet, other than the
19 737. Are there considerations made to implement the
20 737 concurrent with C-checks or is the -- wouldn't that
21 at least minimize the time that the airplane would be
22 down?

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

1 MR. CLARK: Well, I'm still talking about the
2 737.

3 THE WITNESS: Just the 737?

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

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

10 MR. CLARK: How often do they come up?

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

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

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

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

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

11 MR. CLARK: Who writes those issues?

12 THE WITNESS: I don't know.

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

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

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

19 THE WITNESS: Yes.

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

1 lateral controllability.

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

4 MR. CLARK: Some of the issues.

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

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

9 THE WITNESS: Right.

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

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

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

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

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

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

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

19 THE WITNESS: It would be --

20 MR. CLARK: Who sets the policy for Mr.
21 Riggin to make sure that those are all properly
22 resolved?

23 THE WITNESS: It would be Mr. Riggin's
24 responsibility to do it with appropriate management

1 oversight by Ron Wojnar, the manager of the transport
2 directorate, Mr. Stu Miller, who's the manager of the
3 transport policy staff who gives transport policy, and
4 myself and my deputy Beth Yost. I can assure you that
5 all of those people will be in that chain.

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

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

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

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

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

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

1 at Boeing and the FAA.

2 MR. CLARK: But the issue is -- is the issue
3 simply the simulator? I mean, the airplane gave us a
4 demonstration of controllability and we'll be
5 discussing that with the test pilots here in a little
6 bit. But the issue comes back -- am I reading, that
7 you're going to use the simulator to explore those
8 issues further in the reliable controllability?

9 THE WITNESS: I don't have knowledge at this
10 point of exactly what our plan would be to revalidate
11 or relook at the simulator. The point is that if we're
12 going to use the simulator to go out and look at areas
13 of the envelope of that aircraft that we didn't look at
14 in flight tests, we ought to have that validated
15 simulator in there -- that simulator data in there, and
16 that's why we really thought those tests were
17 important.

18 MR. CLARK: Get the simulator down and then
19 you can go do the --

20 THE WITNESS: Right, we're not going to fly
21 to some parts of the envelope.

22 MR. CLARK: -- parameter studies.

23 THE WITNESS: That's not the safest thing to
24 be doing.

1 MR. CLARK: Sure.

2 THE WITNESS: The other thing that you're
3 going to get out of the simulator that you don't get
4 out of the actual airplane is all the what ifs that you
5 want to set up, that you really want to explore
6 instability or marginal conditions.

7 MR. CLARK: Pilot reaction and pilot
8 recovery?

9 THE WITNESS: All of that, right. Although,
10 you're recognizing that the end cap simulator doesn't
11 give you G's.

12 MR. CLARK: The one feedback in the vertical
13 direction.

14 THE WITNESS: Yeah.

15 MR. CLARK: The last area that I would like
16 to cover. We talked about the airworthiness directive
17 dealing with the servo valve and the over travel. That
18 comes under your area also, somewhere down the
19 certification line. Are you aware if any other
20 manufacturers or, I guess, Mr. Walz talked about third
21 party. Are any other third-party people out there
22 approved to implement this AD?

23 THE WITNESS: I don't specifically know the
24 answer to that. But let me, though, describe what the

1 AD requires and that partially answers your question.
2 The AD requires that a specific part number be placed
3 in that PCU. That part number is manufactured by one
4 person, one company.

5 If any other company under a PMA or an S-FAR-
6 36 or an owner-operator of an aircraft were to decide
7 they wanted to manufacture their own part, it would
8 require an alternate means of compliance to the
9 airworthiness directive, because that part number would
10 be a different part number than the one referred to in
11 the AD. That would require the by AD language, that
12 would require the ACO in Seattle to approve that.

13 It's exactly the chain that the CERT team
14 recommended be done for critical parts. So we feel
15 very comfortable that if there's anybody out there that
16 would ever want to make one of the new parts, we've got
17 the right surveillance of it.

18 MR. CLARK: But you're not aware right now if
19 anybody is doing that --

20 THE WITNESS: No, I'm not aware.

21 MR. CLARK: -- other than Parker?

22 THE WITNESS: I'm not aware at this point.

23 MR. CLARK: They may be, but you're not
24 aware.

1 THE WITNESS: I thought I heard Parker was
2 providing them for free.

3 (Laughter.)

4 THE WITNESS: I don't know. But if they
5 were, I can't believe that anybody would ever want to
6 go out and pay for one.

7 MR. CLARK: Well, okay. Thank you.

8 CHAIRMAN HALL: Mr. Marx.

9 MR. MARX: I'm a little bit confused about
10 what -- I've heard the statement on the standby rudder
11 as any galling in that position would not be an unsafe
12 condition. I also heard that this is not a safety of
13 flight issue. Could you tell me what your reasons why
14 you think this is not an unsafe condition?

15 THE WITNESS: We articulated those in a
16 document, which withdrew an airworthiness directive
17 dealing with the galling on the standby actuator. It
18 was a proposed AD. And basically -- I don't remember
19 all the details, but it was basically four cues that we
20 thought were available to tell the pilot. And I don't
21 know if maintenance was also involved in that list, but
22 four cues that would identify that galling was taking
23 place.

24 We also believed that if there was galling,

1 if there is a full seizure, that it would not be an
2 unsafe condition. So on the basis of that, we withdrew
3 that proposed airworthiness directive.

4 MR. MARX: Do you know what those ~~ues~~ are?

5 THE WITNESS: Not offhand, no.

6 MR. MARX: Do you consider galling on the
7 standby rudder to be an extremely remote condition, a
8 probability or would you consider it?

9 THE WITNESS: I really wouldn't know. I
10 don't have any numbers on how often it occurs.

11 MR. MARX: If you knew that it occurred on
12 two airplanes or even three airplanes, would you
13 consider that extremely remote?

14 THE WITNESS: Sixty-seven million flight
15 hours is about 1.5 times ten to the minus eight
16 reliability. If it occurred three times, that would be
17 4.5 times ten to the minus eight. So that's a pretty
18 remote event.

19 MR. MARX: Well, has the FAA looked at the
20 actual bearings, the shafts and the bearings to find
21 out if they had galling and taken a check of airplanes
22 and fleet to find out what the probability is for
23 galling?

24 THE WITNESS: I really don't know if the ACO

1 has done that. The people that would be doing it would
2 be the systems engineers, Ken Frey and others like that
3 in the Seattle ACO. I have really no knowledge of
4 whether they have done that or not.

5 MR. MARX: What's a consideration for a
6 single hydraulic failure in an airplane? Is that
7 considered something that we would need to take into
8 account?

9 THE WITNESS: Under today's rules, you must
10 account for a single failure.

11 MR. MARX: I would like to refer you to
12 Exhibit 9X-I, page 3 and page 4. Actually, it's at the
13 end of page 3 and at the end of -- and the start of
14 page 4.

15 CHAIRMAN HALL: Nine-X what again, I?

16 MR. MARX: I.

17 CHAIRMAN HALL: Nine-X-I.

18 THE WITNESS: Okay.

19 MR. MARX: This states and I'll say, it says,
20 "In the event of a single hydraulic system failure, the
21 standby hydraulic system will come on automatically
22 when the flaps are not in the up position." What is
23 your understanding of that?

24 THE WITNESS: I'm not familiar with that part

1 of the design. I couldn't tell you. My assumption is
2 that's a valid description of the Boeing airplane.

3 MR. MARX: So if we had a single hydraulic
4 failure, it would expect that the standby would then be
5 operational if the flaps were not in the full up
6 position?

7 THE WITNESS: I mean, I don't know. I'm not
8 familiar with this part of the design and what triggers
9 the single -- what is triggered by the single hydraulic
10 failure.

11 MR. MARX: Well, if this was true, if you had
12 a single hydraulic failure and you had galling that
13 occurred onto the bearing of the standby and all the
14 rudder control is now by the standby, would this be a
15 safety of flight issue?

16 THE WITNESS: To determine that, we would
17 have to -- I would have to look at what the resulting -
18 - deflection of the rudder, what the resulting reaction
19 on the airplane would be. I couldn't give you that
20 answer off the top of my head now.

21 MR. MARX: Okay. Thank you. That's all the
22 questions I have.

23 CHAIRMAN HALL: Did the CDR team look at that
24 issue, Mr. Marx, are you aware?

1 MR. MARX: Well, I think we've asked some
2 questions that deal with the standby, but I don't think
3 that -- there isn't anything that I could find in that
4 exhibit that would indicate that they did.

5 CHAIRMAN HALL: Mr. Schleede.

6 MR. SCHLEEDE: Thank you, Mr. Chairman. I
7 just want to try and clarify several issues here that
8 are not quite clear to me, but might be to other
9 people. First of all, Mr. McSweeny, could you describe
10 what the principal differences are between -- or
11 principal differences between the certification
12 requirements for the 737-100 to 500 versus what would
13 be required today on a new airplane?

14 THE WITNESS: I mean, without bounding~~it~~ and
15 even if you bound it, I'm not so sure I could do it. I
16 couldn't really give you paragraph or even conceptually
17 what the differences are. I mean, I'm sure we can
18 provide that, but I wasn't prepared to speak to it.

19 MR. SCHLEEDE: Well, I understand there's a
20 great bunch of detail and different amendments and so
21 forth to the rules, but in a general sense, we've been
22 talking about the requirements for FMEAs and
23 probability analyses, those type of things. The
24 broader certification requirements.

1 THE WITNESS: If you're talking about control
2 systems, it's basically that back when the 737 was
3 certified, it was what we call a single failure rule.
4 We now have single failures and multiple failures not
5 shown to be extremely improbable. That change came
6 about approximately the time and I believe was
7 connected to the fact that airplanes were moving from
8 manual reversion airplanes to full all-powered non-
9 manual reversion airplanes. That kind of thinking
10 going to multiple failures would be very logical kind
11 of thinking at that time.

12 MR. SCHLEEDE: And please describe for us
13 again the single failure philosophy?

14 THE WITNESS: Well, the single failure
15 philosophy is your protect against single failures.

16 MR. SCHLEEDE: And at that time, you did not
17 have to calculate -- quantify the probability of
18 failures?

19 THE WITNESS: I don't believe so, no.

20 MR. SCHLEEDE: Well, it's my understanding
21 then. I just wanted to see if that's a fact. You were
22 not required to do the probability analyses in 1965?

23 THE WITNESS: Probability analyses in 1309
24 was not on the books in the '60s, in the late '60s.

1 MR. SCHLEEDE: Do you have Exhibit 9X-N as in
2 November? Its title is "Critical Design Review,
3 Executive Summary."

4 THE WITNESS: Right.

5 MR. SCHLEEDE: And the pages aren't numbered,
6 but there's slide numbers down in the bottom left
7 corner. I would like to go to slide number 10. I
8 don't believe there's a page number on it. It's like
9 three from the end. These are the results of the CDR
10 executive summary of their report?

11 THE WITNESS: Correct.

12 MR. SCHLEEDE: I would like to talk about the
13 first one there, "The Boeing 737 meets all
14 certification requirements." Do you agree wiht that
15 conclusion?

16 THE WITNESS: Yes.

17 MR. SCHLEEDE: And that's based on the CDR
18 findings?

19 THE WITNESS: That's based on the CDR team's
20 full assessment of the certification of the aircraft.
21 Those are the certification requirements listed in the
22 type data sheet for the 737 airplane.

23 MR. SCHLEEDE: And did that basis require --
24 or include the failure analysis of certain components?

1 THE WITNESS: I don't believe it did.

2 MR. SCHLEEDE: It did not?

3 THE WITNESS: I don't believe it did, no.

4 MR. SCHLEEDE: Well, there was a failure
5 analysis produced for the airplane as part of its
6 original certification, various items --

7 THE WITNESS: I'm aware that there was one --

8 MR. SCHLEEDE: Have you ever reviewed it?

9 THE WITNESS: -- that the team looked at.
10 I'm not aware of it. I haven't looked at it myself.

11 MR. SCHLEEDE: You haven't looked at it?

12 THE WITNESS: No.

13 MR. SCHLEEDE: You've described and defined
14 for us an extremely and probable event as one that can
15 occur one time in the life of the aircraft?

16 THE WITNESS: Life of a fleet of aircraft.

17 MR. SCHLEEDE: The fleet of the aircraft. I
18 presume that means then it cannot occur twice. If one
19 occurs twice, that definition -- it cannot be
20 characterized as extremely improbable?

21 THE WITNESS: Technically, no, it could not.

22 MR. SCHLEEDE: Could not. Okay. If it was -
23 - something was certified under that and determined to
24 be extremely improbable and then there were -- if

1 there's one failure, first of all, is there any action
2 necessary?

3 THE WITNESS: It would really depend on the
4 failure. As I mentioned before, when you have a
5 failure in-service and that failure is a serious
6 failure, I think you're compelled to correct it. I
7 don't think you can go back and recalculate the number
8 and say, well, gee, that was ten in the minus, still
9 ten in the minus. So we're going to forget about that
10 failure. I don't think anybody in the FAA would think
11 that way.

12 MR. SCHLEEDE: And how is that number
13 calculated?

14 THE WITNESS: With a lot of experience and a
15 lot of engineering knowledge. We, for instance, have
16 reliability and probability assessment training courses
17 for our own people just because it is an art. It takes
18 a fair amount of experience to know how to do it. And
19 it takes experience with equipment.

20 Most people that do it --like, for instance,
21 engine manufactures. I speak of that as an example,
22 because I -- we recently had some discussions at my
23 level about it. When they look at the probability, say
24 a fan blade failure or things like that, they throw in

1 factors about that count for the fact that the system
2 is maybe a new technology. They'll maybe knock it down
3 by a factor of three or four.

4 It's probably very conservative, but yet they
5 recognize that some of the estimates that they might be
6 making aren't that all fact based yet, and so they
7 account for that, and we would certainly require that
8 kind of a conservatism on new technology.

9 MR. SCHLEEDE: If I recall right from some of
10 the testimony or from the earlier testimony, other
11 witnesses and yourself -- but I think Mr. Kullberg has
12 told us that since the CDR, that Boeing Company --
13 based on the CDR recommendations, the Boeing Company
14 has submitted to the FAA its analysis of the rudder
15 directional control system and determined that a
16 hardover failure to be extremely improbable. Were you
17 here during his testimony?

18 THE WITNESS: Yes, I was.

19 MR. SCHLEEDE: Have you -- has the FAA
20 evaluated and agreed to that submission from Boeing?

21 THE WITNESS: We have not finished our review
22 of it. And, in fact, we're asking some of the more
23 knowledgeable people within aircraft certification in
24 the area of reliability assessments and probability

1 assessments to take a review of all of those reports
2 that have been submitted.

3 MR. SCHLEEDE: And is that one of the reports
4 that you think you will have your results done at the
5 end of this month?

6 THE WITNESS: The ACO has indicated to me
7 they plan to have their assessment done by the end of
8 this month.

9 MR. SCHLEEDE: Along the same lines, there's
10 a couple of terms that we've used here and are used in
11 the regulations, and I'm not sure you've been asked to
12 define it. If you can, the term "uncontrollable event"
13 and "unrecoverable event."

14 THE WITNESS: Right. I can try to do my
15 best. I'm sure Mr. Berven will be able to probably do
16 a far better job than I. But uncontrollable is a
17 flight test term. It's what I would in my mind say is
18 an arbitrary term. And what it usually means is that
19 the particular event has exceeded what we consider to
20 be either a requirement limit or a reasonable limit and
21 it's simply that. That we have set a limit.

22 Let's say you're in a stall and you fully
23 recover from that stall after three turns. The rule
24 says you can't go three turns. So we would say that

1 maneuver is uncontrollable, because it has exceeded
2 this limit that we have set. But yet that maneuver
3 might still be fully recoverable, as the example I
4 gave, the stall.

5 MR. SCHLEEDE: That's the uncontrollable.
6 Now, how about recoverable? Did you --

7 THE WITNESS: Well, recoverable means that
8 you would recover the aircraft without an accident, in
9 my mind.

10 MR. SCHLEEDE: So you could go out of
11 control, yet not crash --

12 THE WITNESS: Be recoverable.

13 MR. SCHLEEDE: -- and be recoverable.

14 THE WITNESS: Absolutely. Now, the problem
15 that I see is I believe that not everybody is using the
16 word controllable as it was used when it was first
17 controlled or conceived by the flight test community.

18 MR. SCHLEEDE: So uncontrollable is in the
19 regulations and in the certification process is defined
20 by some arbitrary --

21 THE WITNESS: I don't know if the word --
22 well, I don't know if the word "uncontrollable" or even
23 -- well, I'm sure the word "controllable" is in the
24 regulation some place. But some of our -- like our

1 flight test advisory circular goes through all the
2 various regulations in Part 25 and says there's a lot
3 of pilot judgment that goes into a lot of stability and
4 handling qualities and things like that.

5 And we've issued advisory circulars that
6 says, for instance, on an auto pilot runaway, you can't
7 exceed X number of degrees of roll angle. I think it's
8 60 degrees or something like that. We consider that
9 uncontrollable. If you had 65, sorry, you didn't meet
10 the intent of what we think the rule meant.

11 MR. SCHLEEDE: Well, I'm sure we can ask Mr.
12 Berven some questions, but I just wanted to ask you
13 some on the same area. We also -- in some of the
14 certification language and documents we've seen, the
15 phrases are certain events that occur are rationalized
16 by the pilot of being able to recover or maintain
17 control -- I'm not sure of the exact word -- without
18 using exceptional --

19 THE WITNESS: Exceptional piloting skills.

20 MR. SCHLEEDE: -- piloting skills. Could you
21 help us figure that one out?

22 THE WITNESS: I will decline that request. I
23 do -- I am not an expert on exceptional piloting
24 skills. I am not a pilot. I would really not want to

1 hazard any kind of an opinion on that.

2 MR. SCHLEEDE: I appreciate that. But it is
3 a term that's used in the certification --

4 THE WITNESS: Yes.

5 MR. SCHLEEDE: -- in the world and the
6 documents, and it's something that we're trying to
7 understand.

8 THE WITNESS: Right. Frankly, because it is
9 subjective in some regards, when we do a certification
10 program, if we have any doubts about that subjective
11 criteria, we can form what we call MEOTs, multiple
12 expert opinion teams and it would basically -- in this
13 case if it was a pilot thing, it would be three or four
14 pilots that would fly the same aircraft. And that team
15 would come up with a decision that they would then
16 submit to management as the team's opinion of that
17 particular aircraft.

18 Now we have done that in the past. Not very
19 frequently, but we have done it.

20 MR. SCHLEEDE: I'm going to try to pull this
21 together in one more question. If we have an extremely
22 improbable event that occurs and it results in an
23 uncontrollable situation and unrecoverable, in both, is
24 that in the certification world an acceptable

1 situation?

2 THE WITNESS: Yes, because the rule says you
3 must protect against multiple failures not shown to be
4 extremely improbable. If the failure condition is
5 extremely improbable, it is acceptable.

6 MR. SCHLEEDE: Well, part of our dilemma, I
7 think, or at least mine -- maybe I'm the only one -- is
8 that the FAA has not made a determination about the
9 rudder hardover being an extremely improbable event.
10 That determination has not been reached by the FAA.
11 And yet, what we understand from the data and from our
12 investigation, that in certain flight regimes, the
13 lateral control system is insufficient to handle a
14 hardover rudder.

15 Can you help me understand, see my perplexion
16 here? Does that airplane meet requirements?

17 THE WITNESS: Well, the airplane, as the CDR
18 team correctly determine, meets its certification
19 basis.

20 CHAIRMAN HALL: What is its certification
21 basis, 1960?

22 THE WITNESS: Right. That certification
23 basis listed in the data sheet. Now, the CDR team went
24 beyond that, and that's -- and I think the question you

1 raised is the question that they have raised to
2 themselves, which I would say postulated the
3 recommendations they made, let's go back and look at
4 that. And that's what we're really trying to do right
5 now.

6 MR. SCHLEEDE: Well, maybe I'm confused
7 because of the summation in the results section of the
8 executive summary says the Boeing 737 meets all
9 certification requirements.

10 THE WITNESS: Right.

11 MR. SCHLEEDE: I was just trying to fair it
12 out. It's all of the certification requirements that
13 existed in 1960.

14 THE WITNESS: That it's required to meet,
15 right.

16 MR. SCHLEEDE: I've still got some more here.

17 THE WITNESS: Now, keep in mind, we have not
18 stopped at just that statement. That's what the whole
19 CDR is about and that's what the whole discussion is
20 about at this hearing, I would say, or Board of
21 Inquiry. Let me be correct there.

22 MR. SCHLEEDE: In some of the original -- and
23 I asked these questions of some other witnesses
24 earlier. In the original certification failure

1 analysis, there were certain items listed and responses
2 as used as a basis for that failure analysis. One of
3 them was a jam in the directional control system that
4 would lead to a hardover rudder and that was the
5 condition listed to be evaluated. The result or the
6 response to that was that the pilot could deviate
7 hydraulic systems.

8 My question and I know the CDR team looked at
9 this, but they didn't come to definitive conclusions.
10 They just raised concerns. My concern is that there is
11 no procedure in the flight manuals for pilots for
12 hardover rudder situations to turn off the hydraulics,
13 even though this condition was cited as the proper
14 response to that condition. How do you reconcile that,
15 so that I can understand it that's not a problem?

16 THE WITNESS: Well, I would look at any
17 condition like a full rudder deflection in two phases.

18 The first phase that I would look at is getting
19 control of the aircraft. And then second phase is now
20 troubleshooting what happened and how can I resolve the
21 problem I have in front of me. I would contend that
22 that is the way the original certification looked at it
23 based upon the small amount that we can glean out of
24 some of the material we have from some of the type

1 board meetings.

2 So the first step is gain control of the
3 aircraft, level the wings or whatever. Gain a
4 reasonable altitude, and now try troubleshooting it. I
5 think it's the troubleshooting phase that this shutting
6 off of the A&B hydraulic system was talking about. I
7 don't think anybody would suggest that before
8 controlling the airplane, that anybody would start
9 shutting off hydraulic systems.

10 Unfortunately, I would say in this particular
11 accident, they never reached phase two.

12 MR. SCHLEEDE: Do you think there is the
13 ability to get to phase two under when those
14 circumstances exist?

15 THE WITNESS: Under the circumstances of 427,
16 I think there is, yes.

17 MR. SCHLEEDE: Could you explain?

18 THE WITNESS: Well, I think if the aircraft
19 were to accelerate slightly, it's my understanding from
20 talking to the people that work in aircraft
21 certification, that you would gain more authority then
22 of the ailerons. You would be able to at least write
23 the wings and pull up the aircraft. Then is the time
24 you enter phase two.

1 MR. SCHLEEDE: Then it goes back to my
2 original question about that type of a failure mode.
3 I'm not aware of any procedure or training in that
4 maneuver existing or required for pilots. So how could
5 that be an acceptable situation?

6 THE WITNESS: I think we're looking at what
7 was perceived in the minds of the certifiers back in
8 1967. I wouldn't disagree with your assumption or with
9 your statement that there are no procedures spelled
10 out. We, though, have over the years many, many events
11 where pilots have been very -- have used great
12 ingenuity in troubleshooting aircraft. And it comes
13 from their understanding of the systems during pilot
14 training on that particular aircraft during their type
15 rating.

16 I think, like some of the other things that
17 we've tried to deal with here that have given us
18 difficulty, we're trying to resurrect in the minds --
19 in our minds what people had in their minds back in
20 '67.

21 MR. SCHLEEDE: Thank you. I would like to
22 skip to a couple other subjects here. On the service
23 difficulty reporting system, I don't think you
24 mentioned specifically -- well, on the subject of how

1 you get incident input. I want to go beyond the SDR
2 system to input from the international community or
3 from the arena. How does the FAA get service
4 information on international?

5 THE WITNESS: There are a couple of ways.
6 Service information is provided back to the
7 manufacturers from the international operators through
8 a network that the manufacturers have. We have access
9 to that any time we want. We would become aware of
10 events that are of significance.

11 Also as authorities -- the authorities of
12 Europe and the United States have pretty close working
13 relationships. If there are any significant events,
14 that information is shared immediately. We talked
15 earlier about or some people talked about the roll
16 event or the oscillating roll event in England. I was
17 aware of that the day after it happened by a fax sent
18 from Peter Harper, my counterpart at the U.K. CAA.

19 Those kinds of communications are almost
20 routine. There are even -- there are more
21 communications between the working levels of those
22 authorities and the various ACOs or the Brussel's
23 office.

24 MR. SCHLEEDE: And is that frame work for

1 that type of communications within any ICAO annexes or
2 requirements?

3 THE WITNESS: Well, the only ICAO requirement
4 that I can think of that would be related would be the
5 requirement for us to provide as say the certifying
6 authority of U.S. products, service information
7 worldwide. And we do that with the airworthiness
8 directives and if there are matters that are of -- we
9 deem to be significant that aren't airworthiness
10 directives, we sometimes writes letters and send them
11 to a list of authorities that we have.

12 We know by authority throughout the world
13 which authorities have which aircraft on their
14 registry.

15 MR. SCHLEEDE: Another subject. On the
16 service bulletin issue, we understand service bulletins
17 when they're issued are not considered safety of flight
18 items. There was earlier testimony on that.

19 THE WITNESS: Service bulletins themselves
20 generally aren't. The manufacturers sometimes issue
21 redline service bulletins or make recommendations that
22 there be mandatory. They are not mandatory in the
23 sense of the FAA until we issue an airworthiness
24 directive.

1 MR. SCHLEEDE: But when a manufacturer issues
2 a plain service bulletin with no other adjective, is it
3 considered a reliability, maintainability issue or is
4 it content?

5 THE WITNESS: My impression is that most of
6 them are that or product improvement. Anything that
7 would, for instance, reduce the amount of inspection
8 time that a carrier would have to take on a product by
9 working a service bulletin, they would certainly want
10 to do that.

11 MR. SCHLEEDE: And we understand that Boeing
12 has testified they're preparing service bulletins for
13 and working on yaw damper situations and standby rudder
14 actuators. If an event such as a yaw damper
15 malfunction that's not considered a safety of flight
16 item causes an accident, does that change the --

17 THE WITNESS: Yes.

18 MR. SCHLEEDE: -- definition?

19 THE WITNESS: If an event can be proved to
20 cause an accident and a service bulletin is issued to
21 correct that event, there's almost certainty that would
22 be an airworthiness directive.

23 MR. SCHLEEDE: And this might be nitpicking.
24 But if a flight attendant gets knocked down and breaks

1 an arm, which is defined as an aircraft accident, would
2 that count?

3 THE WITNESS: Yes. We would give great
4 consideration to that event as being an unsafe
5 condition.

6 MR. SCHLEEDE: One other question regarding
7 the testimony of the SAE committee and the assistance
8 that you've asked for on the fluid contamination. Was
9 it -- I think I understood from the testimony yesterday
10 from Mr. Knerr, that the FAA came to him or the
11 committee in October for assistance? The SAE --

12 THE WITNESS: A-6.

13 MR. SCHLEEDE: The SAE committee, is that
14 correct, in October?

15 THE WITNESS: I don't recall, but that sounds
16 like about the right time.

17 MR. SCHLEEDE: That's all I have, Mr.
18 Chairman.

19 CHAIRMAN HALL: Mr. McSweeny, we have kept
20 you up here a long time. I have some questions,
21 however, and I want to try to go through them and I'll
22 try and do them as quickly as I can. First, in your
23 position as the director of the Aircraft Certification
24 Service, how many employees report to you and do you

1 have an idea of what your budget is?

2 THE WITNESS: We have a little over 900
3 employees, and my budget, hopefully this year, which
4 was just --

5 CHAIRMAN HALL: Well, we both know -- well,
6 it was signed.

7 THE WITNESS: Ours was signed. We're back in
8 business. It's around \$71 million.

9 CHAIRMAN HALL: Well, while all of us here
10 have an interest and the parties in this organization,
11 you and the members of the FAA and the NTSB are in a
12 slightly different category, because we're funded by
13 the public.

14 We have this system set up which has seemed
15 over the years to work pretty well, but it requires
16 extent scrutiny in regards to accidents and
17 particularly major accidents in this country involving
18 scheduled airline service. We have a situation before
19 us that with these two accidents that, of course, has
20 commanded a lot of our resources and obviously a lot of
21 your resources, as well, as the parties.

22 My interest in this is to try and be sure
23 that we are doing everything in as timely a fashion as
24 possible and reporting to the public in as timely a

1 fashion as possible, and that was one of the reasons
2 that I wanted to have this, what I guess has been
3 called an unprecedented second hearing on this
4 investigation. But we have expended or you have
5 expended quite a bit of resources in terms of this
6 critical design review.

7 There are, I believe, 27 recommendations that
8 have been made. And rather than try to walk you
9 through those, what I was wondering is would you be
10 willing to provide for the record within say a seven-
11 day period of time, the current status of the FAA on
12 those 27 recommendations?

13 THE WITNESS: Yes.

14 CHAIRMAN HALL: Mr. Haueter, if you could
15 please follow up on that. And, again, my interest is
16 that we are sure that -- and this hearing reflects to
17 the public everything that has been identified --
18 everyone is moving with the type of diligence that I'm
19 sure the public expects, to address concerns that have
20 been raised and recommendations that have been raised
21 in this report.

22 In that regard, there was a discussion, I
23 guess, earlier of the Boeing 737 events that have
24 occurred. That, I believe, is Exhibit 13X-C. Of those

1 events, I believe 15 of those events have been reported
2 by USAir. That gets me to the subject that Mr. Haueter
3 has raised in regard to this retrofit that is a
4 modification of the power control unit, which is called
5 the Mac Moore phenomena, in which the industry had five
6 years to complete this modification.

7 We received testimony in Pittsburgh that
8 USAir had accelerated this replacement program from Mr.
9 Michael Cohen, their vice president of maintenance,
10 stating that they anticipated having the 235 aircraft
11 retrofitted with the reworked power control units by
12 the end of 1995. Do you know the status of that, sir?

13 THE WITNESS: No, I do not, but I certainly
14 can provide it to you.

15 CHAIRMAN HALL: General, would you know and
16 could that be provided to us, sir?

17 GENERAL ARMSTRONG: We can provide that to
18 you.

19 CHAIRMAN HALL: Thank you very much. I would
20 also like that to be part of the record. Again,
21 insuring the public that we are doing everything in
22 this investigation to insure that every item is
23 followed up on.

24 In addition, if I can find my notes here --

1 I've got so much paper I can't see over it.

2 (Pause)

3 CHAIRMAN HALL: Just again to clarify the
4 results of the study where it says, "The Boeing 737
5 meets all certification requirements." Would you
6 please tell me, in your opinion, what that statement
7 says?

8 THE WITNESS: In my opinion, it says that the
9 airplane meets the certification requirements embodied
10 in the certification of the basis of the airplane as it
11 was type certificated originally.

12 CHAIRMAN HALL: Thank you. I'm going to find
13 this hear in a minute, if you'll bear with me.

14 (Pause.)

15 CHAIRMAN HALL: I had some follow up here on
16 if you were aware of some reported incidents regarding
17 a phenomena called "blue water."

18 THE WITNESS: Somewhat, yes.

19 CHAIRMAN HALL: Could you explain for us what
20 blue water is and what information the FAA has on that
21 particular item?

22 THE WITNESS: There have been some events on
23 aircraft where there have been unusual attitude
24 changes, roll events, or pitch events. And after the

1 fact, they've observed that in the forward avionic's
2 compartment, there is either blue water or reminisce of
3 blue water. The blue water being water coming from the
4 laboratory receptacle.

5 CHAIRMAN HALL: And have there been a number
6 of these incidents?

7 THE WITNESS: There have been a number of
8 cases where that liquid was discovered in the avionic's
9 bay. I would say numbers -- I don't know. Number
10 being somewhat below ten and greater than five maybe,
11 that I'm aware of.

12 CHAIRMAN HALL: Well, what is -- what can
13 happen if that -- what are the consequences of having
14 blue water in the avionic's bay?

15 THE WITNESS: I'm not so sure we fully know
16 what the consequences are. There appears to be some
17 correlation between electrical conductivity and that
18 blue water. Whether that is water or a dry compound.
19 In one case when it's liquid, I believe, it clearly
20 transmit electricity, and when it's powdery, it's less.

21 But it does -- like any other liquid, impact on the
22 electrical transmission, shorts if it should get into
23 connectors and things like that.

24 CHAIRMAN HALL: How did you all -- how did

1 this come to your attention, of the attention of the
2 FAA?

3 THE WITNESS: I believe it was as a result of
4 an incident on an airplane in which -- and trying to
5 troubleshoot the cause. They were in the avionic's bay
6 and they discovered it. I don't know exactly who
7 discovered it.

8 CHAIRMAN HALL: It didn't come out of the
9 service SDR?

10 THE WITNESS: I don't believe so, but I'm not
11 really that up to date on that issue.

12 CHAIRMAN HALL: Let me ask you just one
13 question and kind of -- so, I guess, just in the common
14 sense category, in my opinion. Is one individual --
15 we've heard testimony yesterday that one of the
16 witnesses, Mr. Newcombe -- I guess, he's the fellow
17 that handles the SDRs?

18 THE WITNESS: Yes, the flight standard's AEG.

19 CHAIRMAN HALL: Is one person adequate to do
20 that for the 737 considering the fact that we've had
21 two unexplained accidents?

22 THE WITNESS: Well, he was, I believe
23 speaking about his role in the flight standards
24 organization dealing with service difficulty reports.

1 In addition to him, there are several people in
2 aircraft certification that would deal with the report.

3 CHAIRMAN HALL: Just give me some comfort.
4 Tell me how that process is handled and how many people
5 are involved in it and has there been any changes made
6 in that process as a result of Colorado Springs and
7 Pittsburgh?

8 THE WITNESS: The service difficulty reports
9 that deal --

10 CHAIRMAN HALL: Again, I guess, Tom, what got
11 my attention is he said he did the ATR, as well, and
12 that happens to be another accident that we're working
13 on, so.

14 THE WITNESS: But we get the service
15 difficulty reports as does flight standards. When they
16 reach the Aircraft Certification Office, they are
17 organized according to discipline. Is it an avionic's
18 problem, is it an airplane problem, is it a power
19 plant's problem. They then go to the branch that deals
20 with that discipline and in that branch, there is a
21 person that is responsible for that product, be it the
22 737.

23 So in the Seattle ACO, there would be a
24 minimum of five people that would be following design

1 issues related to service difficulties. And the system
2 itself has -- and the transport directorate has been
3 evaluated, I think, a year or two ago and more
4 formalized to insure that the follow up and appropriate
5 action was being taken on all the service difficulties
6 received.

7 CHAIRMAN HALL: Do you feel comfortable,
8 because this area is under your responsibility, that
9 there is adequate personnel to do that function and you
10 have adequate resources to provide it?

11 THE WITNESS: Yes.

12 CHAIRMAN HALL: Okay.

13 THE WITNESS: And the reason being that it's
14 our number one priority. We always are going to have
15 resources to do our number one priority.

16 CHAIRMAN HALL: Well, I believe that covers
17 most of my questions. Unless other members at the
18 front table, the technical staff have questions?
19 Captain, all the parties?

20 CAPTAIN LeGROW: Thank you, rM Chairman. I
21 just have one follow-up question. During Mr.
22 Schleede's questioning, you talked about the single
23 failure as opposed to multiple failure, and you said
24 that that changed around the time that airplanes went

1 from manual reverse into fully powered flight control.

2 THE WITNESS: That's my recollection.

3 CAPTAIN LeGROW: Can you tell us whether the
4 737 has manual reversion on the rudder?

5 THE WITNESS: It does not have manual
6 reversion. It has a standby system.

7 CAPTAIN LeGROW: Thank you. I have no
8 further questions.

9 CHAIRMAN HALL: Well, Mr. McSweeney, you have
10 certainly been patient. I appreciate very much on
11 behalf of this board and this investigation, the time
12 that you have put forward. I will say we just continue
13 to look forward to working with you under Mr. Haueter's
14 direction, to continue to use the public funds that we
15 are provided to insure that we have done everything on
16 these two accidents to see if we can determine a
17 probable cause and come up with remedies.

18 I would assume that with the action of your
19 CDR team, that you're looking very closely at your
20 certification process and monitoring very closely
21 everything in regard to this plane until we all put to
22 rest any questions that we have to satisfy our
23 responsibilities in the safety area to the American
24 people.

1 I look forward to continuing this with you
2 and with the other outstanding individuals that work
3 with the FAA. Thank you and you're excused.

4 THE WITNESS: Thank you.

5 CHAIRMAN HALL: We will take a one hour lunch
6 break and return here promptly at 2:15. We stand in
7 recess.

8 (Whereupon, a lunch recess was taken.)

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

2 (Time Noted: 2:15 p.m.)

3 CHAIRMAN HALL: I would like to resume the
4 Board of Inquiry hearing. I'll call our next witness,
5 Mr. Les Berven. He's a Flight Test Pilot for the
6 Federal Aviation Administration, located in Seattle,
7 Washington.

8 Welcome.

9 (Witness testimony continues on the next
10 page.)

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3 LES BERVEN, FLIGHT TEST PILOT, FEDERAL AVIATION

4 ADMINISTRATION, SEATTLE, WASHINGTON

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6 Whereupon,

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LES BERVEN,

8 was called as a witness by and on behalf of the NTSB,

9 and, after having been duly sworn, was examined and

10 testified on his oath as follows:

11 MR. SCHLEEDE: Mr. Berven, will you give us
12 your full name, please, and business address?

13 THE WITNESS: My name is Lester Berven. I'm
14 employed with the FAA at Seattle, Washington.

15 MR. SCHLEEDE: And your position with the
16 FAA?

17 THE WITNESS: I'm currently the supervisory
18 flight test pilot in the flight test branch of the
19 Aircraft Certification Offices in Seattle.

20 MR. SCHLEEDE: Would you please give us a
21 brief description of your education and background that
22 qualifies you for your position, including your
23 ratings?

24 THE WITNESS: Sure. I have a BS degree in

1 aeronautical engineering from California State
2 Polytechnic University in California. I have some
3 graduate work in aerodynamics and advanced math. I
4 have been a pilot since I was 16 years old. I have
5 about 7,000 hours and about 3,500 of those are in
6 certification or engineering flight test.

7 I have ratings in all the Boeing airplanes,
8 except the 707.

9 MR. SCHLEEDE: Thank you. Mr. Jacky will
10 proceed.

11 MR. JACKY: Good afternoon.

12 THE WITNESS: Hi.

13 MR. JACKY: We spoke together up in the first
14 hearing up in Pittsburgh and I welcome you back this
15 afternoon. Before we get started, I would for you to
16 give us just a little description about what your job
17 duties are as a supervisory flight test pilot.

18 THE WITNESS: Well, I'm kind of a playing
19 coach, so to speak. I pretty much fly a lot and I also
20 assign and direct four other pilots -- five other
21 pilots within my branch and assign them to different
22 projects and monitor their operations and make sure
23 that they're following all procedures and techniques
24 correctly and they coordinate with me if there's any

1 kind of a problem or a controversy comes up.

2 MR. JACKY: And you have been involved with
3 the 427 investigation for quite some time. I was
4 wondering if you might tell us what sort of
5 participation you have been included in?

6 THE WITNESS: I've been kind of acting as a
7 consultant to the NTSB. I'm not on the performance
8 board or a member of the accident board, but they come
9 and ask me questions from time to time and want me to
10 fly the simulator, because I have a fair amount of time
11 in the 37 and I have done some certification work on
12 the follow-on programs and on the 1984 certification.

13 MR. JACKY: When you refer to the 1984
14 certification, would that be for the 737-300?

15 THE WITNESS: Three hundred, right.

16 MR. JACKY: As far as the work you did, that
17 would be flight test certification?

18 THE WITNESS: Yes, it would.

19 MR. JACKY: Could you briefly describe
20 describe the type of certification flight test that you
21 did in support of the 300?

22 THE WITNESS: I didn't do a lot of that,
23 because I was involved in other projects at the time.
24 I did some of the stability control work and some of

1 the engine out VMCA and VMCG tests. I'm kind of a
2 local expert on engine out stuff.

3 So the rest of the pilots did probably 85
4 percent of it, and I just kind of kept my hand in on
5 that project.

6 MR. JACKY: As part of the certification
7 requirement or part of the certification test, what
8 sort of hardover or jam conditions would you have to do
9 for any of the primary flight controls?

10 THE WITNESS: We don't really do hardover
11 tests for any of the primary flight controls. We do
12 jam tests, which are somewhat different. A jam assumes
13 that the pilot puts a control there and he can't get it
14 back out again. We use the deflection that we can
15 think are most probable the pilot would be using in his
16 normal operations.

17 So we look at jams of the rudder and we look
18 at the jam of the aileron and we also look at the jam
19 of the elevator. And typically, we look at these at
20 the worst-case conditions. For instance, on the
21 elevator jam, we go out to VMO, the redline air speed
22 at full forward CG, and assume that the elevator gets
23 stuck right there, the stabilizer gets stuck right
24 there. Then you come back and land it without having

1 to retrim it. And there's some limitations on the
2 force and you can do that quite readily.

3 So the jams themselves are not too big a
4 problem. You can come back and land the airplane. We
5 had to show that for any of the flight control systems
6 that jammed at any probable flight condition, that the
7 pilot would use a normal operation and you could make a
8 continued safe flight and land it, and we did
9 demonstrate that.

10 MR. JACKY: So then if I could summarize
11 perhaps. Then the work that you did was jams to
12 whatever the maximum extent you would expect for a
13 normal operation of the airplane?

14 THE WITNESS: That's correct.

15 MR. JACKY: That's correct. Okay. What
16 about trim systems, do you have to test for runaways or
17 hardover trim conditions?

18 THE WITNESS: Yes, we check trim runaways
19 primarily on roll and yaw, because the pitch control
20 system on the Boeing airplanes are basically multiple
21 redundant and has a break, as well as cut-out switches,
22 and that's considered so reliable that we don't do it.

23 Because the instinctive pilot reaction in a trim
24 runaway is to push on the stick. And if you push on

1 the stick, an opposition to trim motion locks it up.
2 So basically you can't really get a trim runaway that
3 gets to any significance.

4 For the directional control with trim, we run
5 that all the way to the stop in all flight conditions
6 and come back and land that way. And the aileron trim
7 also. Those are very low authority systems. So it's
8 really not a problem.

9 MR. JACKY: So then you would look at the
10 system at the maximum trim position authorized by the
11 system?

12 THE WITNESS: That's right. We run until it
13 won't go anymore.

14 MR. JACKY: Is there any sort of -- when
15 you're doing the certification for that, do you look at
16 it in terms of a static position? Do you put the
17 rudder out there, or do you actually try and run the
18 trim at its normal trim rate to that position and then
19 hold it?

20 THE WITNESS: We just run it up to the normal
21 trim rate until as far as it goes and then we fly back
22 and land that way.

23 MR. JACKY: I would like to talk to you a
24 little bit about some flight test work that has been

1 referred to at least this morning and probably some
2 other times yesterday. What I would like to talk about
3 is the simulator calibration flight. So I was
4 wondering if you could give us a brief description
5 about your participation in those flights.

6 THE WITNESS: Certainly. We basically set
7 those flights up to insure that the simulator tests and
8 evaluations that we have been doing for the NTSB were
9 going to be correct. So we basically took the airplane
10 out and did some -- it wasn't a totally comprehensive
11 test, but it was mostly just on the lateral directional
12 axis. We did a couple of tests.

13 The primary thing that we were looking at was
14 what we call aileron rudder trades. In other words, if
15 you stabilize at a given speed and configuration and
16 flat setting gear, if you push on the rudder in a
17 normally stable airplane, you have to counteract with
18 the aileron.

19 So basically the lateral directional
20 stability is measured by how much of that you have to
21 put in, how much aileron you need for a given amount of
22 rudder. So basically what we wanted to look at was
23 what the relationship was between the aileron
24 deflection required to counteract the rudder input and

1 still maintain constant steady heading flight.

2 So we did this primary at flaps one and 190.

3 MR. JACKY: Which basically are the
4 Pittsburgh --

5 THE WITNESS: That's correct.

6 MR. JACKY: So then would it be accurate to
7 say that the objective of the test would be to collect
8 data to be able to compare to the engineering
9 simulator?

10 THE WITNESS: Yes, basically the simulator
11 step is very complex and very sophisticated and quite
12 accurate, but it's not exactly like the airplane in a
13 lot of cases. You just can't do that. Of course, you
14 can't simulate the dynamics and the motion and stuff
15 like that and whatever. But you can get the static and
16 some of the dynamic derivatives very, very close.

17 Basically we went out there just to validate,
18 to see what the simulator, how close it was to the
19 airplane actually.

20 MR. JACKY: And during these tests, what
21 specific types of maneuvers did you accomplish?

22 THE WITNESS: We did essentially three types
23 of maneuvers -- well, four actually. The basic one I
24 just explained was the constant straight heading --

1 steady heading side slips all the way out to the full
2 deflection of the control. And we picked increments
3 like one-quarter, one-half, three-quarters, and full
4 rudder. And we did this at three or four different
5 speeds from 150 all the way up to about 225 knots to
6 look at the relationship with speed and to get a little
7 bit more expansion, a more comprehensive look at our
8 comparison with the simulator data.

9 In addition to that -- and from that data
10 back out, you can plot the aileron required to
11 counteract the rudder input at a constant heading. And
12 that's a very important lateral directional parameter
13 that you use to make your simulator work correctly.

14 In addition to that, each time I got to
15 what I call -- what you call an end point -- in other
16 words, you were stable there with X amount of rudder at
17 a given speed and holding constant heading. As I
18 finished that point, I would release the ailerons and
19 look at the resulting roll rate, take the aileron
20 forced back to zero and watched the airplane roll and
21 look at the roll rate. Basically, to see how fast it
22 would roll, because that's another extremely important
23 simulator parameter.

24 In addition to that, we did ~~and~~ some

1 rudder hardovers. And the way we did that was to
2 mistrim the rudder to a certain X amount while the
3 pilot was holding it steady to neutral and then release
4 the rudder. The way we did that was try to make it
5 consistent between each point, because it's not really
6 possible to put in a fixed deflection rudder hardover,
7 unless you have some kind of a restriction on the pedal
8 and we didn't want to do that.

9 So basically, we trimmed the rudder over to a
10 certain deflection holding the pedals neutral and then
11 quickly release the rudder pedals, which essentially
12 resulted in a hardover rudder to whatever position we
13 had selected on the trim. We did that to one-quarter,
14 one-half, and three-quarters rudder deflection. We
15 were unable to do the full rudder deflection because of
16 structural problems with the maneuver at that flight
17 condition.

18 MR. JACKY: What sort of structural problems
19 are you referring to?

20 THE WITNESS: As I understood it, during the
21 safety analysis and the safety briefing we went through
22 to look at this maneuver, the Boeing structure's people
23 indicated that if you did that maneuver to full
24 deflection at 190 knots, in that configuration, that

1 you would come very close to reach the limit load on
2 the fin.

3 Now, that's not exceeding it, but it's up to
4 limit load. And Boeing rightly so says that they don't
5 want to go to more than I think it's 80 percent of any
6 limit load in any structure unless it's instrumented.
7 And they were willing to do that, but we had to pay
8 more and wait longer.

9 MR. JACKY: Before we go on, maybe I should
10 back you up a bit. Could you tell us what type of
11 airplane was it that you were doing the tests on?

12 THE WITNESS: It was a 737-300. I don't know
13 the end number. It was a USAir airplane, 533-AU, I
14 believe.

15 MR. JACKY: Thank you.

16 CHAIRMAN HALL: Who was paying more now?

17 THE WITNESS: Whoever was paying for the
18 tests.

19 CHAIRMAN HALL: Well, we divided that ~~tes~~
20 four ways, didn't we?

21 THE WITNESS: I don't believe that structural
22 instrumentation on the rudder was part of the original
23 deal.

24 CHAIRMAN HALL: But it's something that can

1 be done?

2 THE WITNESS: Yes. And they would have done
3 it if we had had instrumentation.

4 CHAIRMAN HALL: Well, I just didn't want to
5 leave the impression that Boeing had nixed it --

6 THE WITNESS: No.

7 CHAIRMAN HALL: -- because all four of us
8 were participating. Mr. Seth Schofield had gotten that
9 plane for us, which we greatly appreciate.

10 THE WITNESS: No, they didn't nix anything.
11 Basically, it was just brought up as an important
12 safety item and a consideration to be done. And the
13 fact that we were getting data at one-quarter, one-half
14 and three-quarters made it a very simply and reasonable
15 extrapolation to the last quarter of the travel. It
16 wasn't cost-effective to do it.

17 MR. JACKY: Were there any other maneuvers,
18 specific maneuvers that were performed during this
19 flight test?

20 THE WITNESS: Well, I also did what I call a
21 slow-down turn, which is basically in the configuration
22 that I was in, I went up to 225 knots and put the
23 aircraft in a one and a half G turn and held one and a
24 half Gs at idle power, as the airplane slowed down

1 until I got into stickshaker. And basically that's a
2 maneuver we do to look at stall warning and other
3 characteristics. But basically what I wanted to do was
4 to evaluate that to validate the drag model on the
5 simulator, to see if the deceleration rate was the same
6 and also if the stall warning came on, the same angle
7 of attack and G speed.

8 MR. JACKY: Were there any maneuvers done in
9 comparing roll rates due to wheel combined?

10 THE WITNESS: We did do some roll rate
11 testing, too. We had modified our mark, the control
12 wheel position on the column, so we could get
13 proportional deflections of the aileron there. And we
14 did a bunch of roll rates due at one-third, one-half,
15 and three-quarters and full to look at the roll
16 capability.

17 We did -- several of these tests were done
18 both with and without the yaw damper. It's quite a lot
19 of data. I think they're still trying to analyze it
20 all.

21 MR. JACKY: And from these maneuvers and -- I
22 should ask you this. How many of the flights were you
23 participating in?

24 THE WITNESS: I had made one flight. I think

1 the flight that I was on was two and a half hours or
2 something like that.

3 MR. JACKY: Okay. And during this time in
4 any of the maneuvers that you performed, were you
5 surprised in any way? Were there any differences from
6 what you would expect in the engineering simulator?

7 THE WITNESS: There was nothing that I
8 thought was unusual. We had basically done all of
9 these maneuvers, except the hardovers prior to this.
10 So it was nothing unusual. In the comparison to the
11 simulator, we did notice that the rudder deflection
12 that we were achieving in the airplane was somewhat
13 more than it was in the simulator, about two degrees.
14 Eighteen in the simulator and a little over 20 in the
15 airplane.

16 MR. JACKY: Was there any reasonable
17 explanation for why this occurred?

18 THE WITNESS: I have no idea.

19 MR. JACKY: Then in comparison with the
20 engineering simulator, when you were performing -- or
21 how were you able to determine the differences between
22 the airplane and the simulator?

23 THE WITNESS: Basically, we had the rudder
24 deflection instrumented. For an important part of this

1 test, was to calibrate the rudder deflection at
2 different air speeds. And basically, we got to that
3 point on the straight steady heading side slip at the
4 last, at the end point where we were at full deflection
5 on the rudder.

6 So we could just look at the instrumented
7 gage or read it from the instrumentation on the back
8 and they would tell us what the rudder deflection
9 actually was.

10 MR. JACKY: And you mentioned the steady
11 heading side slip test. What were the varying speeds
12 again that you attempted or accomplished these
13 positions at?

14 THE WITNESS: I remember we did them at 150
15 knots, 170 and 190, 210, and 225.

16 MR. JACKY: And there's been some talk here
17 about lateral stability and lateral control. Could you
18 tell us for each one of these air speeds, approximately
19 how much rudder you believe that you could counter with
20 full aileron?

21 THE WITNESS: Well, it depends on entirely
22 pretty much on your air speed. There's a cross-over
23 point at about 190 knots or just a little bit less. At
24 which point, the rudder -- full rudder deflection can

1 be counteracted with full aileron deflection.

2 Now on the airplane, that was right at 190
3 knots, maybe just a hair less. In the simulator, it
4 was a little bit less than that, but it was very close,
5 within two knots or so. That's about as good as you
6 can do.

7 At 210 knots, you could only go to -- the
8 maximum rudder deflection there was only 14 degrees
9 with full pedal. So you could counteract that easily
10 with the ailerons. At 170 knots, you couldn't use full
11 rudder. You were out of aileron before you got to full
12 rudder. At 150 knots, you were considerably out of
13 aileron before you got to full rudder.

14 So below about 170 knots, basically the full
15 rudder deflection over rolls the roll capability of the
16 airplane.

17 MR. JACKY: At the 150 knot condition, could
18 you remember how much rudder you actually could control
19 with full aileron authority?

20 THE WITNESS: It wasn't exactly 150. It was
21 a little less, 146 or 147, when we finally got
22 stabilized. The data that I've seen here shows 14
23 degrees of rudder with maximum wheel, which resulted in
24 about ten degrees of side slip.

1 MR. JACKY: And you've flown all these types
2 of maneuvers on the engineering simulator also?

3 THE WITNESS: Yes.

4 MR. JACKY: And how does the difference that
5 you said you saw in the rudder, how would that play as
6 far as the lower speeds in the side slip maneuvers?
7 Could you tell a difference?

8 THE WITNESS: Little changes like -- well, in
9 the simulator, you also over roll the ailerons at slow
10 speed, too. Once you get considerably below 190 with
11 flaps one, the simulator is actually pretty
12 representative of the airplane except for the small
13 change in the rudder deflection.

14 So the principle is exactly the same. The
15 cross over speed is just a little bit less, because in
16 the original simulator, we didn't have quite the right
17 rudder deflection. With the new updated simulator,
18 it's very, very accurate.

19 MR. JACKY: You mentioned updating the
20 simulator. Out of all of these tests, how much
21 difference or updating would you see of the simulator?

22 THE WITNESS: I believe they only did the
23 rudder hinge moment update. So that any stability and
24 control derivatives that came out of our testing have

1 not been put into the simulator. They only upgraded to
2 the new rudder deflection versus air speed.

3 MR. JACKY: But in terms of the other flying
4 that you've done in the simulator, the maneuvers that
5 you performed in the test airplane seem to be fairly
6 representative?

7 THE WITNESS: Yes, they were.

8 MR. JACKY: So it was only the difference in
9 the rudder. That is the only obvious thing that you
10 noticed in flying it?

11 THE WITNESS: And the effect of having less
12 rudder. You've got different speeds in the simulator
13 before it had been upgraded.

14 MR. JACKY: Okay. You mentioned a speed
15 affecting the stability. Are there any other factors
16 that would affect the stability? The center of
17 gravity, for example, weight?

18 THE WITNESS: The center of gravity has a
19 fair amount of effect on stability, but not a lot on
20 lateral directional. Basically, the only effect is in
21 the length of the tail arm, which is kind of a
22 secondary thing.

23 So I think we were at a relatively
24 representative CG with respect to the simulator

1 testing. I'm sure that when they do the simulator
2 analysis, the data -- the analysis of the data that we
3 took and incorporated into the simulator, you can
4 easily correct for the CG position.

5 MR. JACKY: What would the effect be as the
6 CG, say, moved from aft of the airplane to forward of
7 the airplane? Would you expect the stability air speed
8 to rise, to lower?

9 THE WITNESS: Probably from the standpoint of
10 the lateral directional trades, if the farther forward
11 in the CG that you are, the longer your rudder arm and
12 more effectiveness that you would have. So your
13 tradeoff speed would move up slightly.

14 MR. JACKY: As a flight test pilot, do you
15 have any way of comparing the type of flying that you
16 do to a typical airline pilot?

17 THE WITNESS: Well, it's considerably
18 different. We don't get to fly with too many airline
19 pilots. Sometimes we jump seat places to places to
20 kind of watch what's going on, and sometimes we get to
21 fly with people during evaluations, like we did here on
22 the USAir.

23 It's pretty much a difference, more of a
24 difference in attitude, I think, than anything else.

1 What we're looking at is to go out and find something
2 new in the airplane and do something strange. And most
3 of our tests are done under pretty controlled
4 conditions with smooth air and good weather and
5 preplanned by 25 engineers.

6 And airline pilot, on the other hand is put
7 in all kinds of unusual situations in a short order
8 with darkness and bad weather and flying with different
9 crews all the time. So it's a whole different ball
10 game.

11 MR. JACKY: Have you ever flown at conditions
12 of approximately 190 knots, flaps one degree?

13 THE WITNESS: Certainly.

14 MR. JACKY: What sort of phase of flight
15 would that be in?

16 THE WITNESS: Well, it's typically you're
17 there on a short period of time during your
18 acceleration on takeoff when you're retracting the
19 flaps, but that's a very short duration, maybe only 20
20 seconds or something.

21 So where you would spend a lot of time on
22 there, sometimes you're in a congested terminal area
23 and ATC wants to space you in with another airplane
24 that has that same speed, and they want you to go 190

1 or some speed like that. So you basically don't want
2 to slow down below 210 and without any flaps. So you
3 put the flaps down and go to 190. And you're going
4 along there for a while until ATC tells you to turn
5 here or you're clear for the approach or slow down or
6 do something.

7 So you can spend five, even ten minutes at
8 flaps one.

9 MR. JACKY: In what speed range could you
10 typically use flaps one setting?

11 THE WITNESS: The maneuvering speed for flaps
12 one, at least on a reasonably light airplane, the ones
13 that we fly all the time, is 190 knots. They basically
14 recommend that speed, because it gives you a reasonable
15 maneuverability margin there. I don't know what the
16 actual number comes from. I think it's 1.4 times the
17 stall speed or something like that.

18 MR. JACKY: But would you say you leave the
19 airplane in the flaps one configuration say down to 150
20 knots all the way or all the way up to 225 knots or
21 what is that range that you typically operate the
22 airplane at flaps one?

23 THE WITNESS: Well, typically the margin that
24 we use is about plus or minus 20 knots. At flaps one,

1 you're allowed to go to 230, which is the flap placard
2 speed, and you can go all the way down to stickshaker
3 if you wanted to. I guess, that would be down around
4 130 or 140 with the flap setting like that.

5 The training that we get basically says to
6 put the flaps down when you're decelerating toward the
7 speed within 20 knots of it or if you're accelerating
8 towards, you can raise it once you're within 20 knots
9 of it. So if I'm decelerating from flaps up, I would
10 start the flaps down at 210 and then fly at 190 if I
11 was going to be flaps one for a long time.

12 If I'm raising the flaps from five, basically
13 I would start them up to one at 170 if I'm
14 accelerating.

15 MR. JACKY: So can I characterize the speed
16 range as say maybe 170 to 210 knots? Would that be
17 fair?

18 THE WITNESS: That's correct.

19 MR. JACKY: And during this time, would you
20 be -- how much use of the rudder would you expect to be
21 doing?

22 THE WITNESS: Well, basically none, as long
23 as both engines were running.

24 MR. JACKY: Would you have your feet on the

1 pedals?

2 THE WITNESS: Yes, I would.

3 MR. JACKY: You mentioned in talking about
4 the simulator and the things that you saw in the
5 simulator calibration flights -- as part of your job
6 duties, is there any sort of report or documentation
7 that you have to make to your superiors or would you
8 with Boeing in regards to the flight tests?

9 THE WITNESS: Are you talking about basic
10 certification or this simulator test?

11 MR. JACKY: Not basic certification, but just
12 the flight tests that were accomplished in Seattle.

13 THE WITNESS: Well, it happens about the same
14 in both ways. Your basic certification test and this
15 test were handled pretty much the same way by the
16 Boeing system. We wrote a test plan and in the cert
17 program, we write a TIA, which is a type inspection
18 authorization, which is an approval of the test plan.

19 Then FAA and Boeing gets together and agree
20 on the test plan and say, here's how it's going to be
21 and then okay. Then they write a test sequence, which
22 is each altitude and each speed and what sequence
23 you're going to do it in. Then go up and do the tests.

24 And the engineers get the data, and we come back and

1 land and have a post flight and discuss what we saw and
2 whether it was acceptable and whether we need to go do
3 some more or not.

4 Then the engineers get together with that
5 data off of their instrumentation system and analyze
6 it, look at what we did, and then they ask us is there
7 any questions on pilot comments. They get together
8 with us. And then they write up a report called the
9 certification report, and they send it to us. And if
10 we like it, we sign it. And that becomes part of the
11 certification documentation, the type inspection
12 report.

13 In this case, it will just go back to whoever
14 asked for the test.

15 MR. JACKY: In the certification report,
16 would you expect comment about this two degree rudder
17 difference that you're talking about?

18 THE WITNESS: I would think so, yes.

19 MR. JACKY: Is there any sort of procedure
20 within the FAA that you would send that to your
21 supervisor or what sort of reaction would you expect
22 from the FAA on something like that or to yourself?

23 THE WITNESS: What type of report would I
24 expect, is that what you asked?

1 MR. JACKY: Do you have to indicate to anyone
2 that there is a difference or is that a concern?

3 THE WITNESS: No, that basically comes out in
4 the post flight. In fact, I did that when I said, it
5 looked like to me there's more rudder deflection on
6 this airplane than there was in the simulator, and they
7 wrote that down. That's going to be included in the
8 CERT report with a little paragraph about how they're
9 going to address that. Basically, they're going to
10 upgrade the simulator to the new deflections.

11 MR. JACKY: If and when the simulator is
12 updated, is there any sort of requirement for you to go
13 back and check that and say, yeah, that looks like the
14 airplane or sign off or anything like that?

15 THE WITNESS: I don't think there's a
16 requirement. I think there's an interest in both
17 parties in getting the simulator as accurate as
18 possible, but I don't think we do a very comprehensive
19 test. Before they got around to analyzing all the data
20 and upgrading the simulator to the maximum to all the
21 data that they have. That may take several months.

22 MR. JACKY: Now, I would like to switch gears
23 a little bit and start talking about the wake vortex
24 flight test. Could you tell us a little bit about your

1 participation in those flight tests?

2 THE WITNESS: Yes, I was basically the FAA
3 project pilot, along with the Boeing project pilot, Mr.
4 Mike Carriker. And the requirement came that we were
5 going to go out and try to evaluate what the response
6 of the 737 would have been at a certain number of miles
7 behind the 727 to evaluate the encounter that looked
8 like happened on the 427 accident.

9 So the first thing we did was just get
10 together and talk about it and say, how are we going to
11 do this and how is it going to be safe? So we looked
12 at the technology and we had a simulator that basically
13 had the vortices shown visually in the picture of the
14 outside view of the simulator. And they were set up
15 technically so that as you flew into the vortex, that
16 you got the same rolling moment or the same vortex
17 intensity that they felt that had occurred during the
18 USAir accident.

19 So we flew the simulator to start with. We
20 looked at it from the standpoint of what the reaction
21 to the airplane would be, how safe it was going to be,
22 and we also used it to write up the test plan, to look
23 at some reasonably valid things we could do.
24 Configurations to use and entries to use and bank

1 angles and rates and such like that.

2 So we used the simulator as a tool not only
3 validated from a safety aspect, but also to come up
4 with a reasonable test plan. Once that was done, we
5 coordinated with the other people at the FAA Technical
6 Center to make sure we had the airplane and the people
7 interested in what we were doing. It was an overall
8 coordination between all the people involved; the NTSB
9 and USAir and Boeing and the FAA. It was pretty much a
10 coordinated effort.

11 Then once we got down to the point where it
12 looked like it was going to happen at X number of days
13 or whatever, we wrote up what we called a safety plan.

14 And we looked at every aspects of the tests to make
15 sure we hadn't forgotten something that could bite us
16 during the test program.

17 So we looked at all the aspects of the
18 interface between the chase pilot, when one was needed
19 and how much and how long and what type, and the
20 briefing between the flight crew in the 737, a briefing
21 between the 737 and the 727 crew, any external people
22 from the tower and ATC and such as that, and all the
23 responsibilities and duties of each individual involved
24 in the project.

1 Each one of us sat down and said, what could
2 possibly go wrong. And we had four or five or six
3 pages of things. Some of them were a little bit far
4 out, but at least we over shot, rather than under shot.

5 So we had every possible thing that we thought of that
6 could happen and we addressed it. Where if this
7 happened, what do we do, and what are the consequences
8 if we do it wrong and what would be better. Is there
9 an alternative if it doesn't work.

10 So we had pages and pages of this stuff. And
11 we got together with all the pilots involved and the
12 flight crew and briefed everybody on this before the
13 mission. And this was a test plan that was agreed to
14 and sent up to the highest levels of the FAA, all the
15 way up to the administrator, I believe.

16 MR. JACKY: Was the test conducted under or
17 to the conformity of the test plan then or the hazard
18 plan?

19 THE WITNESS: Pardon?

20 MR. JACKY: Was the test accomplished per the
21 hazard plan?

22 THE WITNESS: Yes, it was. We briefed
23 everyone. We spent an hour or more before we ever made
24 the first flight and explained to everyone exactly what

1 was going to be and we had weather minimums and such as
2 that. It turned out very well.

3 The test was actually flown very, very
4 professionally. Everyone did an excellent job.

5 MR. JACKY: Could you tell us exactly how you
6 were able to fly into the vortices of the 727?

7 THE WITNESS: Well, the 727 had been modified
8 with smoke generators on the wing tips of the airplane.

9 That was loaded up with the same kind of smoke that
10 they use at air shows. It's called orcopus oil, I
11 believe, which is an actual system that lights off and
12 it's a combustion type system and burns the oil and
13 makes a thick white smoke. They had it on the wing tip
14 of the airplane. So that as it came out of the back of
15 the smoke generator, the flow field around the wing
16 picked it up and you could visualize the vortex. You
17 had one of those on each wing.

18 So they would light these off basically when
19 we got where we thought we were at the right spacing
20 behind the airplane and had adequate weather and good
21 clearance and the chase plane was in position. They
22 would light off these smoke generators. And then a
23 minute or so later, however long it took us to fly the
24 three-mile separation, you would start picking up these

1 smoke trails. They were very, very easy to see. In
2 the morning, especially, with the low sun angle, they
3 were just iridescent flight.

4 MR. JACKY: What time of day were the flights
5 flown?

6 THE WITNESS: Well, we were willing to fly
7 just about any time of day, except for when it was
8 dark. But we ran into some weather problems and got
9 delayed a day or so there. It was low ceiling and
10 visibility. Finally we found what looked like a good
11 size hole. So we launched both of the airplanes and
12 headed out to where we thought our test area was, but
13 the weather was too bad and we couldn't get joined up.

14 So we called air traffic and they let us go
15 out in some warning area off of the coast of New
16 Jersey, about 50 or 80 miles off the water, and found a
17 big hole out there.

18 As part of our safety plan, we required that
19 we do this at high altitude first, 15,000 feet or
20 greater, in case there was some type of an upset that
21 would take some time to recover from. So we did our
22 initial tests. And, in fact, we were above a deck of
23 clouds at about 18 to 19,000 feet for the very first
24 encounter. We found a big enough hole that we could

1 have the 27 going straight and the smoke generator on,
2 and we could pick up the vortex trails quite easily.

3 This first interaction was not a lot of
4 quantitative stuff. Basically, it was kind of a proof
5 concept to see if we could fly in and out of this thing
6 without causing any trouble with the airplane or if it
7 was going to be an unusual rolling rate or some kind of
8 other problem.

9 So basically both of the pilots decided that
10 we would go out and go ahead and give this a try. So
11 we just flew formation on the vortex and took a look at
12 it and then basically stuck one wing in it and that
13 didn't seem too bad. We stuck the other wing in it and
14 that was all right, too. We got a little farther and
15 then we flew below it and stuck the tail up in it, and
16 then we came down through it and up above it and across
17 it.

18 Then we tried it in other different ways. We
19 tried it with the auto pilot on, the auto pilot off,
20 and we tried it hands off. And it turns out that we
21 got about, it must have been 30 minutes of evaluation
22 during that very first flight on the very first morning
23 out over the water. And it did give us some indication
24 that basically the vortex interaction was kind of like

1 what we thought it was going to be, no big deal. And
2 the airplane wasn't rolling very rapidly or very far,
3 and that the G forces that were being counted on a
4 perpendicular or a high angle entry were not going to
5 be significant either. And that the airplane had
6 controllability to recover from or to control it as you
7 go through any part of the vortex, left, right or both.

8 So we decided since the weather was getting
9 even worse, we would break that off and decided that we
10 had, in fact, fulfilled the requirements of the safety
11 plan, to look at this as a proof of concept from a
12 safety standpoint of high altitude. So we checked that
13 off.

14 The next one we wanted to do was a bunch of
15 visual stuff under very, very good conditions, so we
16 could get pictures and some data and good comments on
17 each different small angle changes and roll rates and
18 angles and stuff like that. So we had to wait for good
19 weather on the next one.

20 So we were down for a day or so there waiting
21 for that, because there was a lot of fog.

22 MR. JACKY: When you were performing the
23 vortex interaction, what type of maximum upset or roll
24 angle did you see during the encounter?

1 THE WITNESS: It varied between how you did
2 it and where you came into it. But as a general rule,
3 what we saw was there was four different cases we
4 looked at. One with the pilot flying normally, as he
5 would react as he went through the vortices. And the
6 other one was with the auto pilot on, with the auto
7 pilot in CWS. And then one, we could --

8 MR. JACKY: Would you explain what CWS is,
9 please?

10 THE WITNESS: Oh, excuse me. The auto pilot
11 has two modes; one is command mode where it follows the
12 heading bug or tracks the localizer, and the other one
13 is CWS, which is control wheel steering, which is kind
14 of a submode of the auto pilot that basically says that
15 if you're less than five degrees, I'll level the wheels
16 for you. If you're between five and 30, I'll just hold
17 that bank. And if you're more than 30, I'll roll back
18 to 30. It's kind of an assist to the pilot. It's kind
19 of a submode to the auto pilot.

20 We looked at that from the standpoint that
21 somebody might actually be flying in that when they ran
22 into a vortex. And the fourth one was just completely
23 hands off. Just trim the airplane and fly through the
24 vortex without touching the controls.

1 MR. JACKY: For the four different types of
2 interactions they were talking about, as far as
3 control, what in general would give you the greatest
4 amount of upset?

5 THE WITNESS: Well, let's see I'll just give
6 you the angles on all four intercepts and you can see.

7 Basically, if you intercept at the vortex trails at a
8 more than a ten degree angle, you basically got no roll
9 at all. It was just a couple of bumps at about 1.4 Gs,
10 but very sharp -- bang, bang -- as you went across, but
11 no roll at all.

12 To get any roll out of it, you had to be less
13 than a ten degree intercept angle. Between five and
14 two is pretty good. So the ones we tried were five.
15 It's hard exactly to tell you exactly where the track
16 angle on the vortex was. So we just kind of guessed at
17 it. So it was somewhere around five or maybe a little
18 less.

19 When you flew the airplane with normal
20 control inputs, you could see the vortex coming up like
21 this, and you basically could just put her right
22 through your window. You can into it at about five
23 degree intercept angle. If you stuck -- if you just
24 flew beside it and stuck the wing tip in it, you would

1 just get a little trim change and you could sit right
2 there and fly like that.

3 If you went into it at an angle, basically
4 the airplane would start to roll as you went into it.
5 And basically it would roll up into the vortex like
6 this and then it would spit you out into the middle.
7 And then as you hit the right vortex, it would roll you
8 back up to level again or maybe a little bit less.

9 So we did a whole bunch of those. The most
10 representative angle that I found was about a ten
11 degree roll angle if you were flying an airplane
12 normally and a maximum of about 20 degrees. That was
13 the same numbers we got on the auto pilot also and also
14 with CWS.

15 The difference in the CWS controllability was
16 that you had a little bit more force to go with. But
17 if you're willing to put it in, it was not a problem.

18 On the hands off conditions, where we trimmed
19 the airplane up and basically just held onto the bottom
20 of the column to steer the airplane to go through the
21 vortex without putting any lateral directional inputs
22 in at all, those angles are a little bit bigger. I
23 would say the typical roll in that case was about 20
24 degrees, and the maximum I saw was about 30.

1 We did some other stuff, too. We were trying
2 to get into the left rolling vortex in a left bank.
3 And to do that, basically we came across the vortex
4 trail underneath and rolled up to 30 degrees into the
5 right vortex, and you got basically the same answer.
6 With hands off, they would roll you 30 degrees more.

7 So the numbers that I just gave you were
8 basically incremental to whatever bank you went into it
9 with. If you were 20 when you went in, you would be 30
10 when you came out or something like that, if the pilot
11 was flying.

12 Another test that we did interacting with the
13 vortex was to try to stay in the middle of it. That
14 was a very difficult maneuver, because basically the
15 vortex doesn't want you in there. It spits you out.
16 So that if you're hands off and if you don't really
17 fight with it, it will just shoot you out one side or
18 the other, and you're only in it for a second or two,
19 which is the reason you don't get much bank out of it.

20 If you try to fight with the vortex,
21 basically we found that the most roll angle, roll
22 inputs required was to have the vortex coming right up
23 over the cockpit, right on the top of the airplane and
24 hitting the vertical fin. In that case, at flaps one

1 and 190, you basically needed almost full aileron
2 deflection to stay there.

3 We were able to stay in there from two to
4 three to five seconds a couple of times, with maximum
5 aileron deflection without rolling it off. So we felt
6 that was a good indication, if we knew the control
7 power of the airplane, what the intensity of the vortex
8 can be. I think you can calculate it out of that.

9 We did other interactions, too, where we flew
10 up between the vortices and down between the vortices.

11 And in those cases, there was very little roll at all,
12 just a couple of little bumps again.

13 MR. JACKY: Did you try flying into a wake
14 that was descending at all?

15 THE WITNESS: Yes, we did. We had the 727
16 descend at a three degree angle and basically flew
17 through that. And that was essentially no difference
18 than a level wake where you flew up through it at three
19 degrees, depending on once you hit it. If you hit one
20 of them, it would roll you a little bit one way or the
21 other. If you came up between them exactly
22 symmetrically, basically it wouldn't roll. It would
23 just bump as you went through there.

24 MR. JACKY: If you weren't trying or

1 attempting to stay in one of the vortices or between
2 the vortices, could you characterize how long it took
3 for you or how long the interaction was that you felt
4 like you were being affected by the vortices?

5 THE WITNESS: Well, it was pretty consistent.

6 The vortex itself was not totally homogeneous. In
7 other words, it was oscillating a little bit. It
8 didn't get bigger and smaller and like that. It was
9 really hard to track it, especially when you're sitting
10 there with full aileron deflection and the vortex was
11 hitting the windshield and you can't see where it's
12 going. But it was basically a stable roll situation as
13 long as you were in it. As long as you were in the
14 middle of the vortex, it took basically full aileron.

15 MR. JACKY: Full aileron which way?

16 THE WITNESS: Opposite to whichever way the
17 vortex was turning. In other words, if you were in the
18 right vortex which was turning left, you would have to
19 have a right aileron.

20 MR. JACKY: Could you make some comments
21 about, in general, the behavior of the vortices and how
22 the vortices behaved, I guess?

23 THE WITNESS: They varied anywhere from
24 perfectly straight and parallel to incredibly complex.

1 I was just astounded at how durable they were. We
2 would get into some -- the top of some clouds or in
3 some thermal turbulence or something like that, and
4 they would become practically an art form, if you want
5 to call it. It would be so convoluted that you
6 couldn't even tell which way they were going,
7 intermixing with each other, but they were still
8 unique. Each vortex was still a constant rotating
9 vortex.

10 The ones that we found that were the best was
11 -- seemed to be more of a function of temperature.
12 Really cool in the morning, were the smoothest and more
13 well-defined and constant stable vortices. As it got
14 warmer, you got closer to the top of some clouds where
15 there's energy in the top level and more moisture, they
16 would become more and more up and down and left and
17 right. But they stayed together quite well. At three
18 to four to five miles even back, they looked exactly
19 the same as they did brought up the wing.

20 MR. JACKY: Now, you mentioned being three or
21 four or five miles back. How did you determine the
22 distance that you were behind the 727?

23 THE WITNESS: As I understand it, we had a
24 radar tracking system. It was calibrated with respect

1 to the 737. He could tell us exactly how far back we
2 were. So he would keep telling us, 3.1, 2.9, and we
3 would close it up or back off from that. We had T-CAS
4 also, which was kind of a rough indication. We could
5 get into position with that and he could tell us
6 exactly within a tenth of a mile where we were.

7 MR. JACKY: And at what distances behind the
8 727 did you attempt these encounters?

9 THE WITNESS: I flew the first part of it and
10 I think I flew four and three mile. I think they got a
11 little closer earlier than that -- later than that, but
12 the only encounter I saw was typically around four
13 miles or a little closer.

14 MR. JACKY: And could you characterize the
15 upset, if you will, based upon the distance behind the
16 airplane? Was it more upset at three miles or four
17 miles?

18 THE WITNESS: I think you'll have to talk to
19 the second crew here, because I didn't do anything
20 closer than about three and a half miles.

21 MR. JACKY: So you couldn't tell much of a
22 difference in the --

23 THE WITNESS: I couldn't tell any difference
24 between four and a half and three and a half, no.

1 MR. JACKY: Have you received any training at
2 all on vortices or encountering vortices or how to
3 avoid or minimize encounters?

4 THE WITNESS: Sure. Typically, you learn
5 that in basic flight training and some recurrent
6 training that you go through the airlines. They
7 basically say stay at or above the other airplane's
8 flight path on takeoff or landing. In other words,
9 make sure that you touch down after he has touched
10 down, so that wake vortices are gone and take off
11 before he lifted off to keep out of the vortices, as
12 general rules.

13 MR. JACKY: And did you see anything during
14 your -- during the flight test that would make you
15 change or update the training that you received?

16 THE WITNESS: No, I wouldn't say he would
17 change. The training, I think, was quite validating
18 what we saw. The vortices off the 27 were typically
19 almost always 300 feet below his altitude and they
20 stayed there. And they came right up the wing, and a
21 100 yards later, they were where they were going to be
22 and they stayed that way all the time, even back to
23 five miles back.

24 So 300 is a good number, if you want to know

1 where the vortices are on an airplane you're trailing
2 behind. It was an amazing test to be able to see these
3 things and visualize them and know exactly where they
4 were and fly into them and look at them from all
5 different angles and all different positions.

6 I guess I did get a different -- have a
7 different feeling about vortex interaction after I saw
8 this test, if we did this for a couple of hours. It's
9 hard to explain, I guess. But, again, as a pilot, you
10 see these things all the time. You've been in and out
11 of the vortex encounter a 100 times if you fly in an
12 airline environment at all.

13 Typically, you'll be flying along doing
14 something and all of a sudden, whoosh, you'll be rolled
15 up a little bit and back out again and you'll say, ah,
16 a wake encounter. And sometimes you'll say, boy, we
17 really dodged the bullet that time because we must have
18 been very, very close to this other big vortex over
19 here, because that wasn't very much. So you say, wow,
20 got out of that one again.

21 And in truth, after having done this test,
22 there is no big vortex. What you see with that little
23 ten degrees or 15 degrees roll rapidly, but not very --
24 it doesn't last too long. That's as bad as it gets.

1 You're never going to see anything worse than that.

2 So basically it validates that the three to
3 four mile separation for ATC is not a problem, at least
4 on this class of airplanes.

5 MR. JACKY: You mentioned in a roll up set,
6 did you happen to notice in encountering these
7 vortices, any upset in the pitch axis?

8 THE WITNESS: No, there was very little
9 effect on pitch or yaw. There was some turbulence, of
10 course. But no sustained pitch or yaw at all. In
11 other words, it was difficult in pitch tracking,
12 because the thing was so convoluted in going like this.

13 So you're really tracking the airplane to keep in the
14 vortex, if that's what you were trying to do. But I
15 didn't see any kind of a pitch upset at all. It was a
16 very slight trim change as you went through it up and
17 down, but nothing you couldn't handle with four or five
18 pounds of stick force.

19 MR. JACKY: And then you mentioned yaw. Was
20 there any large change of heading after you flew
21 through or during in the encounters?

22 THE WITNESS: I saw very little. A couple of
23 times we would be flying on a vortex and it would curve
24 back like this. And I think as you went -- when the

1 rudder went through that, it would kick a little bit,
2 but nothing significant. There was no sustained yaw or
3 anything you could even talk about. Just light
4 turbulence, like moderate turbulence.

5 MR. JACKY: Could you feel the vortices
6 hitting the airplane?

7 THE WITNESS: From time to time you could.
8 It was a very interesting interaction. If you got just
9 in the right place and the vortex hit the windshield,
10 you could hear it. It was kind of a strange sound,
11 like you're being hit by a stick on the outside of the
12 airplane. It would go woomph. And that was only one
13 time when the vortex was right in the middle of the
14 windshield.

15 If you came up and flew right in there, it
16 would smack you right in the windshield and make that
17 sound. You couldn't actually feel it. I mean, it was
18 just a sound. It was very unusual.

19 MR. JACKY: Were you able at any time, able
20 to get the vortices along the side of the fusel lodge
21 or maybe into the engine galling or something like
22 that?

23 THE WITNESS: We tried it about in every
24 place you could think of. We put the wing tip in it

1 and both sides, and we walked it all the way down the
2 wing and into the fusel lodge and under the fusel lodge
3 and then on the tip of the tail, the middle of the tail
4 and on both windshields, and every place you wanted to
5 look at. The interesting point -- I time I flew over
6 and stuck the vortex in the engine and that was an
7 interesting point, too, because I was interested to see
8 if it would have any affect on the engine operating
9 characteristics.

10 So I stabilized over there and let the vortex
11 go in the engine inlet, watching the engine
12 instruments, having somebody else watch the engine
13 instruments. Basically, it was really, really
14 interesting. You could see from the visual, from the
15 chase plane.

16 What happens is the vortex is about -- it
17 must be four feet in diameter, at least the smoke trail
18 part of it is. And that's much smaller than the in lot
19 of the airplane. And the vortex goes straight in the
20 in lot of the airplane and comes right out the back,
21 the size of a fan diameter. So it's small when it goes
22 in and big when it comes out. And you could actually
23 hear it when it went inside the engine. It was kind of
24 a strange sound like blowing over the top of a bottle.

1 It had no effect on the engine. I think it
2 was just an acoustic phenomena and there was no effect
3 on the engine, other than the fact that you could smell
4 it as it came through the air conditioning system.

5 MR. JACKY: What would it smell like?

6 THE WITNESS: Orcopus oil.

7 (General laughter.)

8 MR. JACKY: I'm surprised.

9 (General laughter.)

10 THE WITNESS: G-E processed orcopus oil.

11 (General laughter.)

12 MR. JACKY: We were talking about the upsets
13 on any of the three axis. At any time during your
14 encountering at vortices, were you surprised or
15 startled or did you ever feel like you got into a
16 condition that was of concern to you?

17 THE WITNESS: No. I think my final
18 conclusion was that there was one uncomfortable
19 condition that we flew. It was with the ones with the
20 auto pilot in the CWS mode and you try to stay in the
21 vortex. That was an extreme workload from a forced
22 standpoint, because the aileron deflections and rates
23 required there meant that you had to bottom out the
24 servo on the roll axis. And basically, you were

1 holding from 30 to 40 to 50 pounds of roll force to
2 keep the aileron fully deflected and move in those back
3 and forth. About two minutes of that is all you want
4 to put up with.

5 But the airplane certainly had enough
6 controllability to do that. It was just kind of
7 obnoxious maneuver. I would say probably you wouldn't
8 want to be doing that with the auto pilot on.

9 MR. JACKY: Would you say that the auto pilot
10 would be trying to correct the airplane for entering
11 and going through the vortices?

12 THE WITNESS: Yes, it would.

13 MR. JACKY: Would you feel like it would a
14 fairly effective job of riding the airplane?

15 THE WITNESS: An effective job of what?

16 MR. JACKY: Riding the airplane or balancing
17 of the wings?

18 THE WITNESS: Yes. As I said, if you had the
19 auto pilot on, it was about essentially the same
20 reaction as the crew did. If the auto pilot was on, it
21 didn't roll more than about ten degrees.

22 MR. JACKY: Did you feel that after flying
23 through these -- or the encounters that you did, were
24 there any sort of geometry or condition that you didn't

1 fly or are you pretty well satisfied that you
2 accomplished everything you could, as far as geometries
3 and what not?

4 THE WITNESS: I think we covered just about
5 everything that could be done. Like I say, we put the
6 vortex in every relative position of the airplane,
7 wing-wise and tail-wise and fuselage-wise, and we went
8 up and down and cross ways and rolling and non-rolling.

9 We stayed in the vortex for it must have been a half
10 an hour total right in the middle of one or two or both
11 of them.

12 So basically if you watch the video, I think
13 that's coming up later, you'll see that you can just
14 pull right up in there with absolute impunity and fly
15 anywhere you want with respect to either one or both of
16 those vortices without a controllability problem.

17 MR. JACKY: And could you compare the flight
18 test to flying the airplane in the simulator or through
19 the vortices that were in the simulator?

20 THE WITNESS: I was pleasantly surprised to
21 see that the simulator was extremely accurate. The
22 roll angles that we got out of the simulator before we
23 did this test were almost exactly the same as we got in
24 the airplane. The only difference that we did see was

1 the vortices pair in the real world were a lot closer
2 together than the one in the simulator. I don't know
3 why that is. But basically, it had the same effect.
4 It just happened quicker.

5 In fact, in the real world, you would go
6 through the front one and roll back out quicker than
7 you did in the other airplane. In that simulator, you
8 would roll up and go for a while and then roll back out
9 again. So it wasn't a substantive difference. Only in
10 the geometry of the vortex. The intensity of the
11 vortex and the effect on the controllability of the
12 airplane is exactly the same, as far as I could see
13 subjectively.

14 MR. JACKY: What was the difference in the
15 distance between the vortices cores?

16 THE WITNESS: Pardon?

17 MR. JACKY: Well, you mentioned that the only
18 difference would be in the amount of distance between
19 the two cores.

20 THE WITNESS: Yes.

21 MR. JACKY: What was that distance?

22 THE WITNESS: I think it probably must have
23 been half, maybe a little more than that.

24 MR. JACKY: So during the flight test, how

1 far apart would you typically say the vortices were?

2 THE WITNESS: I would say they were about --
3 it's hard to guess. But you'll see it from the
4 picture. You can get both wing tips and the vortices
5 at the same time. In fact, more than -- in board from
6 there. You'll have to see it from the picture.

7 MR. JACKY: So wing tip to wing tip, how far
8 apart would that be then?

9 THE WITNESS: I don't know. What's the wing
10 span, a 100 feet, 60? I don't know.

11 MR. JACKY: And during the encounters, did
12 you feel like the airplane was on the verge or out of
13 control at any time?

14 THE WITNESS: Not ever, no.

15 MR. JACKY: Have you ever taken any sort of
16 unusual attitude training?

17 THE WITNESS: Yes, I had unusual attitude
18 training during my initial instrument training and I've
19 done aerobatics at night and I flew air shows for about
20 three years and I taught aerobatics for about three
21 years.

22 MR. JACKY: Did any of that training help you
23 towards the wake vortex encounters?

24 THE WITNESS: No.

1 MR. JACKY: And the reason being?

2 THE WITNESS: Well, the angles and the rates
3 were so small and so slight, that it was nothing
4 approaching any kind of an aerobatics maneuver or
5 anything you would want to consider as an unusual upset
6 or an unusual attitude.

7 MR. JACKY: During any of the encounters, did
8 you happen to see the rudder moving at all?

9 THE WITNESS: Well, you can't see the rudder
10 moving. There's no indicator. You would have to ask
11 the chase pilot.

12 MR. JACKY: Is there any sort of indication
13 in the cockpit or rudder movement?

14 THE WITNESS: The yaw damper indicator, I
15 think.

16 MR. JACKY: Did you happen to look or observe
17 the yaw damper during -- the yaw damper indicator
18 during any of the encounters?

19 THE WITNESS: I didn't pay particular
20 attention to it. I assumed that it would be working,
21 because it was turbulent, but I didn't pay particular
22 attention. I think it was probably instrument. You
23 could tell -- you could see what the rudder deflection
24 and the frequency spectrum of it was from the data

1 output from the maneuvers.

2 MR. JACKY: I don't believe I have any
3 further questions. Thank you very much.

4 THE WITNESS: Okay.

5 MR. HAUETER: Mr. Chairman, thank you. Just
6 a couple. First to help clarify the record, one of the
7 reasons we didn't go past the 80 percent limit load is
8 this was a -- the airplane was going back into revenue
9 service. And there was considerations that if we did
10 any damage, we would have to buy a new vertical
11 stabilizer. I just wanted to clarify that a little
12 bit.

13 You mentioned there was no problem during the
14 wake encounters between the 727 and the 737. That it
15 was all controllable.

16 THE WITNESS: Yes.

17 MR. HAUETER: That's strictly fo~~r~~that
18 combination of aircraft. Correct?

19 THE WITNESS: That's correct.

20 MR. HAUETER: I wanted to make sure that the
21 private pilots weren't out there thinking this was not
22 a problem.

23 THE WITNESS: No, I said for that class of
24 airplanes.

1 MR. HAUETER: Okay. Good. Going back to the
2 steady heading side slip work that you did, that was
3 done as a steady. What results would you think there
4 would be if there was more dynamic, if the rudder came
5 in much faster, at 190 knots, flaps one?

6 THE WITNESS: Wel, we did do that test. We
7 did dynamic rudder inputs at a quarter, one-half, and
8 three-quarters. So we'll have data on what the
9 difference is between the static value and the dynamic
10 value. Typically, the side slip that we got in the
11 simulator was about at 190 knots, full rudder side slip
12 would give you about ten degrees. And the dynamic
13 rudder input would give you about 14. So it's 30 to 40
14 percent more side slip. And, therefore, more rolling
15 on it due to the dynamic input than you have when it's
16 steady.

17 So it will roll faster if you put the rudder
18 in dynamically than it will statically.

19 MR. HAUETER: Okay. Thank you. At 190
20 knots, flaps one, if you had a dynamic rudder input,
21 would that be a controllable event, in your opinion?

22 THE WITNESS: Well, I guess we'll have to get
23 back into the philosophical discretion of controllable
24 and recoverable here. That depends again on what you

1 do with the pitch control. Basically at 190 knots, if
2 you don't change the air speed at all and you have a
3 dynamic full rudder input, the airplane will roll
4 rapidly and it depends on how long you delay it too.

5 Some background on controllability and
6 recoverability. These terms were basically invented
7 during spin testing, where you have an airplane that's
8 not approved for spins and you have to do a one turn
9 anyway to make sure that during the postal gyration
10 that nothing unusual or bad happens and you can recover
11 it. After that one turn spin intentional, you have to
12 be able to recover in one additional turn.

13 Now, if it didn't meet that, if it didn't
14 meet the requirements in the rules for that spin
15 recovery, we said that it was uncontrollable. So
16 basically, if you had a spin that was supposed to be
17 recovered in one turn and it took three, then that was
18 what we called uncontrollable but it was recoverable.
19 It was only unrecoverable if you had to jump out.

20 So this became kind of a flight test shop
21 talk. And it may be a bit confusing to people who
22 don't do that all the time. So I think better than
23 using uncontrollable will change that over to a little
24 bit better syntax and say that it's less than

1 acceptable controllability. I think that will be
2 better.

3 So now you have an airplane that can be less
4 than acceptable controllability, but recoverable. And
5 I think that's what we have in this case.

6 The auto pilot requirements -- in other
7 words, using the auto pilot as an example. If you have
8 an electric flight control system or any type of
9 stability and controlled augmentation to hook to the
10 flight controls that's electric, you have to look at it
11 from a failure standpoint. And if the failure is not
12 extremely improbable, you have to demonstrate it in
13 flight. Then you have to pick a number that you decide
14 for yourself what is acceptable controllability and
15 what is it.

16 Obviously, if the thing goes hardover, that
17 is a full maximum, as fast as it will go, as far as it
18 will go and stays there that rolls the airplane
19 inverted in one second. Most all pilots are not going
20 to make it out of that one. If it rolls five degrees
21 in 20 seconds, everybody's going to recover from that.

22 So somewhere between those two, there's a
23 limit of acceptable controllability. And what the FAA
24 has chosen, based on experience and the type of pilots

1 that are flying the airplanes, little airplanes, and
2 the business jets, as well as the airline operators, we
3 have chosen to be in the roll axis 60 degrees after a
4 three second delay. That's the crew's case. We assume
5 the pilot is on -- the auto pilot is on and the pilot
6 is reading this map or talking to the co-pilot or
7 talking to ATC, and when something happens, he doesn't
8 see it immediately. Then when he does see it, he says,
9 what's that? Let's get rid of this auto pilot, but
10 then he has to reach up and grab it and disconnect it.

11 So we give him a reasonably conservative
12 three seconds to do that before he gets to an
13 unacceptable angle. And the angle we used for a
14 tradeoff between those configuration of acceptable
15 controllability and unacceptable is a 60 degree bay,
16 after three seconds after the pilot recognizes
17 something is wrong.

18 The British, the CAA use a little bit more
19 precise, I think. And they use four seconds from the
20 input of the hardover. And it comes out about the same
21 in most cases. So if the airplane rolls more than 60
22 degrees in three seconds after the thing has moved far
23 enough for the pilot to see it, then we say that's an
24 unacceptable level of controllability.

1 Now, it's not unrecoverable in most cases.
2 And generally the case is you can get back out of it,
3 but you have to look at it from the standpoint of human
4 factors and look at it from the standpoint of the whole
5 cross section of the pilot community that's going to be
6 flying it, levels of experience, and the mood that day.

7 Whether it's nice or dark or is it a rainy night and
8 it's turbulent, and what the workload is. And
9 basically, our feeling is that if it rolls more than
10 that, you're going to start picking up a significant
11 number of people who are going to lose it from a
12 standpoint of disorientation.

13 So we say 60 is the limit. So --

14 MR. HAUETER: Um -- I'm sorry. Go ahead.

15 THE WITNESS: Pardon?

16 MR. HAUETER: Have you -- I'm sorry. I
17 interrupted you.

18 THE WITNESS: I was just going to say that
19 there's also -- there's an equivalent requirement in
20 the pitch axis or plus or minus 1 G for three seconds.

21 And that's basically two to zero are the limits. You
22 can't go any more than that in pitch or more than 60
23 degrees in roll.

24 MR. HAUETER: Just going back and clarifying

1 that you would say this is undesirable --

2 THE WITNESS: I would say --

3 MR. HAUETER: -- controllability,
4 unacceptable controllability?

5 THE WITNESS: Well, we're going back and
6 looking at the effective -- the pitch inputs on this
7 hardover at 190 knots. Basically, in the simulator, at
8 least, we didn't do the full deflection in the
9 airplane. But once they had upgraded the rudder
10 deflection, we did some hardovers in the simulator,
11 too, with a three second delay to take a look at it.

12 Basically, it's a lot -- how far you go is a
13 lot of function of what you did with the stick. If you
14 don't do anything at all, you just let the other pilots
15 stante on the rudder and hold it there, when you see it
16 start to move, you count -- mark one thousand one, one
17 thousand two, one thousand three, and then go quick
18 full ops of the aileron, leaving the rudder in,
19 assuming that you can't get it back out again, and the
20 airplane rolls up to about -- depending on how you did
21 it. If you don't use any pitch input at all and let
22 the airplane nose drop and accelerate, you'll wind up
23 with about a 75 degree bank.

24 Now, the other move that I did was I tried it

1 again. And instead of letting the airplane go on its
2 own and accelerate any way it wanted to, I held enough
3 back stick to keep it at 190 knots in that maneuver.
4 If you do that, it rolls up to past 80 degrees, almost
5 90.

6 So basically, in this condition, if you put
7 in -- the more back stick that you add to it, the worse
8 it gets. If you try to keep the wings level and slow
9 down below 190, it's going to go on over, I think.

10 MR. HAUETER: In the trials that you had in
11 the simulator, about how much altitude loss did you see
12 in the recovery?

13 THE WITNESS: It wasn't a real significant
14 altitude loss, because we didn't go on over.
15 Basically, we considered that -- at least I did. Based
16 on the three second delay in recovery that it was an
17 unacceptable level of controllability, but it was
18 always recoverable.

19 In other words, we could always get the thing
20 to roll back out, especially if you accelerated. On
21 the one, that at 190, it wouldn't draw out. It
22 basically stayed at about 70 degrees and just sat there
23 in a spiral. Until I dropped the nose and let it
24 accelerate out until about -- at 200, it started coming

1 back. And at 210, it's not a problem. A little bit of
2 air speed increase helps you out a lot.

3 MR. HAUETER: Did you lose 2,000 feet in the
4 recovery or --

5 THE WITNESS: No, I don't think it was that
6 much. I don't even think it was even 1,000.

7 MR. HAUETER: Do you think it takes special
8 training for pilots to recognize this more than they
9 currently get to be able to recognize or recover from
10 such a maneuver?

11 THE WITNESS: That's hard to say, I guess,
12 because it presumes that they are going to handle an
13 auto pilot hardover. I don't think they're trained to
14 do that. Basically, the presumption is that that three
15 second leg gives them time to figure out what happened
16 and instinctively correct for it by going opposite in
17 the opposite axis of which way is going hardover.

18 So I don't think we've ever done ~~an~~ auto
19 pilot hardovers in any airline recurrent training that
20 I've ever been to.

21 MR. HAUETER: Okay. Thank you, sir.

22 CHAIRMAN HALL: Other questions from the
23 Technical Panel?

24 (No response.)

1 CHAIRMAN HALL: The parties? I see Boeing,
2 the Airlines Pilot Association, the FAA, Boeing
3 Commercial Airplane Group. Mr. Purvis.

4 MR. CLARK: Can we follow up just on that
5 last question, just real quick?

6 CHAIRMAN HALL: Mr. Purvis, would you mind if
7 Mr. Clark follows up on that last question?

8 MR. CLARK: This last discussion you had with
9 Mr. Haueter, I thought you were talking about an event
10 with the rudder hardover. And then right at the very
11 last, it seemed like we jumped over to auto pilot
12 failures.

13 THE WITNESS: I think we were just relating
14 the two. He asked me if a pilot, an airline pilot
15 should be trained to handle -- specially trained to
16 handle an auto pilot -- not an auto pilot, but a flight
17 control system hardover. And I said, I didn't think
18 so, because the -- that is analogous to having an auto
19 pilot hardover right now and they are trained to do
20 that.

21 MR. CLARK: But just the immediately previous
22 discussion was still dealing with the rudder issue for
23 a flight control hardover?

24 THE WITNESS: Yes.

1 MR. CLARK: Okay.

2 CHAIRMAN HALL: Mr. Purvis.

3 MR. PURVIS: Good afternoon, Mr. Berven. How
4 many of the flights did you fly at Atlantic City? I
5 think you said you flew one in Seattle. How many did
6 you do at the Atlantic City tests?

7 THE WITNESS: I flew two in Atlantic City.
8 The first one for the safety evaluation, and the one
9 for data.

10 MR. PURVIS: At the previous hearing in
11 Pittsburgh, I recall that you said a wake encounter was
12 like a giant hand grabbed you. And today, you also
13 used the phrase, boy, we just ducked a bullet there,
14 when you were answering questions from the tech panel.

15 During the wake encounter test with the smoke
16 on in Atlantic City, could you prepare and anticipate
17 for the wake -- prepare for and anticipate the wake?

18 THE WITNESS: Certainly.

19 MR. PURVIS: Under those circumstances where
20 you can see the wake coming, is it less surprising to
21 you do you think?

22 THE WITNESS: Well, certainly. You basically
23 know when it's going to happen. If the wake is not
24 there, it's a surprise, but it basically is nothing

1 that's going to -- it's just unusual.

2 MR. PURVIS: Thank you.

3 CHAIRMAN HALL: Captain?

4 CAPTAIN LeGROW: Thank you, Mr. Chairman.

5 Good afternoon, Mr. Berven.

6 THE WITNESS: Hi.

7 CAPTAIN LeGROW: Just a couple of questions.

8 First of all, during your career at the FAA -- how

9 long have you been with the FAA, by the way?

10 THE WITNESS: Nineteen years.

11 CAPTAIN LeGROW: You weren't here in 1967

12 either?

13 THE WITNESS: No.

14 (General laughter.)

15 CAPTAIN LeGROW: Have you, during your
16 career, participated in the certification flight tests?

17 THE WITNESS: Yes. That's all I do mostly.

18 CAPTAIN LeGROW: Have you participated in the
19 737 certification?

20 THE WITNESS: Yes.

21 CAPTAIN LeGROW: What model?

22 THE WITNESS: Three hundred, 500, and 400.

23 CAPTAIN LeGROW: During those certification
24 tests, did you use the same criteria that the 100 and

1 200 were certified to?

2 THE WITNESS: Yes, except for the propulsion
3 system.

4 CAPTAIN LeGROW: But as far as the controls -
5 - or the controls of the three axis were the same
6 criteria used in 1967?

7 THE WITNESS: That's correct.

8 CAPTAIN LeGROW: You talked about doing some
9 tests with jammed controls. I believe you said that
10 you used the rudder trim -- how much rudder trim
11 authority do you have?

12 THE WITNESS: Well let's see. The rudder
13 statically deflects 26 degrees. I believe on the
14 ground, you get 16. You don't get that much in flight,
15 of course, because for the blow down.

16 CAPTAIN LeGROW: But you've never done any
17 with a full -- until the simulator validation tests in
18 Seattle last month, you had never done any tests with
19 full rudder hardover?

20 THE WITNESS: No, we did not.

21 CAPTAIN LeGROW: During your tests in Seattle
22 for the validation tests, were you surprised at the
23 control or lack of control with the full rudder
24 hardover?

1 THE WITNESS: Not particularly, because
2 basically, that's not an unusual characteristic for a
3 transport airplane.

4 CAPTAIN LeGROW: During Mr. Jacky's
5 questioning, you referred to flying some of the tests
6 at one degree flap between 170 and 220 knots, I
7 believe. Is that correct?

8 THE WITNESS: Yes.

9 CAPTAIN LeGROW: So you -- and I believe you
10 said that something under 190 knots, 185 maybe, would
11 be a good number. That with a full rudder hardover,
12 you did not have enough lateral control.

13 THE WITNESS: That's correct.

14 CAPTAIN LeGROW: And you say this is
15 something you expected?

16 THE WITNESS: Yeah. If you want a further
17 explanation on that, it comes from the fact that we
18 don't do primary flight control system hardovers.
19 Because by definition, they're designed with enough
20 control power to have the pilot do whatever he wants to
21 the airplane. Therefore, if a primary flight control
22 system does go hardover and stay there, you'll very
23 likely lose the airplane every time.

24 Just look at the pitch axis. If you get a

1 full aft stick elevator hardover and if you can't get
2 rid of it, you're done. So basically the flight
3 control system, primary flight control system has to be
4 basically reliable enough that that does not -- it
5 doesn't happen.

6 CAPTAIN LeGROW: I guess that's why in the
7 earlier airplanes we had an angle reversion. Is that
8 correct?

9 THE WITNESS: It's what now?

10 CAPTAIN LeGROW: In the earlier airplanes, we
11 had an angle reversion.

12 THE WITNESS: The 737 has been the same all
13 along, as far as I know.

14 CAPTAIN LeGROW: Were you here for Mr.
15 McSweeney's testimony?

16 THE WITNESS: Yes.

17 CAPTAIN LeGROW: Do you recall I asked him a
18 question about manual reversion in the 737 and his
19 answer was, that the rudder in the 737 did not have
20 manual reversion, but it did have a standby system.

21 THE WITNESS: That's correct.

22 CAPTAIN LeGROW: Is that standby system
23 hydraulic or is it manual?

24 THE WITNESS: It's hydraulic.

1 CAPTAIN LeGROW: Thank you. During your
2 tests in Seattle for the simulator validation tests,
3 were there any other regimes of flight that you flew or
4 any of the other pilots that you're aware of flew with
5 a full rudder hardover and there was no lateral -- not
6 enough lateral control of the airplane?

7 THE WITNESS: We didn't do a real
8 comprehensive test, because that wasn't what we were
9 looking for. We were basically just checking it
10 against the simulator. We did a bunch of other stuff
11 in the simulator. I think it's agreed now that with
12 flaps one, five or even possible ten, that you can over
13 roll the roll axis with the rudder input at slow
14 speeds.

15 CAPTAIN LeGROW: On this -- your discussions
16 about recoverability, I find those terms quite
17 interesting. Does not altitude and time affect
18 recoverability?

19 THE WITNESS: Certainly. If you're too low,
20 you can't make it.

21 CAPTAIN LeGROW: But still -- I guess, it's
22 still recoverable even though you crash?

23 THE WITNESS: I'm speaking of it from a
24 flight control standpoint. You have to presume that

1 you have enough altitude or you'll crash, yeah.

2 CAPTAIN LeGROW: Have you participated in any
3 of the certification flight tests in the newer model
4 Boeing airplanes?

5 THE WITNESS: Yes, quite a lot of times in
6 the 777, 57, 67.

7 CAPTAIN LeGROW: How would you compare the
8 rudder system in the 57 to the 37? Let me put the
9 question another way. During your flight testing on
10 the 75, you have done any full rudder hardovers in the
11 757?

12 THE WITNESS: No, we have not.

13 CAPTAIN LeGROW: Could you tell us what the
14 difference in the certification criteria and the
15 certification of the yaw control in the 75 as compared
16 to the certification of the 73 yaw control?

17 THE WITNESS: It's really very similar. In
18 the older airplanes, the lateral directional stability
19 tests were kind of segmented into a couple of different
20 parts. One of them was just straight directional
21 stability, where you just stabilize in a certain air
22 speed and flap condition and gear and just push the
23 rudder in for a while and release it and see that it
24 came back to zero to check that it was directionally

1 stable and didn't have too much friction.

2 Another test that we did was to put the
3 airplane in a straight steady heading side slip and
4 like what we were doing on these evaluations tests. Is
5 look at the relationship between the rudder and the
6 elevator to make sure there was a positive grady and
7 opposite to each other. And then you would release the
8 stick or release the wheel and see that it rolled into
9 the rudder so that it had a positive dihedral effect.

10 Later on, we decided that those were all the
11 same test. Basically if the airplane had directional
12 stability -- in other words, if you push the nose up
13 and it comes back and if when you released the controls
14 on the side slip, it rolls up, you can tell both of
15 those by just doing a straight ahead side slip.

16 In other words, if you're pushing more side
17 slip and your rudder force is going up and your
18 ailerons are going opposite, it's obvious that if
19 you're holding an aileron force, if you let it go, it's
20 going to roll away to the rudder.

21 Basically, we've combined those tests,
22 synthesized them into just a straight steady heading
23 side slip for static directional -- static lateral
24 directional stability. You get the same effect. So

1 the tests are essentially the same.

2 CAPTAIN LeGROW: Thank you. You're familiar
3 with the CDR?

4 THE WITNESS: Yes.

5 CAPTAIN LeGROW: And the exhibit that's been
6 offered here at these hearings?

7 THE WITNESS: Yes.

8 CAPTAIN LeGROW: And I refer you to
9 recommendation 9. I asked Mr. McSweeny earlier if in
10 light of that or if he felt that increasing the lateral
11 control of the 737 or reducing or restricting the yaw
12 control on certain regimes of flight, maybe one way to
13 get to that recommendation.

14 I would like to ask you, in light of your
15 surprise or what you -- I don't want to use surprise.
16 I don't want to put words in your mouth. But what I'm
17 assuming from your testimony is what you saw wasn't
18 necessarily what you expected. Would that be a fair
19 statement?

20 THE WITNESS: With respect --

21 CAPTAIN LeGROW: With respect to a full
22 rudder hardover.

23 THE WITNESS: No. I guess, that I never had
24 any expectations, because I was always under the

1 presumption that it couldn't happen. It never entered
2 my mind that we would even consider it.

3 CAPTAIN LeGROW: In light that we know that
4 it does happen and this has been going out in the tests
5 in Seattle, do you think that it would be helpful for
6 the FAA and/or the Safety Board to make recommendations
7 to either increase the lateral control of the 737,
8 restrict the yaw controllability of the airplane, or
9 perhaps change some of the operational procedures in
10 the airplane to help get the recommendation in line?

11 MR. PURVIS: Mr. Chairman?

12 THE WITNESS: I think that's four different
13 comments. I think I'm going to answer the first one.
14 Number one, I don't think anybody --

15 MR. PURVIS: I would like to object to the
16 question, to start off with. If he's presuming many,
17 many things that are not verified and including, in
18 particular, full rudder hardovers -- I mean, that's
19 done as part of a test. But that it occurred in this
20 accident is a presumption.

21 CHAIRMAN HALL: Do you want to reconsider the
22 question, Captain, or do you want to restate it and let
23 me --

24 CAPTAIN LeGROW: Well, I'll restate it, if

1 need be, but I wasn't referring to the accident. I
2 don't believe I mentioned the accident. What I was
3 referring to is the test conducted in Seattle for the
4 simulator validation tests.

5 THE WITNESS: The simulator validation test
6 was an in-flight test. And basically, we did the
7 rudder hardover just to validate how accurate it was
8 dynamically with respect to the simulator. Your first
9 presumption that -- in other words, to talk about
10 changing procedures and improving lateral control and
11 decreasing the yaw control, you have to start off with
12 the presumption that you have a rudder hardover to
13 address. Now, I don't think that's been concluded yet.

14 If you want to say if a rudder hardover
15 occurred, what would you do, I can give you a few
16 suggestions on that.

17 CAPTAIN LeGROW: Okay.

18 THE WITNESS: If a rudder hard -- if I was
19 going to go out and fly the 737 and during that flight
20 of an hour and a half or whatever it was, I knew that I
21 was going to have a rudder hardover somewhere in there
22 and I was going to have to handle it or not come back
23 there's a couple of things I would do based on my
24 experience in the airplane and the simulator and all

1 the stuff that I've learned.

2 Number one, I would go faster to start with.

3 If I was at flaps one, I would 200 as a minimum. The
4 second thing I would do is I would keep my hands on the
5 controls. So I don't have a three second delay. I've
6 only got one. Any time that I was out of flaps one, if
7 I was at one, five, or ten, I would either be manually
8 flying the airplane myself or following through if the
9 auto pilot was on.

10 And another thing I would do is basically
11 minimize my time at those flap settings. I would ATC
12 to stay at 210 until I could go to 160 or 170 or 150
13 and slow down to flaps 15.

14 CAPTAIN LeGROW: Thank you. I have no
15 further questions, Mr. Chairman.

16 CHAIRMAN HALL: Mr. Donner?

17 MR. DONNER: Just two questions, sir. Mr.
18 Berven, we've talked a lot about auto pilot hardovers
19 and the three second delay for pilot recognition of the
20 event. Then you've talked about the 60 degree limit.
21 My question is does the 60 degree limit include the
22 pilot's reaction after the three second recognition
23 time?

24 THE WITNESS: Yes, it does.

1 MR. DONNER: Concerning the possible rudder
2 hardover at various flap settings, is the rudder
3 hardover at landing flaps 30 degrees or more capable of
4 being balanced by the aileron?

5 THE WITNESS: Based on all the information
6 and the tests that we've done, yes. Either flaps up or
7 flaps 15 or more, the lateral control system has enough
8 control power to handle it.

9 MR. DONNER: Thank you. I have no further
10 questions.

11 CHAIRMAN HALL: Mr. Clark?

12 MR. CLARK: I have one question in one area.
13 You talked about an event in which, as you were
14 finishing up with the questioning with Mr. Haueter, a
15 three second delay in a 60 degree bank angle. And then
16 I think you talked about possibly going for speed to
17 effect the blow down if you were dealing with rudder
18 hardover. Is that an intuitively reactive -- would
19 that be an instinctive reaction or an intuitive
20 reaction by the crew, by a typical line crew?

21 THE WITNESS: I really don't think it would
22 be, no.

23 MR. CLARK: So that if you were to address
24 that, that would be a training issue then?

1 THE WITNESS: If I had never seen or
2 encountered or even heard of a rudder hardover,
3 basically my job right there was hold altitude so I
4 don't get violated. So if something happens, I'm going
5 to try to solve the problem and get back into control,
6 but I'm also going to try to stay legal at the same
7 time. So you would probably instinctively try to keep
8 the airplane on this altitude until you reached a point
9 where this is more serious than an ATC violation.

10 MR. CLARK: So basically if you were to
11 address this issue, we've been looking at a training
12 issue?

13 THE WITNESS: If you're going to presume that
14 a flight control system hardover can handle, you have a
15 really big training problem.

16 MR. CLARK: Sure. Thank you.

17 CHAIRMAN HALL: Mr. Marx?

18 MR. MARX: No questions.

19 CHAIRMAN HALL: Mr. Schleede?

20 MR. SCHLEEDE: Just a couple, Mr. Berven.
21 These values that you gave when you defined acceptable
22 controllability -- you gave us some numbers -- are
23 those specified in some material?

24 THE WITNESS: They're in an advisory circular

1 wiht respect to auto pilots. It's 1329-1, I think.
2 Either that or it's been put in our flight guide 2570.

3 MR. SCHLEEDE: Thank you. Is there a
4 definition in there also for exceptional pilot skills
5 as mentioned in FAR 25-671?

6 THE WITNESS: No, I think that's part of all
7 the regulations. It says that all the CFR requirements
8 for airworthiness have to be able to be met without
9 exceptional pilot skill. So that's kind of a very
10 subjective call, too.

11 Basically what we have to do is to just
12 presume that when we see some unusual flying qualities
13 or something that's outside of the norm that you
14 wouldn't see instinctively, we have to say would the
15 normal pilot using normal flying techniques be able to
16 pick this up and handle it without causing a problem.
17 Because we go out there sometimes and we do 200 or 300
18 full stalls in the airplane.

19 So by the time we're done with that, we're
20 pretty proficient at it. So we have to ask ourselves
21 if an airline pilot never having done a real stall and
22 the airplane gets into one, what's he going to do? So
23 an airplane that we could recover and meet the rules
24 every time after 300 practice stalls, would not be

1 acceptable for a pilot who only has to do it one time
2 in his entire career.

3 So basically our requirements are that the
4 airplane would really be easy to fly through all the
5 maneuvers required by the regulations, because the
6 airline pilot really encounters a lot more different
7 and unusual conditions than we do.

8 MR. SCHLEEDE: Is there guidance of any sort
9 that helps you reach the subjective evaluation of pilot
10 skills required in any documents or --

11 THE WITNESS: I don't believe there is. It
12 basically comes from just meetings between our flight
13 test pilots and meeting with the airline pilots and
14 flying with them on the jump seat rides and seeing how
15 they fly and what their attitudes are and going to
16 recurrent. We go to the airline recurrent once a year,
17 each one of us. We don't fly with the airline pilots.
18 We fly with their instructors and take the same check
19 rides. So we see what level of proficiency they're
20 trained to.

21 So we try to basically find compliance to a
22 pilot that doesn't require exceptional skill or a lot
23 of practice.

24 MR. SCHLEEDE: Thank you very much.

1 CHAIRMAN HALL: Mr. Laynor?

2 MR. LAYNOR: Just a couple, Mr. Berven. I
3 think you've hit upon it. But in talking to Mr. Jacky
4 about the tests that were conducted, this steady
5 heading side slip test, were they done with all the
6 different flap configurations at the speed -- through
7 the speed range that you discussed?

8 THE WITNESS: They were done mainly just at
9 flaps one, just to check against the simulator.

10 MR. LAYNOR: I'll carry on then. How do you
11 establish what the real control margin, lateral control
12 margins were in fact at the different flap settings
13 that you were referring to in your answer to Captain
14 LeGrow?

15 THE WITNESS: The extrapolation of our
16 comments to five and ten is based on both aerodynamic
17 characteristics of the airplane and the simulators. We
18 did do those tests in the simulator.

19 MR. LAYNOR: Okay. In bounding the ranges
20 that you would recommend as a procedure or if you did
21 recommend any procedural changes, did that include the
22 margin necessary to recover from an upset that would
23 occur with the dynamic control movement or is that just
24 what's needed to balance the two -- the directional

1 lateral controls?

2 THE WITNESS: If I understand the question,
3 at 190 knots, you statically balance the rudder and
4 aileron. So that if you have a dynamic input, you
5 can't stop it until you speed up. Depending on -- with
6 the three second delay. If your hands are on the
7 controls and you only use a one second delay, you can
8 stop it at about 25 to 30 degrees.

9 MR. LAYNOR: But you would have to change
10 your speed in order to have the margin to recover --

11 THE WITNESS: That's right.

12 MR. LAYNOR: -- to a level flight. As
13 strictly hypothetical, because I don't think you could
14 expect the line pilot to do it in the dynamic situation
15 that we're talking about. But you've commented about
16 sitting there expecting such an occurrence and how you
17 would respond to it.

18 Would you consider isometric power or would
19 you consider turning off the hydraulic pressures as a
20 possible response?

21 THE WITNESS: I think those are kind of
22 secondary items that you would do after you try to get
23 control of the airplane, because you have to get on it
24 really quick. To find the hydraulic switches and turn

1 them back off again, you would probably have to have
2 the other pilot do that and you would have to go
3 through the command process to tell him to do that.

4 You could split the engines, you know, if you
5 got to a position finally. In other words, you rolled
6 all the way there and it stopped and you can't get it
7 back out, you can split the engines and roll back out
8 that way. There are several other things you can try.

9 MR. LAYNOR: All right. Thank you. That's
10 all I have.

11 CHAIRMAN HALL: Mr. Berven, I guess my only
12 question is, were you -- did you participate in the
13 critical design review?

14 THE WITNESS: No, I did not.

15 CHAIRMAN HALL: Have you read the report?

16 THE WITNESS: Yes.

17 CHAIRMAN HALL: Do you agree with the
18 recommendations?

19 THE WITNESS: Yes.

20 CHAIRMAN HALL: All right. Well, thank you
21 very much. We appreciate your time.

22 THE WITNESS: I had one more comment here.

23 CHAIRMAN HALL: Surely.

24 THE WITNESS: Based on something that was

1 said earlier this morning about ten to the minus ninth
2 and extremely improbable. My understanding, not being
3 a systems expert but having worked with a whole bunch
4 of them, ten to the minus ninth is an extremely
5 improbable event that does not happen during the life
6 of the fleet.

7 Basically, that's a billion hours. Four
8 typical 737 at this point has got 65,000 hours in 30
9 years, it's going to take 500 years to get a billion
10 hours.

11 So basically, a ten to the minus ninth event
12 is allowed to be catastrophic, because it never happens
13 in the lifetime of the fleet.

14 CHAIRMAN HALL: So the point -- you're just
15 clarifying that?

16 THE WITNESS: Yes, that's just a
17 clarification.

18 CHAIRMAN HALL: All right. You're dismissed,
19 sir. Thank you.

20 THE WITNESS: Thank you.

21 (Witness excused.)

22 CHAIRMAN HALL: We're not moving ~~we~~
23 rapidly, Mr. Haueter.

24 (General laughter.)

1 CHAIRMAN HALL: Mr. Berven gave us several
2 lengthy descriptions of the same flight, and I guess
3 we're now going to have some more?

4 MR. HAUETER: Yes, they should be shorter.

5 CHAIRMAN HALL: Okay. Well, let's take a
6 break and come back at 4:15.

7 (Whereupon, a recess was taken.)

8 CHAIRMAN HALL: We will reconvene this Board
9 of Inquiry, and our next witness, witness number 10, is
10 Mr. Robert Stuver -- Stuever. Sorry, Mr. Stuever. He
11 is the Program Manager of the OV-10 Flight Test-Wake
12 Vortex Studies. And he comes to us from NASA-Langley
13 in Langley, Virginia.

14 Thank you for being here today, Mr. Stuever.

15 (Witness testimony continues on the next
16 page.)

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10 ROBERT STUEVER, PROGRAM MANAGER, OV-10 FLIGHT TEST-WAKE
11 VORTEX STUDIES, NASA-LANGLEY, LANGLEY, VIRGINIA

12

13 Whereupon,

14

ROBERT STUEVER,

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

18

THE WITNESS: Thank you for the opportunity

19

to let me work today while my colleagues are on

20

furlough, too.

21

(General laughter.)

22

CHAIRMAN HALL: We don't have to pay you, do

23

we?

24

(General laughter.)

1 MR. SCHLEEDE: Mr. Stuever, give us your full
2 name and business address, please?

3 THE WITNESS: Robert A. Stuever, Mail Stop
4 247, NASA-Langley Research Center, Hampton, Virginia
5 23681.

6 MR. SCHLEEDE: Thank you. And what is your
7 position at NASA?

8 THE WITNESS: My position is as an Aerospace
9 Research Engineer in the Flight Dynamics and Control
10 Division at Langley.

11 MR. SCHLEEDE: How long have you worked for
12 NASA?

13 THE WITNESS: I've worked for NASA for five
14 years.

15 MR. SCHLEEDE: Could you give us a brief
16 description of your education and background?

17 THE WITNESS: Yeah. I have got a bachelors
18 and a master's degree in aeronautical engineering from
19 Wichita State University. I've worked at NASA for five
20 years in the Flight Dynamics Control Division. Prior
21 to reorganization about a year ago, I was in the Flight
22 Applications Division.

23 I have been involved on the wake turbulence
24 program at NASA-Langley, as well as some other flight

1 research programs that we've had over the last five
2 years.

3 Currently, my duties are as a group leader
4 for a team of researchers studying wake turbulence
5 hazards in the terminal area for terminal area
6 activities for the purposes of looking at airport
7 capacity issues and wake spacing criterion.

8 MR. SCHLEEDE: Thank you very much. Mr.
9 Jacky.

10 MR. JACKY: Good afternoon, Mr. Stuever.

11 THE WITNESS: Good afternoon.

12 MR. JACKY: I would like to ask you first
13 about you said you mentioned you work in the wake
14 turbulence program at NASA-Langley. Could you give us
15 a description of what that entails, please?

16 THE WITNESS: Well, it entails a lot of
17 things. It's a very broad program that NASA is
18 conducting jointly with the FAA for the purpose of
19 looking at ways to increase airport capacity at major
20 airports around the country. Primarily looking at ways
21 to perhaps alter the spacing restrictions in instrument
22 meteorological conditions as they pertain for wake
23 vortex hazards.

24 My particular group is a team we call the

1 hazard definition and assessment team. We're coupled
2 in with another team at Langley that is looking at
3 developing sensors and systems that would be able to
4 predict wake vortex behavior in the terminal area
5 environment and be able basically to space aircraft
6 according to whether wakes are staying in the approach
7 corridors and how strong those wakes are and so forth.

8 My particular team is looking at validating
9 models and validating hazard criteria in terms of
10 aircraft that would actually encounter wakes on the
11 approach corridors and determining if it is, in fact,
12 safe and satisfactory for an airplane to do that.
13 Satisfactory in the sense that a pilot would not be
14 inclined perhaps to maybe make a go around or do
15 something that would disrupt the flow of traffic into
16 the terminal area environment.

17 I might point out when I talk about wakes in
18 the approach corridors and aircraft encountering them
19 safely, really the best example to use is something
20 like you might have a day where a wake from a leer jet
21 might stay in the approach corridor and you wanted to
22 send like a 747 behind it. I mean, that's an example
23 of something that might be acceptable.

24 MR. JACKY: How long has this program been in

1 place?

2 THE WITNESS: Well, the joint program with
3 the FAA has been in place, I believe, about two years.

4 We initiated the program shortly after I got to
5 Langley, which was five years ago. In terms of a
6 flight research project that would help us validate
7 vortex encounter models that would then be put into --
8 well, we would have a systems group at Langley work on
9 developing the actual system that would take these
10 models and convert them into something that the FAA and
11 the air traffic control system could use. But in terms
12 of the joint program, I'm going to guess it was two to
13 three years ago that we put the big program together.

14 MR. JACKY: Is there a program completion
15 date at this time?

16 THE WITNESS: Yes. What we're targeting
17 right now is the test of what we call an aircraft
18 vortex spacing system or AVOSS system. Somewhere in
19 the 1998, '99 time frame, and that would be a prototype
20 system that we would test at major airports with the
21 idea that if that test is successful, somewhere around
22 the year 2000, we would start implementing that system
23 nationwide.

24 MR. JACKY: Can you briefly describe that

1 system? Is that a ground base type of system?

2 THE WITNESS: Yes, it would be a ground base
3 system. At its best, it would be a system of sensors
4 that would be able to measure -- actually, I'm sorry.
5 That would be able to detect, track, and measure wake
6 vortices in the approach corridors.

7 Well, at best, that's what it would be.
8 Coupled with some predictive algorithms that would be
9 able to tell you say at 20 minutes from now, given this
10 weather state, this is what the wake is going to do.
11 When the airplane that is now being marshalled into the
12 approach corridors, when he gets to this particular
13 point, this is what the wake of the preceding airplane
14 might do and this is what the weather state is going to
15 be like, that would drive the transport and decay of
16 that wake.

17 So, yes, it would be a ground base system in
18 terms of a deplorable sensor and a predictive algorithm
19 deployed along with that.

20 MR. JACKY: And as part of the hazard -- I
21 believe you said hazard definition team, what are your
22 functions within this program?

23 THE WITNESS: Well, there's three functions.
24 My particular function, as the team leader, I've got

1 roughly five to six people working on this project.
2 Although, some of them are also working on other
3 things, as well.

4 Basically, we're addressing this particular
5 research task in three ways. One, determining what's
6 the metric for what would be an acceptable terminal
7 area operation? In other words, you have to have some
8 way of defining what a wake vortex hazard is based on
9 something that's already acceptable to a pilot, to the
10 air traffic control and so forth.

11 The second one, which is really our major
12 effort now, it involves a lot of flight test work that
13 we're doing now. We've done a lot of work in the wind
14 tunnels. We're developing flight simulations and we've
15 got some analysis work going on. And that is with
16 respect to validating how you model the interaction of
17 a wake vortex with an aircraft. Not how you model the
18 vortex itself and the decay of the vortex, which is
19 being done by the other team developing the AVOSS, but
20 how you model the interaction of the aircraft in the
21 wake.

22 The third thing that we're doing within the
23 team is once you have these valid models, once you have
24 a metric, how do you apply it to the fleet to develop

1 wake hazards for all the aircraft in the fleet, under
2 all the different categories.

3 MR. JACKY: Thank you. You said that you're
4 doing a lot of flight testing. And you also have said
5 that you're program manager for the OV-10 aircraft. Is
6 this the aircraft that you'll be using for these flight
7 tests?

8 THE WITNESS: That's one of the aircraft.

9 MR. JACKY: And what would be the other
10 aircraft that you would be using?

11 THE WITNESS: Well, the OV-10 is one of the
12 aircraft that we're using to make wake missions and
13 we're also using it to make weather measurements.
14 Initially, when we put the aircraft together as a
15 research platform, we had intended to use that airplane
16 as an encounter airplane. Meaning, we were going to
17 develop a simulator of it, a simulation model of it,
18 and validate our air models with that particular
19 airplanes.

20 About -- I'm going to say about a year and a
21 half ago, we decided to go with our 737-100 model that
22 we have at Langley as our encounter aircraft for a
23 number of reasons. One being that we already had a
24 validated baseline simulation of that aircraft. Two,

1 it more ideally represented an aircraft of the
2 transport fleet. And number three, it was available at
3 the time that we needed it.

4 So the 737 is our encounter aircraft. The
5 OV-10 is another airplane. We are using an aircraft
6 out of Wallops as a wake generator for our first series
7 of tests and that's the C-130 at Wallops.

8 MR. JACKY: Okay. If I can direct your
9 attention to Exhibit No. 13X-H, page 4, please.

10 THE WITNESS: You said hotel?

11 MR. JACKY: Yes, sir. And we also have an
12 overhead slide of this page.

13 THE WITNESS: Oh, okay.

14 MR. JACKY:

15 (Slide shown.)

16 CHAIRMAN HALL: Are we going to get some help
17 with the lights, please?

18 MR. JACKY: You can just -- if you want, you
19 can either use that or turn around and hold the mike.

20 THE WITNESS: Can you hear me?

21 CHAIRMAN HALL: Yeah.

22 MR. JACKY: What I would like for you to do
23 is to kind of step us around the airplane and just show
24 us and describe to us how you utilize the OV-10 as a

1 meteorological measuring airplane platform.

2 THE WITNESS: Okay. Well, basically, this is
3 the OV-10. It's around 11,000 pound airplane, twin
4 turbo prop, high wing and high tail, 40 foot span on
5 the wing. Basically, we've completely -- well, we've
6 completely modified the airplane to make it into a
7 research platform, primarily to take measurements of
8 wake turbulence and to take measurements of
9 meteorological parameters.

10 In terms of the question that was asked
11 regarding meteorological parameters, things that we can
12 measure with this aircraft are temperature -- we've got
13 a temperature probe out on the wing. Actually, we've
14 got two of them. One goes to a standard central air
15 data computer. We've got it mounted with an aircraft
16 hygrometer to measure the dew point or in layman's
17 terms would be the relative humidity in the atmosphere.

18 As you notice, we've got three booms that
19 come off the aircraft. And the three booms are for the
20 purpose of wake measurements instead of weather
21 measurements. But what I want to point out is that at
22 the tip of these booms, we have sensors out here that
23 will help us measure how the air relative to the
24 aircraft is behaving to help us make atmospheric

1 turbulence measurements.

2 And finally, we have positional information
3 in the form of an anersia navigation unit, coupled with
4 the global positioning system receiver that we can then
5 use to back out our winds at altitude.

6 MR. JACKY: Thank you. For the wake vortex
7 flight tests that were accomplished in Atlantic City
8 last month, could you please explain what your
9 participation and the OV-10's participation in the
10 program was?

11 THE WITNESS: Yes. We were asked to come up
12 and collect data that would help verify some of the
13 assumptions that were used in the Boeing wake vortex
14 encounter simulations.

15 MR. JACKY: How many flights or missions did
16 you participate in?

17 THE WITNESS: We flew three missions. Two at
18 the time the 737 was flying, and then we flew an
19 independent mission with just the 727.

20 MR. JACKY: Could you briefly describe what
21 sort of things were you doing during the flight test?

22 THE WITNESS: Two things actually. The
23 initial request came up that there was an interest in
24 making measurements of the 727 wake, again for

1 verification of some of the assumptions in the
2 simulator. So part of what we did was to fly behind
3 the 727, and this is what the 37 and the -- well,
4 actually just the 37 out of the area -- and making
5 penetrations through the wake at various downstream
6 distances to basically characterize the properties of
7 the wake using the flow centers on the booms as a
8 primary measurement.

9 The second thing we did -- and actually we
10 did this on all three flights. One flight was
11 dedicated completely to it, and that was to make
12 weather measurements in the area that the 37 was
13 operating.

14 Essentially, weather measurements within a
15 block of altitude that we thought the wake would be --
16 the wake from the 727 would be behaving within, to get
17 a measurement of temperature at dew point profiles,
18 atmospheric turbulence, and winds --

19 MR. JACKY: Generally speaking, could you
20 give us a characterization of how weather plays in the
21 effect of wake strength indicated?

22 THE WITNESS: Yes. One of the major flight
23 test areas that -- in fact, we're embroiled in it now.

24 And if it weren't for the furlough, we'd probably be

1 out flying today, doing another one. But one of the
2 major flight test areas we're working on right now is
3 the validation of a wake decay model that one of our --
4 one of my colleagues at Langley has developed and we're
5 in the midst of doing a flight test program to go out
6 and validate this wake decay model, which is -- it's a
7 decay model built around the assumption and the
8 observation from several years of having done wake
9 measurements in ground base facilities, that the
10 atmosphere, especially things like atmospheric
11 turbulence and the stability of the atmosphere in terms
12 of temperature dew point, et cetera, play a significant
13 role in the way that a wake decays.

14 MR. JACKY: Now, I understand that you
15 brought along a video today for some of the portions of
16 the flight tests that you participated in.

17 THE WITNESS: Yes, I did.

18 MR. JACKY: Could you maybe -- do you need to
19 set it up at all or talk a little bit about what we're
20 about to see?

21 THE WITNESS: It should be -- yeah, what the
22 -- the video tape is of the first -- in fact, it was
23 the first wake encounter flight that we ever did, and
24 it was actually -- it's the first day that we came up

1 and had an opportunity to fly behind the 727 in
2 Atlantic City.

3 CHAIRMAN HALL: Mr. Stuever, before you go,
4 the Chairman wants to say something, that I want to be
5 sure that the public is aware of. We wanted to have
6 this test for some period of time. I greatly
7 appreciation NASA providing this OV-10. I appreciate
8 the FAA letting us use their 727. And I appreciate
9 Boeing's assistance. But I want a specifically
10 acknowledge Mr. Seth Schofield as the CEO of USAir.

11 We spent, what, about six or seven months,
12 Tom, trying to find the 737. Because Mr. Laynor and
13 others felt -- we all felt that this was an extremely
14 important test. When I visited with Mr. Schofield and
15 explained our dilemma to him, he was able to arrange
16 for a USAir 737 out of service, to be used for these
17 tests.

18 And, General, I hope that you will let him
19 know again, which I have said publicly before, how much
20 we appreciate this. Because I do think not only is
21 this test important to this investigation, it does help
22 advance knowledge in this field and is something that
23 hopefully will make a contribution to flight safety.

24 Thank you, Mr. Stuever, for letting me say

1 that. Yes, Mr. Purvis?

2 MR. PURVIS: Just a quick question. I'm
3 wondering if it can be -- these lights that are shining
4 on the screen and this one that's behind the screen
5 that shines at us can be dimmed? This witness and the
6 next couple have --

7 CHAIRMAN HALL: The TV lights -- in fact, I
8 keep hoping that all the TV cameras will leave, because
9 those lights are about killing me, but --

10 (General laughter.)

11 CHAIRMAN HALL: If we could turn them off for
12 this one video -- if I'm turning my back on the
13 audience, it's not because I'm not interested. It's
14 just those lights after a while get your attention. Is
15 that a problem with the TV, because I think we have a
16 video that we are providing you of what you're going to
17 see anyway.

18 Thank you, sir.

19 THE WITNESS: I just wanted to have you put
20 this slide up here because --

21 CHAIRMAN HALL: Let me just say one more
22 thing and then I'll be out of the way here, because I
23 feel strongly about the cooperation we've gotten from
24 the parties on this investigation. Mr. Laynor reminded

1 me that Boeing had 28 people up there assisting in this
2 test. And we appreciate everything that everyone has
3 done to help with this investigation, but I did want to
4 make those points.

5 THE WITNESS: I wanted to put this slide back
6 up. It's just a precurse of what you're going to see
7 is footage from a video camera that we had in the tail
8 of the aircraft. So what you're going to be looking at
9 is just kind of an over-the-wing shot that we have.

10 Okay. We're ready for the video.

11 (Video played.)

12 THE WITNESS: Okay. These are basically just
13 penetrations straight through the wake of the 727, and
14 we've already made one penetration from the left side
15 to the right side, and we're getting set up to go back
16 through the wake. We started at approximately two
17 miles back with the penetrations. I'm going to guess
18 this is about two and a half miles. You can see the
19 interception there.

20 What we're trying to do is essentially fly
21 the aircraft as best as we can and hit both cores. And
22 with the three booms that we have on the aircraft and
23 the three separate instrument packages on those booms,
24 get a pretty good cut of what the flow fields should

1 look like.

2 As Mr. Berven pointed out, you can kind of
3 see some of the oscillation in the wake here. At least
4 through this part of it. And, again, this is -- a lot
5 of this is driven by an atmospheric turbulence. There
6 also is a kind of a self-destructing mechanic in the
7 wake that you typically don't see for several miles
8 back when you've got conditions that -- in which you
9 don't have a lot of turbulence in the atmosphere. But
10 a lot of this is -- as you can see, it's very hard to
11 model.

12 I will back up what Mr. Berven said It's
13 really not that bad of a ride. It's not a loaded
14 maneuver. It's just a maneuver in the roll. And, in
15 fact, it does smell like orcopus oil. That was not
16 wake induced, by the way.

17 (General laughter.)

18 THE WITNESS: I'll let it go one more time
19 through the wake and then we can turn it off. I
20 believe on this one, this is the very first one we did.

21 I believe we followed it back to, I'm going to guess,
22 seven or eight miles. I would have to look at my
23 notes.

24 Okay.

1 MR. JACKY: Have you ever used the OV-10 as a
2 wake penetration aircraft before?

3 THE WITNESS: No, not before this test.

4 MR. JACKY: Was there anything in flying in
5 the wake vortex tests up in Atlantic City that would
6 have helped you for some of the ongoing projects that
7 you're running right now?

8 THE WITNESS: Oh, yeah. The data from the
9 37. The weather data that was collected at the time
10 the 37 flights were conducted. The data that we
11 collected -- I mean, it's all going to be very useful.
12 In fact, it was -- technically, we were very excited
13 about supporting this.

14 MR. JACKY: Have you been able to make any
15 sort of assessment of the data that you've collected so
16 far?

17 THE WITNESS: No. Unfortunately, you caught
18 us right at the beginning of a very -- well, I'm going
19 to say a three-month test program that we were just
20 starting. We're at the point where we have the data
21 basically digitized and to put into engineering units,
22 but we have not gotten to the point where we corrected
23 it to where it's ready for release. But I don't see
24 that being too far in the future.

1 MR. JACKY: So, therefore, you haven't made
2 any sort of assessment as to the strength of the
3 vortices or anything?

4 THE WITNESS: No, not yet.

5 MR. JACKY: Then you wouldn't have been able
6 to make any sort of comparison back to the time of the
7 accident or the data from there?

8 THE WITNESS: No, sir.

9 MR. JACKY: You mentioned that you had a 737-
10 100 that you're using for part of your tests. Is that
11 going to be used as a wake penetrating airplane or is
12 it generating?

13 THE WITNESS: Yes.

14 MR. JACKY: What will be the wake generating
15 airplane for your tests?

16 THE WITNESS: The aircraft we'll use as the
17 wake generator is the Wallop C-130.

18 MR. JACKY: And you said that those tests are
19 ongoing now or will be in the future?

20 THE WITNESS: That series is supposed to
21 start -- keeping our fingers crossed for the folks in
22 Congress. It's supposed to start the day after the
23 Thanksgiving break.

24 MR. JACKY: You mentioned wind tunnel tests.

1 Have you done any sort of -- or could you describe the
2 wake vortex tests that you've done in wind tunnel work?

3 THE WITNESS: Yes. I'll try to do it very
4 briefly. It's kind of -- maybe difficult to explain.
5 At NASA-Langley, we have -- I should say we had,
6 because it closed about three weeks ago. We had a wind
7 tunnel facility there that was -- they called it the
8 full-scale wind tunnel.

9 It's a low speed wind tunnel that has a test
10 section, that's roughly the size of this ballroom.
11 It's about three times as high, but it's roughly the
12 size of this ballroom. During World War II, it was big
13 enough to put the fighter -- the complete fighter
14 aircraft in there for dry cleanup.

15 In that tunnel, we have the capability to
16 free flight scale models under -- obviously, under
17 pilot control. And we initiated a series of tests
18 about two years ago to look at the feasibility of
19 actually flying wake vortex encounters in that tune.

20 For the first series of tests that we did, we
21 took a business jet configuration that we had and we
22 took a wing that we also had that was built for another
23 test, and essentially put the wing in the forward part
24 of the test section to act as a wake generating

1 airplane and flew the business jet back behind that
2 wing as an encounter aircraft.

3 That test proved successful. So as part of
4 our ongoing program in terms of validating wake
5 encounter models for transport aircraft and based on
6 the fact that we were planning to fly our own 37-100
7 configuration in flight tests, we went ahead and built
8 a free flight model of the -100. And, in fact, that
9 was the last test that was ever conducted in that
10 tunnel.

11 We finished in, I believe, the second week of
12 October. We did wake encounters in that tunnel.
13 Basically, we flew behind aircraft simulating an
14 aircraft the size of the 37 and then another aircraft
15 simulating -- or a wing simulated an aircraft that was
16 twice the size of the 37. And the way you model the
17 wake in the tunnel in terms of downstream distance or
18 wake decay, is essentially you just change the lifting
19 characteristics of the forward wing by changing its
20 angle of attack.

21 So we could vary the strength of the vortex
22 that the aircraft was penetrating to get a good
23 assessment of, for instance, what kind of control power
24 was needed, what kind of encounter trajectories you

1 might see hitting various types of vortices and so
2 forth.

3 MR. JACKY: Would you be able to characterize
4 the type of intercepts that you -- were you just trying
5 to fly the 37 into the wake or were you trying to very
6 precisely put the 37 in the wake or --

7 THE WITNESS: Yes. We attempted to do two
8 things. One thing was to fly precise encounters based
9 on approaching the wake from different positions; from
10 the side, from underneath, from on top, from the
11 middle, and so forth. And we flew several passes for
12 each trajectory for each different vortex strength and
13 got a matrix of test points based on those encounters.

14 Then we also flew some control power studies
15 to look at really how much control power you would need
16 to fly the model in a controllable fashion at different
17 points with respect to the vortex. And by the way, we
18 did mark the wake with a similar smoke system, so that
19 you could actually see the wake in the tunnel.

20 And it's a lot like what Mr. Berven was
21 talking about. We would essentially fly the aircraft,
22 put the wing tip in a core, and we would put the core
23 near the nacelles. We would put it right on the fusel
24 lodge and basically fly around the wake and take that

1 on a control power assessment.

2 MR. JACKY: Was there any particular
3 encounter that gave you a large upset or what encounter
4 did give you the large upset?

5 THE WITNESS: Well, the worst upsets we had
6 were obviously when we had the big wing in there at its
7 maximum lift off efficient or maximum vortex strength.

8 I mean, we kind of expected that.

9 With respect to what we did -- I mean, tying
10 this into what we're going to do with our own flight
11 tests and what we did at Atlantic City, for the
12 configuration where we had a like-size vortex
13 generator, we got encounters, we got model upsets, but
14 we had no trouble recovering from them.

15 MR. JACKY: And in which axis of the airplane
16 was the largest deviation?

17 THE WITNESS: Roll.

18 MR. JACKY: Roll. Did you see any sort of
19 yaw or heading?

20 THE WITNESS: I can't answer that. I can't
21 answer that. I don't know. I didn't actually fly the
22 maneuvers.

23 MR. JACKY: You mentioned the data that you
24 collected during the wake vortex flight test. Do you

1 have any sort of an estimate as to when you might be
2 complete or completing converting the data?

3 THE WITNESS: From which test?

4 MR. JACKY: From the Atlantic City.

5 THE WITNESS: Oh, okay. The long hold on
6 that is with respect doing our video processing. One
7 thing I didn't point out on that slide that is on the
8 exhibit, we have video cameras that are underneath each
9 wing tip. And the reason that we put those video
10 cameras on underneath each wing tip was to record
11 stereoscopic images of either a vortex smoke trail
12 below us. Or in the case of when we do our 737
13 experiments, we're going to use those cameras to record
14 the position of the 37 with respect to the wake,

15 The long hold in terms of our production is
16 the video. So, I mean, we're guessing that's going to
17 be about the end of January for that. Right now, like
18 I said, we have the actual what I call the PCM or the
19 basic numerical data digitized, and we're looking at
20 some time in the December-January time frame to get
21 that out.

22 MR. JACKY: And would you be willing to share
23 that information with us?

24 THE WITNESS: Oh, certainly.

1 MR. JACKY: I want to thank you for your help
2 on the flight test. I have no further questions.

3 CHAIRMAN HALL: Does the Technical Panel have
4 other questions of this witness?

5 (No response.)

6 CHAIRMAN HALL: If not, we'll move to the
7 parties. I see Boeing Commercial Group. Anyone else?
8 If not, we'll move to the Boeing -- Mr. Purvis, with
9 Boeing.

10 MR. PURVIS: Thank you, Mr. Chairman. Mr.
11 Stuever. It's kind of just a -- I'm not sure that I
12 got the answer or heard the response to Mr. Jacky's
13 question. The data that is being provided from the OV-
14 10, I think some of the parties are anxiously awaiting
15 that. Do you know physically when we're going to have
16 that in hand from the testing? Do you supply it to the
17 NTSB and maybe they supply it to us?

18 THE WITNESS: The original request, as I
19 understood it, were estimates of vortex strength, which
20 is -- I mean, based on the fact that there is a few of
21 us that are running this flight test that we are very
22 heavily involved in right now. It's going to take us
23 quite a while to do it. I have gotten a request both
24 from Mr. Jacky and I've also spoken with Mr. Kerrigan

1 about just releasing the data as it is.

2 As far as I'm concerned, the only thing we
3 have to do to it is correct it and basically just give
4 it a once over. So I'm going to say -- well, I'm going
5 to say maybe by Christmas at the latest, you can have
6 the numerical stuff.

7 MR. PURVIS: Thank you very much.

8 THE WITNESS: That doesn't have anything --
9 it doesn't have any estimate of wake strength or -- I
10 mean, we won't actually have done anything with it.
11 It's essentially very similar to the data that I saw in
12 the Boeing exhibit.

13 MR. PURVIS: Thank you. That's all I have.

14 CHAIRMAN HALL: USAir, General?

15 GENERAL ARMSTRONG: Thank you, Mr. Chairman.
16 Can you hear me now?

17 CHAIRMAN HALL: Yes.

18 GENERAL ARMSTRONG: You indicated that you
19 were making some substitutions of a 737-100 for the OV-
20 10 because it was more representative of some of the
21 things that you wanted to examine. Can you give us an
22 idea of the relative weight comparisons of those two
23 airplanes, approximation?

24 THE WITNESS: Excuse me. Did you say weight?

1 GENERAL ARMSTRONG: Weight, yes.

2 THE WITNESS: Our 37 is approximately 85,000
3 pounds. The OV-10 is 11,000.

4 GENERAL ARMSTRONG: Thank you.

5 CHAIRMAN HALL: Other questions from the
6 parties?

7 (No response.)

8 CHAIRMAN HALL: If not, we'll move to Mr.
9 Clark.

10 MR. CLARK: Thank you. Mr. Stuever, the --
11 can you describe the OV-10 compared to -- how does it
12 compare to general aviation type airplanes, say, in the
13 King Air class, the Citation class?

14 THE WITNESS: I would put it in the King Air
15 class, with the exception that it's a high-wing
16 aircraft.

17 MR. CLARK: It's a high wing and you said it
18 weighed about 11,000 pounds?

19 THE WITNESS: Roughly 11,000.

20 MR. CLARK: Are there any special
21 characteristics about it for its roll authority? It
22 runs very effective, more effective than the general
23 aviation type airplanes?

24 THE WITNESS: I don't know.

1 MR. CLARK: When you were making these tests,
2 my understanding is you flew from behind the 727 from
3 two to four miles.

4 THE WITNESS: Yes. Excuse me. Two to four?

5 MR. CLARK: Two to four?

6 THE WITNESS: Two to six or seven or eight.
7 I mean, it kind of depended on when the wake broke up.

8 MR. CLARK: In those tests, were you on the
9 airplane?

10 THE WITNESS: Yes.

11 MR. CLARK: It appeared from the video that
12 some of the onset rates were very sudden. Is that a
13 fair assessment from your perspective?

14 THE WITNESS: Yes.

15 MR. CLARK: But you also said that it was
16 recoverable each and every time. Is that transferrable
17 to an airplane like the King Air, in your estimation?

18 THE WITNESS: I can't answer that. I don't
19 know. I don't know what the roll control power of the
20 King Air is.

21 MR. CLARK: But do you have enough data now
22 to see what kind of roll power it takes to rest a roll
23 rate and possibly go back and look at a King Air to see
24 if it has the proper roll authority?

1 THE WITNESS: Yes, if you knew what the
2 weight characteristics were.

3 MR. CLARK: What were the maximum roll angles
4 that you saw during your testing?

5 THE WITNESS: With the OV-10, the pilot
6 report, which is another exhibit, I believe, but 60
7 degrees.

8 MR. CLARK: Okay. So the airplane was
9 getting up to 60 degrees. Was the pilot resisting or
10 taking corrective action immediately during those
11 encounters?

12 THE WITNESS: Yes, because we were flying --
13 trying to fly a trajectory between -- so that we hit
14 both cores.

15 MR. CLARK: So the pilot could lead with the
16 ailerons trying to minimize the roll and even with
17 that, still ended up at 60 degrees?

18 THE WITNESS: Yes.

19 MR. CLARK: How far behind the 727 were you
20 when you would typically encounter 60 degrees?

21 THE WITNESS: I can't say at this point. I
22 don't know. And a lot of it depends on the vortex, as
23 well, as to what trajectory you're taking and exactly
24 where you hit it.

1 MR. CLARK: But without having all of the
2 data reduced at this time, do you have any observations
3 on whether the encounter was more severe at two miles,
4 four miles, six miles, or eight miles?

5 THE WITNESS: Just from observation -- again,
6 the pilot reported -- I mean, this is his report based
7 on how he was flying the maneuver and so forth. I was
8 kind of in the back talking on the tape and watching
9 the data on the display and so forth. But based on
10 what he said, it was kind of imperceivable as to how
11 severe the upset was at the various separation
12 distances. But then he also made the comment that,
13 again, it depends on how you hit the vortex as to how
14 severe it was.

15 MR. CLARK: If you hit the vortex in a
16 certain way at each one of those miles, then his
17 perception was the -- he couldn't tell a significant
18 difference or a difference between the two.

19 THE WITNESS: Right. You had to reduce the
20 data to be able to identify if there are differences.
21 That's correct.

22 MR. CLARK: The project that you're working
23 on at NASA, that's with the FAA also.

24 THE WITNESS: That's correct.

1 MR. CLARK: You're working in concert with
2 the FAA. And it has to deal with -- that project is to
3 try to establish aircraft separation limits based on
4 wake vortex encounters.

5 THE WITNESS: That's correct.

6 MR. CLARK: Or establish procedures to avoid
7 the encounters altogether. Do you have any thoughts
8 from your observations on this flight test at this time
9 of airplane in the class of an OV-10 or a King Air
10 about the separation requirements? Any observations
11 that you have in that area?

12 THE WITNESS: Only the observation in the
13 sense that a lot of the spacings as they're set up now,
14 are partially -- I mean, the success that they've had
15 with the spacings right now, we think are partially
16 successful, because the wakes have actually left the
17 approach corridors for one reason or another.

18 I mean, I don't think that there's a
19 documented case in the United States of a hazardous
20 wake encounter when aircraft are flying under
21 instrument meteorological conditions and they're being
22 spaced by the controllers at those distances.

23 I can't tell you right now, because part of
24 this system relies on being able to predict where the

1 wake is and how strong it is. And again, whether an
2 aircraft will encounter it or not -- I mean, based on
3 what we flew, I don't know if I would want to encounter
4 that wake at 100 feet off the ground, the way we did.

5 MR. CLARK: Or, for example, if you were at
6 night four miles behind --

7 THE WITNESS: Right.

8 MR. CLARK: -- you don't want to encounter
9 that wake in that type of airplane?

10 THE WITNESS: Right, based on what we saw.

11 MR. CLARK: And you heard Mr. Berven's
12 statement that he was talking about a class of
13 airplanes of a 737 behind a 727, and he felt
14 comfortable that that was no big deal.

15 THE WITNESS: Yeah.

16 MR. CLARK: I guess, the question -- I guess,
17 from what I hear from you, is that it's a bigger deal
18 to have that same encounter with a dissimilar class of
19 airplanes, such as the OV-10 behind the 737?

20 THE WITNESS: Oh, yes.

21 MR. CLARK: You also mentioned that you're
22 going to have future tests where you're going to be
23 flying behind a C-130.

24 THE WITNESS: That's correct.

1 MR. CLARK: Do you have -- is there data
2 available from the tower flybys, for example, on the C-
3 130?

4 THE WITNESS: Meaning something like the
5 Idaho Falls data?

6 MR. CLARK: Yes.

7 THE WITNESS: Not to my knowledge.

8 MR. CLARK: And also, do you have any
9 observations or comments about the influence of the
10 propellers on the C-130 and how that may effect the
11 wake vortex development?

12 THE WITNESS: We've had a lot of discussion
13 about that. And, quite frankly, in going up and having
14 flown several missions behind that aircraft, we haven't
15 noticed any significant -- I mean, once the wake rolls
16 up far enough downstream, it's rolled up into the two
17 cores and you get very nice cores far downstream with
18 that aircraft. And we haven't -- I mean, we
19 specifically looked for that.

20 Well, I guess, I should say until we look at
21 our actual flow field measurements, we can make the
22 assumption that the wake looks pretty good. I mean, it
23 looks as good as we need it.

24 MR. CLARK: But at this point -- I guess,

1 when you do your testing, you may be able to see if the
2 propeller might have an effect on the decay rate and
3 that will be factored into your modeling?

4 THE WITNESS: Right.

5 MR. CLARK: Okay. Thank you.

6 CHAIRMAN HALL: Mr. Marx?

7 MR. MARX: No questions.

8 CHAIRMAN HALL: Mr. Schleede?

9 MR. SCHLEEDE: No questions.

10 CHAIRMAN HALL: Mr. Laynor?

11 MR. LAYNOR: Just one or two, Mr. Stuever. I
12 know that NASA has a great deal of data about vortex,
13 vortices's strength as obtained from tower tests, both
14 NASA and the FAA. How much data exist regarding the
15 strength of vortices at altitudes, out of ground
16 effect?

17 THE WITNESS: Not much. The things that
18 we're measuring right now are -- well, to my knowledge,
19 other than some tests that my old branch had did on
20 behind the C-5 back in the early '70s, and they may
21 have also done one behind a 747, ours are the only set
22 that I know of that we're currently measuring.

23 MR. LAYNOR: Did they actually involve
24 instrumentation to measure the strength of the vortex

1 or was it based on the response of a certain kind of
2 airplane?

3 THE WITNESS: No, they were measured with a
4 probe.

5 MR. LAYNOR: Is the activity that you're
6 engaged in right now going to include any more of those
7 kinds of tests?

8 THE WITNESS: I'm sorry?

9 MR. LAYNOR: Is the project that you're
10 involved with right now intend to examine vortices at
11 altitude and the behavior in any detail?

12 THE WITNESS: The purpose of validating the
13 -- well, we call it the out-of-ground effect model,
14 which is the model at altitude. Is to provide us with
15 a validated model that we can use as an interim model
16 in our aircraft vortex spacing system prototype. We
17 have a program with another group that's working on
18 this AVOSS system. They have developed ground-based
19 LIDARS that actually measure and track vortices in
20 ground effect.

21 The idea is that by the time they get all
22 their data that they need to develop their vortex decay
23 models in ground effect and they have these sensors
24 developed to such a point where they can actually

1 deploy them in the field or around the airports, the
2 ground effect measurements and the ground effect models
3 will be the ones that will be used in the final AVOSS
4 system.

5 The purpose of doing the out-of-ground effect
6 model is to kind of an interim solution that we can use
7 in our AVOSS prototypes. To my knowledge, this
8 particular test is the only one that we're planning to
9 do out-of-ground effect.

10 MR. LAYNOR: Okay. Thank you, sir.

11 CHAIRMAN HALL: Mr. Stuever, were you born at
12 the time the 737 was originally certified?

13 (General laughter.)

14 CHAIRMAN HALL: I don't want to get into your
15 age or anything, but I just was wondering.

16 THE WITNESS: That's a good question, because
17 when we were thinking about making a simulator for the
18 OV-10, I got a hold of some simulation and stability
19 and control documents and the dates were right around
20 the day I was born is when this airplane was designed.

21 CHAIRMAN HALL: Well, I'm certainly impressed
22 with your credentials. On your program that you're
23 undertaking for the FAA that I assume you're familiar
24 with the recommendations the NTSB has made in the wake

1 vortex area.

2 THE WITNESS: Regarding the classification --

3 CHAIRMAN HALL: The separation, yes.

4 THE WITNESS: With the 57?

5 CHAIRMAN HALL: Mm-hmm.

6 THE WITNESS: Yes.

7 CHAIRMAN HALL: And I guess you have all the

8 material that Volpe had done in the '70s and '80s on

9 the tower flyby tests and that sort of information?

10 THE WITNESS: Yes, my colleagues do.

11 CHAIRMAN HALL: While increasing airport
12 capacity is important, how are you going to factor or
13 will it be the FAA's responsibility to factor safety
14 into this equation?

15 THE WITNESS: Well, I mean, it's kind of a
16 joint thing. When we look at this in terms of the
17 hazard definition and when I spoke about defining a
18 metric, that metric is kind of something -- I mean, it
19 has to be something that's agreed upon by the FAA, by
20 NASA, by the airplane operators, by the manufacturers.

21 I mean, it's really a very big effort and, in fact,
22 it's something that we need to get started on right
23 away in terms of how you define this, in terms of
24 having a safe operation.

1 I mean, it's nothing -- I don't know who will
2 have the ultimate responsibility for it. That's the
3 best answer I can give you, but it's something that we
4 all are going to have agree upon and define together.

5 CHAIRMAN HALL: And it's yet to be defined?

6 THE WITNESS: Yes, sir.

7 CHAIRMAN HALL: I guess my last question is
8 the weather in Pittsburgh on the particular day that
9 the USAir flight that we're discussing, I think was
10 very clear. Winds were very calm.

11 THE WITNESS: That's my understanding.

12 CHAIRMAN HALL: How do you take a test on a
13 day that's not similar at an altitude of 15,000 feet
14 versus 6,000 with different weather conditions and how
15 do you then factor that? I'm sure NASA is able to do
16 that, but I'm interested in how do you come up with
17 some better understanding of what the vortices might
18 have been under those types of atmospheric or weather,
19 whatever the right word is, conditions, so that you
20 have a kind of apples to apples situation in looking at
21 it?

22 THE WITNESS: Well, you've given us a lot of
23 credit so far in terms of having the techniques. Part
24 of doing this out-of-ground effect decay test that

1 we're currently involved in, is to validate a model of
2 wake decay out-of-ground effect knowing what the
3 meteorological conditions are. In order to correlate -
4 - I mean, if you wanted to have a simulation of the
5 accident conditions -- well, first of all, it's going
6 to be very hard to do.

7 I mean, it's very hard to repeat the weather.

8 But in order to be able to verify what the conditions
9 were in terms of the wake and its strength and so
10 forth, you need to have either a measurement of the
11 wake at some downstream distance and/or a measurement
12 of the weather coupled with a validated decay model
13 that has weather terms involved in it. And right now,
14 we're at the point of actually flying the flight series
15 that we hope -- well, that we plan to use as the
16 validation for the out-of-ground effect wake model.

17 CHAIRMAN HALL: Now, Mr. Laynor tells me what
18 we flew a number of these at 6,000 feet. Is that
19 correct? And in pretty stable air? I should have
20 asked the expert when he was up here. I apologize.
21 Well, I just -- that's one of those things that I think
22 the layman is interested in in just trying to
23 understand what type of situation that particular plane
24 encountered on that day.

1 Well, we really appreciate your testimony.
2 Is there anything else that you would like to add?

3 THE WITNESS: No.

4 CHAIRMAN HALL: Okay. And we hope you will
5 get back to work soon, just speaking as one taxpayer.
6 But we'll send you back to furlough, then.

7 (General laughter.)

8 THE WITNESS: Thank you.

9 CHAIRMAN HALL: You're excused.

10 (Witness excused.)

11 CHAIRMAN HALL: Very well. The next witness
12 is Mr. Michael Carriker. He's a Senior Engineering
13 Project Pilot on the 737 for the Boeing Commercial
14 Airplane Group in Seattle, Washington.

15 (Witness testimony continues on the next
16 page.)

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1 MICHAEL CARRIKER, SENIOR ENGINEERING PROJECT PILOT, 737
2 BOEING, SEATTLE, WASHINGTON

3

4 Whereupon,

5

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

10 THE WITNESS: I was nine years old when they
11 certified the 737.

12 (General laughter.)

13 CHAIRMAN HALL: That gives me more comfort.

14 (General laughter.)

15 MR. SCHLEEDE: Mr. Carriker, please give us
16 your full name and business address?

17 THE WITNESS: Michael Carriker. I'm with the
18 Boeing Commercial Airplane Group, Seattle, Washington,
19 98124.

20 MR. SCHLEEDE: Your position at Boeing?

21 THE WITNESS: I'm the Senior Engineering
22 Project Pilot for the 737.

23 MR. SCHLEEDE: Would you briefly describe
24 what your duties and responsibilities are in that
25 position?

1 THE WITNESS: I'm involved in the development
2 of airplane's systems, all the systems on the airplane.

3 I work on new airplane projects. I work on continuing
4 improvement of the current airplane projects. I work
5 on accident investigations and other duties. I fly all
6 the other Boeing aircraft on flight tests.

7 MR. SCHLEEDE: Give us a brief description of
8 your education and other background?

9 THE WITNESS: I have a bachelor's degree in
10 science and aeronautic engineering from Wichita State
11 University. I had 12 years in the Navy. I flew A-7s
12 and F-18s. I'm a graduate of the Navy Test Pilot
13 School. I instructed there. And I've worked for the
14 Boeing Company for five years.

15 I have type ratings in all current Boeing
16 production airplanes, and I'm an instructor, a flight
17 crew instructor on the 737 and the 777. I have about
18 5,000 total flight hours.

19 MR. SCHLEEDE: Thank you very much. Mr.
20 Jacky.

21 MR. JACKY: Good afternoon, Mr. Carriker.

22 THE WITNESS: Mr. Jacky.

23 MR. JACKY: As part of your job function, how
24 much time in part of your duty is flying?

1 THE WITNESS: I fly about 300 hours a ~~yea~~
2 and work about 2200 or so, a seventh of it.

3 MR. JACKY: How much of it is devoted to the
4 737?

5 THE WITNESS: About half of that. Half of
6 that 300 hours.

7 MR. JACKY: And have you flown -- been able
8 to fly all the derivatives of the 737?

9 THE WITNESS: I've flown the 300, 400, and
10 500. I have two flights on the 737-200, and I've never
11 flown a -100 version.

12 MR. JACKY: Before we get into talking about
13 the flight test, I would like to direct your attention
14 to Exhibit 9X-I, please. This is an article that's
15 been excerpted from the Boeing Airliner magazine, the
16 October-December issue of 1995. I was wondering if you
17 might be able to give us some background as far as what
18 precipitated this article?

19 THE WITNESS: I think during these -- during
20 the accident investigation process, I was a member of
21 the cockpit voice recorder team. I was an ex-officio
22 member of the performance group. And I am member of
23 the human performance group.

24 I can to a realization that a lot of people

1 did not understand how and why airplanes fly and that
2 we have events that occur in fleet service that on the
3 offset, if you just read the data, don't see to be as
4 critical as the write up.

5 For example, an airplane had a yaw damper
6 failure -- I mean, a three degree hardover hit. An
7 airplane rolled to 11 degrees angle bank on the flight
8 data recorder. The crew was on the flight controls
9 within about one second and actually stopped the
10 original bank angle at five degrees. Then they
11 oscillated and ended up -- when they found the
12 solution, they ended up at 11 degrees angle bank.

13 The crew declared it an emergency. Thought
14 that if they hadn't put in immediate control inputs,
15 the airplane would have rolled on its back, and they
16 declared it an emergency and landed.

17 So from the data that I read and the crew
18 report that I got that we also read, the two did not
19 seem to intermix very well. So we thought at the
20 Boeing Company that we would write an article that
21 stays out there and the crews could read, and it might
22 help explain how and why this system works, what are
23 the actual effects of it. It would stop -- hopefully,
24 stop rumors, put actual information out there and get

1 it to the crews.

2 So myself and Marty Ingham and Al Nader, we
3 sat down and spun out this article and talked about
4 aerodynamics, some human factors points, and what you
5 might expect, to help preload crews. We also know that
6 if you give crews good sound information and training,
7 that they use it very well.

8 MR. JACKY: You mentioned rumors. Could you
9 describe what some of the rumors that you've been
10 hearing about?

11 THE WITNESS: It's just that the people are -
12 - we had different airlines that had different events.
13 We had crews that were doing things like turning off
14 systems prior to landing, just in case, and things like
15 that. We thought that that was not appropriate action,
16 but it was what they had heard, somebody had told them.

17
18 So we thought if we got some straight
19 information out there, maybe these things would slow
20 down.

21 MR. JACKY: The incident that you're
22 discussing, would you characterize that as being any
23 sort of an unsafe condition?

24 THE WITNESS: No, it's a certified -- it's

1 one of the failures that we look at. You go up and we
2 -- for a yaw damper hardover. We go up with a fault
3 injection box. We put the fault in, the rudder slams
4 over to three degrees, at the maximum rate available.
5 We watch it recover, and it gives the same data that
6 crews do when that happens in flight, which is ten or
7 11 degrees. We look at ten or 11 degrees. We know the
8 event is coming. You preplan for it. And you say,
9 okay, this is a nominal event. And, therefore, we
10 don't have to protect against it.

11 If the yaw damper fails in this mode, you
12 reach up and you turn it off and then you fly away.

13 MR. JACKY: Is there a concern within the
14 company that there might be some sort of inappropriate
15 reaction to an onset like this?

16 THE WITNESS: I don't think it's
17 inappropriate. The crews always take appropriate
18 action. They always do what they're trained to do in
19 those events. But the reports back, as they get back,
20 seem to be of an increased magnitude in concern and
21 more concern that we -- than it would seem like the
22 straight numbers would indicate.

23 MR. JACKY: Have you heard any feedback or
24 any feedback from airline crews on this article?

1 THE WITNESS: I've heard feedback from
2 several airlines, and they appreciated the effort.
3 They appreciated the explanation of lateral directional
4 stability, the explanations of startle events, and a
5 readout of what happens when this event occurs.

6 There's more than 5,000 copies out there now.

7 MR. JACKY: Has Boeing sent them to basically
8 every 737 operator?

9 THE WITNESS: We sent them to everybody -- I
10 don't know the exact circulation of the airline of our
11 magazine. But they all got them in the copy of the
12 magazine. And then there's also been 5,000 extra
13 copies printed to hand out either currently or in the
14 future.

15 MR. JACKY: Does Boeing have any other
16 methods for getting information back to crews about
17 kind of recurrency or updates or reminders about
18 certain events?

19 THE WITNESS: Yes, through our Flight
20 Training Department.

21 MR. JACKY: So they have a regular type of
22 publication or something that they put out?

23 THE WITNESS: Yes, the FSOPs. Yes, they have
24 mediums by which -- where they assimilate information

1 and they get those back to the flight crew, back to all
2 the operators, and then the operators do what they want
3 with them.

4 MR. JACKY: So if there would be some sort of
5 recurrent event or something, would someone make a
6 decision and say, we need to remind crews about this?

7 THE WITNESS: Yes. And also, there's through
8 the airplane operation's manual. We make changes to
9 the operation's manual via bulletins, if something
10 specifically needs to be told, and that's another
11 process you can go through.

12 MR. JACKY: Okay. I would like to move on to
13 talking about the simulator calibration flight test
14 that was held in Seattle with the USAir 737-300. We
15 had some testimony from Mr. Berven as far as his
16 observations as far as the results of the tests. I was
17 wondering if you might be able to tell us some of your
18 reactions or impressions.

19 THE WITNESS: I've got to agree with Mr.
20 Berven. I mean, we sat there and we saw the exact same
21 data, the air speeds, all alike. We actually did a few
22 more events than he accounted for. We did cross
23 control events where we put a step rudder input in and
24 then a fixed step aileron we put in and then added up

1 those and see what the result of those things are.

2 On request of USAir, we did a leading edge
3 slide extension to show that the leading edge slats
4 come out symmetrically. So we did that. We also
5 defined the full rudder travel at speeds below the
6 cross-over points. We used asymmetric thrusts to add
7 the extra yawing moment, actually rolling moment,
8 rather, so we could use the full rudder. So we could
9 define what full rudder was at those slower speeds.

10 MR. JACKY: Can you remember what those full
11 rudder positions were at the various speeds?

12 THE WITNESS: No. I can look it up, but I
13 can't remember them right off.

14 MR. JACKY: Okay. Could you make some sort
15 of comparison of the events that were flown on the
16 airplane back to the engineering simulator, the 300
17 simulator?

18 THE WITNESS: We can -- the proof of match,
19 although, Mr. Kerrigan would be the better person to
20 talk about the proof of match. We went out there and
21 we tested the one airplane. We tested the one USAir
22 airplane -- with its trims, with its aileron trims and
23 with its engine trims. And now our simulator matches
24 that airplane.

1 We might go out on a different airplane and
2 get two or three knots different speeds based on lots
3 and lots of different factors. So we had that in the
4 simulator. We found out that the rudder traveled
5 another two degrees more than what our simulator had
6 calculated and there's reasons why that is.

7 So we went back in and increased the throw of
8 the rudder hinge moment of the rudder. We went in and
9 we did -- technically evaluated that versus the steady
10 heading side slip to look over the cross-over point and
11 found a difference of four or five knots. I did a
12 qualitative evaluations on things like engine failures,
13 right after takeoff, using the airplane to do a side
14 slip cross control with the land, wing down, top
15 rudder. And then we did the full rudder inputs and
16 qualitatively, there was not any difference between the
17 old model and the new model.

18 Now, there may have been a degree here or two
19 degrees there or something, but you couldn't pick it
20 out of the data.

21 MR. JACKY: But you did notice the two degree
22 difference in the simulator?

23 THE WITNESS: Yes. It came out the
24 difference at that one specific test condition about

1 four knots difference in increase in the changeover
2 speed.

3 MR. JACKY: Which would mean then that if you
4 were decelerating from 190 knots, you would reach it at
5 a .4 knots higher?

6 THE WITNESS: In the cab, I thought it went
7 from the region of the high 70s, 178, 170, into a
8 region of 183, 184 speed for the cross-over point.

9 MR. JACKY: When you're in a situation like
10 that in a side slip and you do decrease below whatever
11 the cross-over air speed is, do you regain the control
12 once you -- and you start to accelerate, do you regain
13 the control as soon as you reach or you go past that
14 point, whatever the air speed that you lost that?

15 THE WITNESS: There's an anersia term in
16 there and a rate term. So once you overcome that, if
17 you're very slow and you decelerate very slowly and you
18 only go in theory one knot below the magic number, you
19 pick up a very small rate. You don't have to go very
20 slightly above that. You would have to go one knot
21 back -- actually a two knot increase to counteract
22 that. It's fairly close in there.

23 If you two or three knots slow, then you have
24 to pick up three or four knots on the other side of the

1 number to balance it out.

2 MR. JACKY: You mentioned ~~owe~~ we were talking
3 about the two degree difference in the rudder and you
4 mentioned, if I remember correctly, that it would be
5 applicable in only that one air speed type condition or
6 at one portion of the flight envelope.

7 THE WITNESS: Well, again, that's a better
8 question to a person who does simulator proof of match
9 and does the simulator calculations. Whether or not
10 they go all back through the envelope and they change
11 the rudder hinge moment from 340 knots down to a 100
12 knots, I don't know.

13 MR. JACKY: Okay. But what I wanted to ask
14 you was as a pilot, is that difference -- or where in
15 the flying envelope are you going to notice that
16 difference? Where is it going to be applicable to you?

17 THE WITNESS: You never would.

18 MR. JACKY: How about at rudder blow down at
19 higher speeds?

20 THE WITNESS: The idea of the concept here is
21 that you're talking about going along at a high speed,
22 you wouldn't just step on full rudder. There is no
23 maneuver that ever asks you to do that in the normal
24 flying envelope. So if you have an engine failure or

1 an idea when you might use a full rudder, an engine
2 failure right at takeoff, an ABCG at full thrust and
3 low gross weight, you might -- when you hit that, there
4 is probably -- there is a difference in the theoretical
5 amount of rudder pedal you have to put in, but it's
6 probably something like the difference between three
7 and a half inches and three and three-quarters inches.

8 Along the line, and you would never know that as a
9 pilot.

10 MR. JACKY: I asked Mr. Berven this question.

11 I'll ask you the same thing. When you're flying at
12 190 knots and one degree of flap extension,
13 approximately how much rudder would you be using while
14 maneuvering?

15 THE WITNESS: Zero.

16 MR. JACKY: Zero. And in flying the 300 in
17 general, are there any forces within the flight
18 envelope that you would be actively using rudders?

19 THE WITNESS: A lot of Boeing's design goals
20 is to fly an airplane with your feet on the floor. So
21 we have balance lateral forces with the resulting
22 adverse yaw. You don't need to do that. So really the
23 only time that you need to use the rudder pedal input
24 is for steering on the takeoff roll, if you have an

1 engine failure, or if you want to do a side slip
2 landing and to line the fusel lodge with the runway.

3 MR. JACKY: Were you present yesterday for
4 Anne Evans' testimony?

5 THE WITNESS: Yes.

6 MR. JACKY: Were you able to get a good look
7 at the chart of the information that she had from the
8 rudder --

9 THE WITNESS: Yes, generally. I couldn't
10 read the specific numbers, but you could see they were
11 bigger right at zero and plus or minus one.

12 MR. JACKY: Does that surprise you?

13 THE WITNESS: No, you see that all the time
14 on flight data recorders.

15 MR. JACKY: So in your flying the 737, you've
16 never had the -- besides in something like a steading
17 heading side slip, you've never had to put in full
18 rudder?

19 THE WITNESS: No, not in the normal flight
20 maneuver.

21 MR. JACKY: Okay. As part of your training,
22 are you given any sort of training for recovery from
23 control system hardovers?

24 THE WITNESS: No.

1 MR. JACKY: All three axis control?

2 THE WITNESS: That's correct. We don't -- in
3 the Boeing flight crew training for the 737, we don't
4 address auto pilot failures, because they have been
5 shown to result within the certification limits, so you
6 don't have to specifically train for that event. And
7 since it never had, I guess, a rudder surface hardover
8 or a lateral control surface hardover or a pitch
9 control surface full throw, we don't train for events
10 that don't occur.

11 MR. JACKY: To what maximum control position
12 would you train to in as far as recovery from if you
13 had a hardover or a jam?

14 THE WITNESS: Now, we don't -- there's no
15 specific training for jam. And the Boeing flight
16 training syllabus, we go with a stabilizer jam. That's
17 one of the maneuvers that we train to fly and teach a
18 person in runway trims and things like that, to stop
19 them. Use the trim to fly the airplane. But we don't
20 -- there's no discussion of a lateral flight control
21 system jam or a directional flight control system jam.

22 It's different, of course, for certification.

23 MR. JACKY: Now, I would like to talk about
24 the wake vortex tests that were flown in Atlantic City.

1 You were the pilot in command of the 737?

2 THE WITNESS: Yes.

3 MR. JACKY: I would like for you to give us
4 sort of your characterization of the testing and some
5 of the things that you saw while performing the test?

6 THE WITNESS: One --

7 MR. JACKY: Well, first let me ask you, how
8 many flights were you participating in?

9 THE WITNESS: Every one.

10 MR. JACKY: And do you remember how many?

11 THE WITNESS: I'm sorry?

12 MR. JACKY: Do you remember a number of how
13 many flights?

14 THE WITNESS: Eight, I think. Eight and we
15 drew one of them out for bad weather out of those
16 flights.

17 MR. JACKY: I'm sorry. Go ahead.

18 THE WITNESS: I found the wakes to be very,
19 very -- like Mr. Berven said, I found them to be
20 fascinating, what they would do in the sky. They would
21 trail back. They would break up. They would -- we
22 developed a lot of different names for them; pigtails,
23 double Us, just to try to describe what the wake did.
24 It was very interesting from that standpoint just to

1 sit there and watch what the wakes did.

2 They are not frozen ropes in the sky.

3 They're not just this straight line in the sky. It
4 seems like in all the manuals that I've read, they
5 would always depict the wake vortex as an expanding
6 thing, like a funnel shape, especially in the ground
7 pictures that you see. You always see them expanding
8 out and they don't expand.

9 They stay at this three, four, five foot
10 diameter core all the way back until they burst. Four
11 or five or six miles back behind the airplane, which is
12 something unusual. They flow left, right, up and down,
13 inside maybe a 15 foot diameter tube on a stable day.

14 What one wake does ~~sees~~ to have no bearing
15 on what the other wake does. The events, to me, were
16 not startling, because we had only planned on doing
17 this for six months. But the outcome of the wake
18 encounter was an unpredictable event by -- what I mean
19 is, you think you've got it all set up, you think
20 you've got it and this is what's going to happen and it
21 doesn't. You think that you're not going to have a
22 roll and you get a bigger roll. You think you're going
23 to have a bigger roll and you get a smaller roll off.

24 It is possible to quickly hit the same wake

1 twice, because the wake is not fixed in space. You
2 could possibly get a left roll and the fact that the
3 wake vortex is actually on your left side at that point
4 in time, if you cross over, it means that you roll
5 right back into the wake.

6 Then again, you could have a left wake and
7 the wake is bent to the right slightly in front of you
8 and it gets you clear quickly. It's a bit stronger
9 than I would have expected. I would have said before
10 briefs that it was in the 20 to 25 degree region, and
11 it was probably 25 to 30. So it's not any monumental
12 amount.

13 When the fusel lodge -- as Mr. Cash presented
14 yesterday morning, it's only when the fusel lodge hits
15 the core that you get the thump noise. It's not when
16 it hits the wing or the tail or any part else. It's
17 when the fusel lodge has just been right at the core in
18 that time period. I also remember that the core is
19 where you get the fastest roll, the biggest roll
20 acceleration.

21 As Mr. Berven said, we did take one right
22 down the engine and it had no effect on the engine. It
23 had an audio noise, you smelled it, but the engine
24 operating characteristics were just right down the

1 line.

2 One thing interesting that it did is it
3 actually lifted the windshield wiper perpendicular off
4 the wind screen and then it popped back with a rather
5 subtle clicking noise. And we're pursuing -- I would
6 like to see pursued to see if that event is the
7 clickety click noise that we hear on the cockpit voice
8 recorder. That's tough to tag, because it's only when
9 I -- I don't think you can hear -- you won't hear it on
10 the audio tape, unless I've said, okay, there was the
11 click, and we have to find that and have to back it up
12 and find that tape time. Go back, get the CDR out,
13 find that exact same tape time. It's a huge process to
14 get that out.

15 The flow direction around the fusel lodge was
16 such that on occasion, we would get the angle attack,
17 the stickshaker to fire, which means that the local
18 flow at the side of the fusel lodge has changed from
19 one to two degrees up into where the stickshaker fires,
20 which is about 27 degrees angle of attack. I could
21 check on that stickshaker.

22 At three nautical miles behind the wake, the
23 vortex, to stay in there, the wake -- the vortex had
24 the strength to roll the 737 at 35 degrees per second,

1 which is about 12 times the nominal auto pilot rate.
2 How do we know that? Because we have data where we sat
3 in the core with full aileron displacement, zero rudder
4 displacement, and very little bank angle change, and
5 that condition outside the core resulted in a 35 degree
6 per second roll rate.

7 As you heard Robert say, the wake vortex can
8 be formed at five, six, seven miles behind it.
9 Although, we never went back there. And I would agree
10 with the decay. We did a box the wake test, where we
11 tried to find the relative strength of the wake day per
12 day, to say well, Tuesday was like Wednesday and
13 Wednesday was different than Thursday. And in that
14 test, we found out that putting a wing tip in the core
15 at two nautical miles was almost the same as three
16 nautical miles and three nautical miles was almost the
17 same as four nautical miles.

18 So if you got put in one of those position
19 and opened up your eyes, you wouldn't know, but you
20 could probably tell the difference between two and four
21 nautical miles. When it was 25 or 30 degrees a wheel
22 at three miles, it was probably 30 to 35 degrees at two
23 miles, and 25 degrees at four miles. There's a little
24 bit of difference, but not very much.

1 MR. JACKY: I understand that you brought
2 along a video tape also.

3 THE WITNESS: Yes, I did.

4 MR. JACKY: Do you need to set up the video?

5 THE WITNESS: Yes. And I think I would also
6 have the house lights down, because there's some of the
7 points I want to look at that are a subset of the whole
8 video. I mean, it's a small inset picture. So we can
9 actually see hand position.

10 CHAIRMAN HALL: Can we get all these lights
11 off again? Was everybody able to see back there on the
12 last one? Did we have enough lights out and it was
13 contrast and everything was okay? Fine.

14 THE WITNESS: One thing about it, I don't
15 have any nice picture to show of the 737, but we had
16 seven video cameras installed on the airplane. There
17 was one on the top of the tail looking forward down
18 over the fusel lodge. There was one in the cockpit
19 looking down into the cockpit where you can see the
20 pilot and the copilot -- the pilot and first officer.

21 You can one out on the wind screen looking
22 straight out of the cockpit. There was one on each
23 wing tip looking straight forward and one in the fusel
24 lodge looking down each wing.

1 Now, we're using these to position the wake
2 vortex exactly in space. That's the only way you can
3 record where the wake vortex was.

4 (Video played.)

5 THE WITNESS: It may appear that the 727 is
6 climbing. That's because actually the wake is
7 descending. The first of these two are wake stability
8 characteristics. In the first, you can see how it
9 moves and flows. One wake is higher than the other.
10 And how uniform air flows affect the wake. You can see
11 it lifting there. In the 727, it was actually level
12 the whole time.

13 If you can turn the audio up -- that was when
14 it went over part of the Delaware Bay. And whatever
15 reason why, it just lifted up the whole wake and then
16 it just drops right back down again.

17 This next one, some more of the wake
18 stability characteristics. You can see how it flows
19 and moves. Even in the -- and even in smooth
20 conditions. Notice, right when the airplane goes
21 through it, that the wake bursts and we get a plus or
22 minus -- still get a plus or minus 20 degree roll.

23 You can see it just blowing up right there
24 when we go through. The next one is a standard auto

1 pilot turn. It's Captain Jim Gibbs from USAir in the
2 right seat. And also, you notice at the very
3 beginning, we have an inadvertent hit of a wake
4 turbulence when we're just turning around and you can
5 see how it just kind of shakes the whole cockpit.
6 That's engaging the auto pilot there.

7 Then you see how much the wheel deflects.
8 That's the auto pilot limit. The auto pilot limit is
9 24 degrees of wheel throw when the flaps are out of
10 their position. And there, I was getting chastised by
11 the flight engineers for not performing the test
12 correctly.

13 The next one is an auto pilot wake encounter.

14 It's with Les Berven of the FAA. It's coming in from
15 the left side. The first thing you see is the outside
16 view, and you get about a plus or minus 20 degrees of
17 roll. This is the camera looking straight out of the
18 airplane.

19 This is the same view from the inside. You
20 can see how the auto pilot commands the wheel. You can
21 see the wheel moves a lot quicker when the auto pilot
22 needs to.

23 The next one is where the wake is descending
24 in the three degree path, i.e., the 727 was coming out

1 of the sky at about 1100 feet per minute and the
2 resulting 60 degree roll happened. So we just hit the
3 right wake, the right core, excuse me.

4 Now, that is hands off. It's just hitting
5 the core and letting the airplane fly and then I
6 recovered. Now, you see the outside picture of it.
7 This is taken from the T-33 chase airplane. You can
8 see how the other wing tip disturbed that wake. If you
9 notice, that other core is actually a correcting
10 moment.

11 The next one is when we did the cockpit voice
12 recorder flight for Mr. Cash, and this is just another
13 -- I didn't know they were going to play a video. The
14 first hit is the -- oh, excuse me. I'm sorry. This is
15 the fin and the core, if I'm not mistaken there.

16 This is myself. You'll notice that my right
17 hand is almost vertical and you can see that it goes
18 against the roll stop and that the airplane isn't
19 rolling. The camera gets precluded because of the oil
20 and the smoke. I had my feet off of the rudder pedals
21 so that the data reduction would be easier.

22 The last one is a CVR flight. If you listen
23 to it -- I really need the audio up on the very first
24 pass here.

1 (Audio turned up.)

2 THE WITNESS: And that's that.

3 MR. JACKY: Were the test conditions and
4 trying to fly through the wake, were they fairly
5 repeatable?

6 THE WITNESS: Yes, within the bounds of what
7 we tried to do. We were tasked to -- it was easy to
8 hit the three degree wake. That's easy to set up. We
9 were tasked to do two degree, five degree, and ten
10 degree intercepts, and that task was not easy. We had
11 to know the heading of the 27.

12 So we took some special precautions to do
13 that. I would say our two degree task was that we
14 probably didn't hit it any less than two, but it wasn't
15 any more three or four and our five degree task
16 probably went from four to six or seven. The ten
17 degree task was easier. It was easier to take that
18 bigger cut.

19 MR. JACKY: Could you tell us what type of
20 upsets you would see in each axis?

21 THE WITNESS: In each axis, there is -- as
22 Mr. Berven said, there is basically a roll upset. And
23 it has been said before, it's a function of how you hit
24 the wake and how you happen to hit the combination of

1 the wake. There's also a little bit of a vertical G
2 bobble, a plus or minus .1 and .15 Gs, and very little
3 lateral accelerations.

4 MR. JACKY: How about in the pitch axis?

5 THE WITNESS: Very little pitch attitude
6 change. Just a pure heaving moment.

7 MR. JACKY: Were you able during any of the
8 encounters to look at the yaw damper indicator in the
9 cockpit?

10 THE WITNESS: Yes, and it was -- as a matter
11 of fact, we had to turn it off. We turned the yaw
12 damper off, because, again, to make the data reduction
13 easier, we wanted to get the rudder motion out of the
14 computation. So we did these events. We would cross
15 from left to right with the yaw damper on, cross right
16 to left with the yam damper off, so that we could make
17 those calculations easier.

18 MR. JACKY: And when you left the yaw damper
19 on, could you see that it was moving --

20 THE WITNESS: Yes.

21 MR. JACKY: -- as you went through there?

22 THE WITNESS: Oh, yes. That's the specific
23 reason why we turned it off, because it was working all
24 the time.

1 MR. JACKY: When you had the yaw damper off,
2 obviously, you didn't have any sort of indication in
3 the cockpit as far as what the rudder was doing. But
4 could you feel any sensation that the rudder was
5 moving?

6 THE WITNESS: No.

7 MR. JACKY: Did you feel that when you --
8 during the encounters that you had with the auto pilot
9 on, that the auto pilot was able to correct for any
10 upset that you found?

11 THE WITNESS: Yes. The auto pilot would
12 react and it would -- even as fast as the auto pilot
13 rate is, which is some place around 50 degrees per
14 second, it was still slightly behind. It would dampen
15 out the motions. As the first motion would come in, it
16 would put in an opposing motion and then it would have
17 to take it right back out as it crossed the other wake.

18 It was actually a probe rolling moment at that point
19 in time until it takes it back out.

20 MR. JACKY: But it was reacting to each --

21 THE WITNESS: Yes.

22 MR. JACKY: -- individual wake?

23 THE WITNESS: Yes, to each wake, each
24 individual wake.

1 MR. JACKY: As you went through the wake, did
2 you notice any sort of large heading change or yaw?

3 THE WITNESS: No. We specifically were
4 looking for that. We only had one or two or maybe
5 three instances where we had a lateral acceleration
6 and/or a heading change that you could actually feel.

7 You had a little bit of a rolling moment that
8 was just a little bit -- was little bit of lateral G,
9 but there wasn't any unknown lateral acceleration in
10 there that we hadn't seen before.

11 MR. JACKY: Do you feel that there were any
12 sort of geometries or encounters through the wake that
13 would give you a large heading change?

14 THE WITNESS: A large heading change?

15 MR. JACKY: Yeah, that you didn't fly?

16 THE WITNESS: No.

17 MR. JACKY: No. During the encounters, could
18 you give us an assessment about -- if you weren't
19 trying to stay in the vortices or keep the wing tip in
20 the vortices or keep the tail in, approximately how
21 long do you feel like you were in the effect of the
22 vortices?

23 THE WITNESS: Well, on the two degree
24 crossing rate, I'd say two seconds on the nominal one.

1 We also hit one where we only had one wake core, but
2 because of the way the wake was oscillating in front of
3 us, we also stayed in one wake core for two seconds
4 plus.

5 MR. JACKY: Okay. And could you think of any
6 way that you would -- if you weren't purposely trying
7 to fly through the cores or in the wake effect, that
8 you would keep in the wake effect?

9 THE WITNESS: No. There is a possibility
10 that one, you could come into a core and like I stated
11 a little bit before, it could roll you up and roll you
12 to the left. And the fact that the wake is actually
13 coming from there -- it's bending in and coming in your
14 left side, you could roll back into that. But that's
15 about it.

16 You could get tossed into the other wake, but
17 the other wake is a correcting moment. So you may
18 bounce around in there a couple of times and get three
19 seconds, four seconds, but you would have to set the
20 wake structure up to do that. Now, we didn't have any
21 of those. Didn't inadvertently hit that ever.

22 MR. JACKY: And at any time during any of the
23 encounters, did you feel like you were losing control
24 or about to lose control of the airplane?

1 THE WITNESS: No.

2 MR. JACKY: Did you have any encounters that
3 would have startled you or surprised you?

4 THE WITNESS: Not for the fact that myself
5 was in there. Like I said, we had been planning on
6 doing this now for months. Had all the time
7 preparation and practicing in the simulator, saw the
8 smoke, entered the wake, along that line. And the
9 resulting 20 degrees angle of bank was within a couple
10 of percent, 10 percent of the predicted value.

11 So, no, it wasn't. I mean, the very first
12 time you hit the wake, you didn't quite know. But
13 after that, it went down.

14 MR. JACKY: Would you characterize any of the
15 encounters that you had as being disorienting to you?

16 THE WITNESS: No, they're not disorientated.
17 Sometimes you're behind on the flight controls. You
18 don't quite know what to do with the flight controls.
19 If the task was to maintain wings level throughout the
20 event, then you're a little bit behind, because the
21 rolling moment influenced on the airplane changes so
22 fast, that you can't keep up with it. So you're kind
23 of -- I'll just keep what I got here. The engineers
24 can worry about it later.

1 MR. JACKY: If you weren't able to see the
2 vortices as marked by the smoke, do you think any of
3 the encounters would have been disorienting?

4 THE WITNESS: I don't know about
5 disorientating, but I know that they would be -- in
6 reports that I've received, especially through things
7 like the Aviation Safety Reporting System, where they
8 have a third of all uncontrolled airplane events are
9 attributed to wake turbulence, I would see how it is
10 possible to conceive that a crew when they hit one of
11 these events and they put in full control motion and
12 nothing happens at that point in time, because they are
13 in a wake core, that they may have a momentary point
14 where they're going, well, I put in full left wheel and
15 the airplane didn't instantaneously react to that event
16 and then it does a second later or two seconds later as
17 you come out of the wake vortex.

18 MR. JACKY: So would that mean that they
19 might overreact to the encounter?

20 THE WITNESS: I don't know. I think that's a
21 -- tasking my human performance group knowledge and I
22 don't know really how to answer that question. I've
23 only begun to start to approximate these things and
24 calibrate myself into crews that have had 6,000, 7,000

1 hours of routine flying and they hit these event in the
2 dark of the night at the end of their fourth day flight
3 -- fourth flight of the day.

4 Something along that line. And that's what
5 we're using these other reports and these feedback
6 reports, so that you can -- just like we calibrate a
7 strain gage. If you're in flight test and you have an
8 event that rolls to 20 degrees, well, data shows that
9 it is possible that airline crews are going to report
10 that event as 40 degrees in that kind of excitement.
11 Then they have to add that into your knowledge of is
12 this acceptable, is this not acceptable, does this take
13 exceptional pilot skill, and things like that.

14 MR. JACKY: Do you have a definition for
15 exceptional pilot skill?

16 THE WITNESS: I have some in electronics. I
17 have developed some very much ones for flight
18 management computer operations. But exceptional pilot
19 skills, what I do is I've taken the people that I've
20 trained in the 737 and seen what their skills are. I
21 fly with line crews once a year to try to get an idea
22 of what they are. I read the SRS reports and things
23 like that to try to build up a database of what is
24 acceptable.

1 Like I said, we certify the yaw damper -- I
2 didn't certify. The yaw damper hardover is certified
3 as an event that is satisfactory, except where we've
4 had two of them and the crew has declared emergencies
5 and landed. So that kind of skews your calibration of
6 what's acceptable and what's not acceptable.

7 MR. JACKY: Was the wake encounters that you
8 had in the flight tests, were they comparable to what
9 the simulations were in the M-CAB?

10 THE WITNESS: Yes, they are. With the
11 limitation of the M-CAB, as a bounding to it, they are
12 very good. I think that the M-CAB motion is a bit more
13 abrupt than the nominal wake encounter that we have.
14 And in comparison to that, I thought that the VMS
15 simulator that we did in NASA-Ames a was a bit -- just
16 a bit on the milder side. And we fed it the same set
17 of data.

18 It's kind of a basis on a nominal event. The
19 accelerations are a little bit smoother in the VMS than
20 they were in the airplane. In our M-CAB they're more
21 abrupt.

22 MR. JACKY: What would account for the
23 difference between the VMS and the M-CAB simulator?

24 THE WITNESS: In the M-CAB, we try to drive -

1 - since we want to get these higher rates, we have very
2 little throw. We drive the rates very quickly at the
3 very beginning to try to get it up, because you only
4 have two feet to go. So you use it up fairly quickly.

5

6 Although, I've said that difference, that's a
7 qualitative opinion. I've been asked that a lot. Are
8 these good? And they are both good representations of
9 the wake vortex.

10 MR. JACKY: I have no other questions.

11 CHAIRMAN HALL: Does the Technical Panel have
12 other questions?

13 (No response.)

14 CHAIRMAN HALL: No. Questions from the
15 parties? I see the hand of Boeing Airline Group,
16 Airline Pilots Association. Anyone else? Very well.
17 The Airline Pilots Association, Captain.

18 CAPTAIN LeGROW: Thank you, Mr. Chairman.
19 Good afternoon, Mr. Carriker.

20 THE WITNESS: Good afternoon.

21 CAPTAIN LeGROW: Just a couple of questions.
22 First of all, the Exhibit 9X-India, this is from the
23 Boeing Airliner. Is that the name of the publication?

24 THE WITNESS: That's correct.

1 CAPTAIN LeGROW: There was some conversations
2 and questions in how this is distributed. Is this
3 document distributed to flight crews for the various
4 airlines or just to the managements of the flight
5 crews, of the airlines?

6 THE WITNESS: I don't know that answer. I
7 think that probably is dependent upon the airline.

8 CAPTAIN LeGROW: But Boeing -- I guess my
9 question is does Boeing have a way to distribute it to
10 the line pilots throughout the country?

11 THE WITNESS: I don't know that.

12 CHAIRMAN HALL: Mr. Purvis?

13 MR. PURVIS: I know a little bit about that,
14 in that it is sent to the airline, not to the pilots.
15 And the distribution is about 40,000 copies.

16 CHAIRMAN HALL: I assume you have no
17 objection if it's copied.

18 MR. PURVIS: No, in the front, it has the
19 right to do that, just so long as it's attributed.

20 CHAIRMAN HALL: Very well.

21 THE WITNESS: We don't even know that -- we
22 can send an operation's manual change and it only goes
23 to the airline. It doesn't necessarily even go to the
24 pilots.

1 CAPTAIN LeGROW: Thank you. You told us that
2 you've been with Boeing for five years. Is that
3 correct?

4 THE WITNESS: Yes. Six years come next
5 month.

6 CAPTAIN LeGROW: Six years. Of your 5,000
7 hours total flying time, how much of that would be in
8 the 737?

9 THE WITNESS: I have 1400 hours in the 737.

10 CAPTAIN LeGROW: Fourteen hundred hours.
11 Have you throughout your career ever flown for a
12 scheduled airline operation with carrying passengers?

13 THE WITNESS: No. Oh, carrying passengers or
14 a scheduled airline?

15 CAPTAIN LeGROW: A scheduled airline carrying
16 passengers?

17 THE WITNESS: No, I have not.

18 CAPTAIN LeGROW: You talked about early in
19 your testimony about rudder hardovers. And I believe
20 you made the statement, correct me if I'm wrong, that
21 there had never been a rudder hardover, full rudder
22 hardover in the 737?

23 THE WITNESS: That's correct.

24 CAPTAIN LeGROW: You talked about exceptional

1 piloting skills or pilot skills. Could you define more
2 specifically exceptional pilot skills? Is that
3 correct? Is that the term you used?

4 THE WITNESS: I think that was Mr. Jacky's
5 term. And then when he asked me that question, I said
6 that -- I can't remember what I said. I could ask the
7 court reporter.

8 CAPTAIN LeGROW: Well, what is your
9 definition of the --

10 THE WITNESS: It's -- my exceptional piloting
11 skills. I know the people who operate the 737, and I
12 know that they don't always include U.S. flag carriers.
13 So in our exceptional pilots skills, you go to -- for
14 the Boeing Company, you go to what I would think is not
15 the lowest common denominator, but down there some
16 place. Because I know that we have -- there are a lot
17 of ab initio crews that come in, and it's the first
18 airplane they've ever flown, is the 737.

19 So that's the basis that I take in that event
20 to try to predict, because that's one of my jobs. Is
21 to have a failure in the simulator and ascertain
22 whether or not it is acceptable or unacceptable and
23 then to promote that data. It's not my opinion
24 personally. It is the Boeing pilot's opinion, and then

1 we present out opinion to the FAA, and either concur or
2 they don't concur.

3 CAPTAIN LeGROW: I'm a little unclear on who
4 the Boeing pilots are.

5 THE WITNESS: There's the Boeing engineering
6 pilots, the Boeing production pilots, and the Boeing
7 flight crew training pilots. They'll all be used to
8 evaluate scenarios.

9 CAPTAIN LeGROW: You are an instructor for
10 Boeing; is that correct?

11 THE WITNESS: Yes. I am also an engineering
12 pilot.

13 CAPTAIN LeGROW: Would you say, in your
14 opinion, the average U.S. flag carrier pilot, would he
15 be considered an exceptional pilot, having exceptional
16 pilot skills?

17 THE WITNESS: No.

18 CAPTAIN LeGROW: He would be below?

19 THE WITNESS: No. He has average pilot
20 skills.

21 CAPTAIN LeGROW: But he would not have
22 exceptional pilot skills?

23 THE WITNESS: Some of them would.

24 CAPTAIN LeGROW: And that's determined by the

1 pilots at Boeing.

2 (General laughter.)

3 CAPTAIN LeGROW: I have no further questions.

4 THE WITNESS: I would like to respond to
5 that. That's an FAA definition. And we have to
6 operate by the FAA definition. If we go in and there's
7 something that happens in the airplane, in the cab or
8 the simulator that we simulate, and it takes a skill
9 level that is not thought to be there and that is based
10 upon training. We know the FAA syllabus for training.
11 We know the Boeing recommended flight crew training
12 syllabus.

13 In those type of events and the skills and
14 then we look at it. Then you make a valued judgment
15 based on people's opinions, not just mine, but possibly
16 20 other pilots. And they say, is this acceptable, is
17 this not acceptable. And then that determination is
18 made.

19 Then usually these things are done hand in
20 hand with the FAA. When we go to do pilot tasking
21 skills, we have a rapporteur of about 50 pilots that we
22 bring in, and they are not Boeing engineering pilots.
23 As a matter of fact, the FAA will not allow Boeing
24 engineering pilots to do some of these big assessments.

1 We have pilots come up from our production
2 flight crew and we bring pilots in from the outside to
3 ascertain the answers to these questions when they get
4 down to the tough questions. Sometimes, it's basically
5 obvious that you cannot -- that it's unacceptable.

6 CAPTAIN LeGROW: Thank you. I have no
7 further questions.

8 CHAIRMAN HALL: Thank you, Captain. Other
9 questions from the parties? Mr. -- I'm sorry.
10 Mr. Purvis, of course, Boeing Commercial Airplane
11 Group.

12 MR. PURVIS: Thank you, Mr. Chairman.
13 Mr. Carriker. Back to your experience, are you, in
14 fact doing initial operating experience with Cathay?

15 THE WITNESS: Yes, for a month, I'm going to
16 be one of the four instructors for Cathay Pacific's
17 initial operating experience on the 777 flying out of
18 Hong Kong, Sidney, Bancok, Manilla.

19 MR. PURVIS: You indicated earlier that you
20 were an instructor for Boeing 37 and 77 airplanes. Are
21 you also instructing on the line for the 77?

22 THE WITNESS: Instructing on the line for the
23 777.

24 MR. PURVIS: For the 777.

1 THE WITNESS: Yes.

2 MR. PURVIS: Onto the Atlantic City tests and
3 those that preceded it in Seattle, you indicated eight
4 flights. Does that include the Seattle, do you
5 remember?

6 THE WITNESS: No, I believe we had eight
7 flights in the Atlantic City area.

8 MR. PURVIS: In all of those flights, were
9 you the pilot in command?

10 THE WITNESS: Yes.

11 MR. PURVIS: Regarding some of the things
12 that we saw in the video, first of all, does -- how far
13 back does that wake persist?

14 THE WITNESS: We only went back-- it persist
15 -- the farthest back point that we were was four
16 nautical miles, and it was still formed at four
17 nautical miles.

18 MR. PURVIS: So it would be beyond four
19 nautical miles?

20 THE WITNESS: Yes. Robert stated that it was
21 back to six, seven, and eight nautical.

22 MR. PURVIS: On the video, you showed first
23 an auto pilot engaged roll up 20 to 30 degrees. And
24 then later, one not on auto pilot rolling beyond 60

1 degrees. Those are numbers -- especially the 60 is --
2 higher than Mr. Berven testified to. Was Mr. Berven
3 present on those flights?

4 THE WITNESS: No, he was not.

5 MR. PURVIS: There is -- what sort of wheel
6 input does it take to maintain wings level on wake
7 encounters?

8 THE WITNESS: I guess, you have to define
9 wake encounter.

10 MR. PURVIS: Well, a wake turbulence. What
11 force of full -- of wheel, is it full wheel to maintain
12 wings level?

13 THE WITNESS: I guess, again, you have to
14 define what the task is here. If you're talking about
15 staying in the core, that's full authority. If you
16 cross it at 90 degrees, you don't need any wheel input.

17 MR. PURVIS: At say three nautical miles and
18 you encounter it.

19 THE WITNESS: If it's on a three degree
20 descent and you want to encounter it, you would
21 probably end up with almost full wheel. At least at a
22 point, about 60 or 70 percent of the wheel.

23 MR. PURVIS: I should have clarified. To
24 keep the tail in the wake.

1 THE WITNESS: Oh, to keep the tail in the
2 wake, it's full wheel -- sorry -- at three nautical
3 miles. It was interesting to note that it was equal
4 and opposite to the rolling moment -- available rolling
5 moment of the 37.

6 MR. PURVIS: You indicated that when you
7 heard the thump, that it meant the fusel lodge was in
8 the center of the wake. Is that correct?

9 THE WITNESS: Yes.

10 MR. PURVIS: At that point, can you talk
11 about the roll accelerations that you experienced?

12 THE WITNESS: The standard wake vortex
13 theories says that that's the largest moment, because
14 the velocity at the center of the core is zero, and it
15 increases linearly out to the maximum value, which is
16 about two to three feet. And then it decays at one
17 over R square squared. So if you put the center of
18 gravity right down the middle of the core, you're going
19 to get the biggest rolling moment available, because
20 your other wing tip is just barely in the correcting
21 moment of the other wake.

22 MR. PURVIS: And that's when we've heard the
23 thump?

24 THE WITNESS: Yes.

1 MR. PURVIS: Are those roll accelerations
2 beyond the auto pilot rate that most pilots are
3 accustomed to?

4 THE WITNESS: Well, yeah. Yes, because the
5 normal auto pilot roll rate is -- although, in the old
6 airplanes it's four degrees per second and in the new
7 airplanes it's a function of bank angle ramping up to
8 four degrees per second. If you have a 25 degree bank
9 angle selected and the maximum roll rate is three
10 degrees a second for the auto pilot and this roll accel
11 is -- or this roll -- steady state roll rate is not
12 exactly a direct comparison, is 35 degrees per second.

13 MR. PURVIS: On the wake test\$hat you did,
14 how many wakes do you estimate that you personally flew
15 through during the tests?

16 THE WITNESS: About 200.

17 MR. PURVIS: On most of these encounters, did
18 you have a chance to anticipate and prepare for the
19 wake encounter?

20 THE WITNESS: Yes. As a matter of fact, we
21 had very specific tasking, to hit an exact spot in the
22 wake.

23 MR. PURVIS: So when you were doing these
24 encounters, could you see the wake before you hit it?

1 THE WITNESS: Yes, otherwise, we couldn't do
2 the test.

3 MR. PURVIS: Could you always correctly
4 anticipate what it was going to do to you when you
5 finally hit it?

6 THE WITNESS: No, not with -- you could come
7 within about 15 or 20 percent. If you thought it was
8 going to roll 20 to 25 degrees, it may have rolled only
9 15. And if you thought it was going to roll 15 or 20,
10 it may have rolled 30.

11 MR. PURVIS: On other parts of the test when
12 you were maneuvering, were there occasions when the
13 smoke generator was turned off and that you actually
14 encountered the 27 wake?

15 THE WITNESS: Yes, because we're always in
16 the four nautical -- we're trying to stay four nautical
17 miles behind the -- three to four nautical miles behind
18 the 27.

19 MR. PURVIS: So were you or any of the other
20 crew members surprised when you encountered these
21 wakes?

22 THE WITNESS: Yes, because you couldn't see
23 them coming. So there was elements. You were
24 surprised and all of a sudden you were shaking. As it

1 showed in the video there, all of a sudden you just
2 bounced.

3 MR. PURVIS: That was the one we saw in the
4 video.

5 THE WITNESS: Yes.

6 MR. PURVIS: Did you find that your wake
7 encounters had the potential to be confusing?

8 THE WITNESS: Not to me.

9 MR. PURVIS: To other pilots, possibly?

10 THE WITNESS: I think so, because in pilot
11 reports, like I said, one-third of all uncontrolled
12 airplane actions are related to wake turbulence events.

13 MR. PURVIS: How would you expect that that
14 confusion would occur? What would cause it?

15 THE WITNESS: An initial rapid roll
16 acceleration that cues the pilot that in a few seconds
17 things could be not very good, and as you hit the other
18 side, it corrects it. So by the time you think that --
19 this is spatulation. This is what the performance,
20 human performance group is looking into, is how crews
21 react to these kind of events.

22 MR. PURVIS: Would any of the noises that had
23 occurred be an issue?

24 THE WITNESS: Any sort of noise that you hear

1 during an event is another input into what the pilot
2 has to think about what's going on. So it's another
3 sensory input that you have to think about.

4 MR. PURVIS: You indicated earlier that you
5 had been involved with three groups; the human
6 performance group, the performance group itself, and
7 the CDR group. Is that correct?

8 THE WITNESS: That's correct.

9 MR. PURVIS: During that investigation, have
10 you interviewed the crews and studied events involving
11 some of these unexpected upsets?

12 THE WITNESS: Yes. All the ones that come
13 into the company that we have and they come into the
14 performance, human performance group, we would look at
15 and try to match up crew comments with the terms off
16 the flight data recorder.

17 MR. PURVIS: In your work doing this, have
18 you found crews can get startled or do get startled by
19 wake turbulence or other unexpected events?

20 THE WITNESS: Yes.

21 MR. PURVIS: Is there a chance that they
22 might misperceive or over perceive the extent of the
23 upset?

24 THE WITNESS: I suppose in the way you word

1 it, there is a chance that could happen, but it would
2 vary per airplane crew and per event and per phase of
3 flight. I think if you're flying along at 35,000 feet
4 and everything's been fine for the past 16 hours, you
5 may have a bigger event than if you're on takeoff and
6 you know that there's a 747 departed three miles in
7 front of you.

8 MR. PURVIS: Do they ever feel threatened by
9 this encounter or surprised?

10 THE WITNESS: We have quotes from pilots that
11 said that it was going to roll on its back and with the
12 exact same roll acceleration terms.

13 MR. PURVIS: Going on to the updated
14 simulator at Boeing. Have you flown the updated one
15 now that we've put in the corrections?

16 THE WITNESS: Yes.

17 MR. PURVIS: How many occasions?

18 THE WITNESS: Twice.

19 MR. PURVIS: And it's been when the aircraft
20 is simulated for flight at flaps one and 190 knots?

21 THE WITNESS: You could ask the simulator
22 match people, but that's where the point that we
23 specifically evaluated the airplane for and we
24 specifically updated the simulator for.

1 MR. PURVIS: And have you then put in a full
2 rudder input in the simulator at that point?

3 THE WITNESS: Yes.

4 MR. PURVIS: At that point, is the 737
5 controllable after the input is made?

6 THE WITNESS: Again, you have to remember --
7 if you remember what Mr. Berven said about the time
8 constraints, what the time is. If you ascertain how
9 much roll control input the crew uses and how fast he
10 puts it in and what he does with the angle of attack,
11 what he does with his foreign aft column, you can get
12 variations on an answer. But if you just come along at
13 190 knots and you step on full rudder pedal, you wait
14 two solid seconds and then apply full wheel -- not 60
15 percent, not 70 percent, but full wheel. Then the
16 resulting roll angle is in the mid 20s before you
17 recover. And if you don't have the task of keeping
18 exactly 190 knots and exactly the tasked altitude, you
19 vary off altitude by several hundred feet and you would
20 probably pick up seven or eight knots.

21 MR. PURVIS: Is it recoverable at that point?

22 THE WITNESS: Yes, because it was not -- yes.

23 MR. PURVIS: Out of control?

24 THE WITNESS: Yes.

1 MR. PURVIS: Can you define again
2 controllable and recoverable?

3 THE WITNESS: Do I have to?

4 (General laughter.)

5 THE WITNESS: A controllable airplane, I
6 define it -- I define an uncontrollable airplane, in my
7 terms, as an airplane that impacts the ground. I
8 define an airplane that you can recover as one that's
9 controllable. I guess, an example is if you have an
10 engine failure after takeoff. If you don't do
11 something about that, you will have a crash.

12 So is it controllable? ~~es~~. Is it
13 recoverable? Yes. Is it uncontrollable? Well, it is
14 if I don't do something about it. So the FAA has come
15 -- as Mr. Berven explained, in the spins. You have to
16 put a boundary upon the exceedence, and that comes from
17 the one that we use, the one that I've been using.
18 It's from the auto pilot section, where you're allowed
19 to have 60 degrees angle of bank. If you exceed 60
20 degrees angle of bank at any point during the maneuver,
21 then you have to prohibit that maneuver. You cannot
22 allow that occurrence to happen.

23 The prime example on the 737 is the auto
24 pilot system. You have to have both auto pilots up and

1 running with their full monitoring system, because if
2 one auto pilot goes down -- and it's not just the auto
3 pilot. It could be the symbol generator in an EFIS
4 airplane. It could be an anersia navigation unit. You
5 have to turn the other auto pilot off, because with the
6 four second criteria, the airplane rolls with a roll
7 auto pilot hardover to about 50 degrees. But in the
8 recovery, you exceed -- in the one test that they did,
9 they exceeded 60 degrees angle bank.

10 So, therefore, from now on in the 737, you
11 have to turn the auto pilot off when you don't have a
12 monitoring device on top of it.

13 MR. PURVIS: No more questions. Thank you.

14 CHAIRMAN HALL: Questions -- well, that's
15 encouraging. Mr. Wurzel with the IAM.

16 MR. WURZEL: I have one question, Mr.
17 Carriker. Good afternoon.

18 THE WITNESS: Good afternoon.

19 MR. WURZEL: If you say that most airline
20 pilots have only average pilot skills, not exceptional,
21 do you think that the 737 aircraft is so critical that
22 it has to be flown by only average pilots or by above-
23 average pilots?

24 THE WITNESS: Well, I dug myself a hole,

1 didn't I? You have to take -- what you do is your take
2 the normal pilot out there and you assign his skill
3 level, which is far and above the average skill level
4 of the worldwide fleet, and you assign that value of
5 normal. That's it. And that's normal. There are some
6 better pilots out there. There are some not better
7 pilots out there. So that's the task we have.

8 The average U.S. pilot, the average U.S.
9 carrier pilot trained through the FAA system has above-
10 average skills compared to I would think probably the
11 worldwide fleet of airplanes. And that is based on --
12 because a lot of people are flying this airplane. Like
13 I said, this ab initio airplanes. It's the first
14 airplane they've ever flown.

15 So you can't have 5,000 hours of experience
16 in flying the airplane the same day you stepped into it
17 for the first time. So the average U.S. airline pilot
18 has average skill.

19 CHAIRMAN HALL: Other questions? Captain.

20 CAPTAIN LeGROW: Thank you, Mr. Chairman. I
21 have just one follow-up question. You said that in
22 your duties as an accident investigator in this
23 accident, you served on three groups. Is that correct?

24 THE WITNESS: Two groups and in the

1 performance group, I provided simulating and piloting.

2 CAPTAIN LeGROW: You said that you had
3 interviewed some pilots that had been involved in
4 events in the 737 during the course of this
5 investigation?

6 THE WITNESS: I did one phone interview. I
7 did one by correspondence interview. And I read the
8 flight data recorders, and I read the crew reports.

9 CAPTAIN LeGROW: And this was in connection
10 with your duties in this accident as a -- on which
11 group would that be? Would that be the human
12 performance group?

13 THE WITNESS: Yes.

14 CAPTAIN LeGROW: And your assessment of the
15 pilots that you interviewed, was that the consensus of
16 the entire group?

17 THE WITNESS: I don't think -- the question
18 was not posed to me as the consensus of the group. I
19 thought the question was posed to me as to my judgment.

20 CAPTAIN LeGROW: And my question is was that
21 the consensus of the entire group or your judgment
22 only?

23 THE WITNESS: The consensus if the group will
24 be published in the group's final report.

1 CAPTAIN LeGROW: Thank you. I have no
2 further questions, Mr. Chairman.

3 CHAIRMAN HALL: Very well. Mr. Clark.

4 MR. CLARK: We've talked earlier about the
5 changeover point, where we changed from dominate wheel
6 authority to the dominate pedal authority. And at one
7 point, I thought that was 190 knots and then I heard
8 you talk about a changeover point that raised from 179
9 to 183, and I wasn't tracking that. Can you help me
10 out with those?

11 THE WITNESS: Yes. I got in the cab and I
12 did it and I thought the value was in the low 180s. It
13 would be afterwards. In the airplane that we flew, it
14 was 190 knots to one side and it was in the high 170s
15 to the other side. Now, I can't explain that one.

16 I know that Mr. Kerrigan just didn't like me
17 mentioning that. You take another airplane out there
18 the next day with a different center of gravity with
19 ailerons that are rigged slightly different, so you
20 have more effective ailerons, and you take an airplane
21 out there where you match the end ones, but one of them
22 has a brand new engine on one side and one's got a
23 10,000 hour core on the other side, and then you have
24 300 pounds of asymmetrical thrust with equivalent end

1 ones, you're going to get slightly different speeds,
2 but they're going to be in the range of three, four,
3 five knots.

4 MR. CLARK: Well, Mr. Kerrigan has either
5 probably a half hour or until tomorrow morning to bone
6 up on that one. You also talked about an area that in
7 the recovery process, it wasn't clear to me that if you
8 got one knot below the changeover point, you would
9 start an excursion. And then you said you had to go at
10 one knot above to recover or if you got five knots
11 below, you had to go five knots above. Could you
12 elaborate on that?

13 THE WITNESS: Well, there's an anersia term
14 in there and a weight term that you have to overcome.
15 So the static point -- it's the difference between
16 statics and dynamics. If you have a dynamic situation,
17 you have to stop a rate, you need a bigger force to
18 stop a rate than you do to just stay put. So that's
19 the part and that's one of the hardest thing for the
20 simulator to calculate, are all those anersia terms.

21 MR. CLARK: Then in that, if you were, for
22 example, one knot low but your reaction was somewhat
23 delayed, you may have to go to a greater speed than one
24 knot above to recover?

1 THE WITNESS: I think in a general term, yes,
2 because if you allowed that rate to develop --
3 although, you might just go to a steady rate. I've
4 never even thought about that. If you go one knot
5 slow, you probably just go to a steady state rate. It
6 wouldn't be an increasing rate.

7 MR. CLARK: In the data that was recovered
8 for the simulator calibration, are you satisfied with
9 those tests? Are there any more tests that need to be
10 done in that area?

11 THE WITNESS: I would like to see --
12 personally, I would like to take another airplane out
13 there and do the exact same test to verify that you do
14 get the exact same speeds, along that line. I would
15 also like to do it on a 737-500 and a 737-400 to get an
16 idea of what the tail moment -- the different tail
17 moment is. Because I've done them in a 737-500 and the
18 speed is in the mid 170s, because of, I think, the
19 different tail arm length.

20 MR. CLARK: The tail arm is the length of
21 the --

22 THE WITNESS: The difference between the
23 center of gravity and the center of pressure on the
24 vertical tail.

1 MR. CLARK: Now, we've been talking a lot
2 about 190 knots. I think you stated that in a normal
3 course of operation, you would never have a need to use
4 full rudder in that situation. If you have an engine
5 failure, typically how much pedal would you need or how
6 much rudder would you need?

7 THE WITNESS: At 190 knots?

8 MR. CLARK: Yes.

9 THE WITNESS: I would say about a quarter;
10 although, that's a pretty good -- I mean, that's an
11 estimate. I've never been in that configuration to do
12 it. All I know is if it passed through there -- of
13 course, it depends on what the -- the thing is, at a
14 190 knots, you don't have a full takeoff power on the
15 engine normally. So they have to take that moment out.

16 So if you're coming down there flying 190
17 knots, your level of flight is about a quarter of a
18 rudder pedal. But if you're on takeoff and you get
19 full thrust on that engine, it's some other different
20 value, somewhat greater, but --

21 MR. CLARK: That's 190 knots and it's well
22 above any type of VMC speed?

23 THE WITNESS: Oh, yes. VMC is -- you could
24 ask Mr. Berven, he probably knows VMC better than I do.

1 MR. CLARK: So basically we're looking at
2 probably a small pedal in the normal course of
3 operation at these speeds?

4 THE WITNESS: Yes.

5 MR. CLARK: Would you -- you said something
6 about a two foot throw on the end cap simulator and was
7 comparing that to the VMS simulator. Could you
8 describe a little bit about -- a little bit more about
9 the VMS simulator? What does this two foot throw mean?

10 THE WITNESS: The vertical motion simulator
11 is -- our large motion simulator is located at NASA-
12 Ames. There's some rough numbers. I don't know the
13 exact travel, but it can move approximately up and
14 down, plus or minus 35, 30 feet and left and right 30
15 feet on a center box. It's a huge apparatus. So you
16 can sustain a lot -- you can sustain higher
17 accelerations for a longer period of time, because you
18 have the displacement to move.

19 Our multi-purpose cab is a standard six
20 degree of freedom cab simulation, with about plus or
21 minus 30 degrees in roll and pitch and about 30 degrees
22 in yaw. Plus only two feet of travel in heave and
23 lateral and longitudinal acceleration. So you get what
24 you get in two feet. No matter how hard you drive it,

1 you still have to stop after two feet. Whereas, the
2 vertical motion simulator can drive for 70 feet. You
3 can sustain that a lot longer.

4 MR. CLARK: In other words if simulators have
5 -- you gain some feet back from the accelerations --

6 THE WITNESS: That's correct.

7 MR. CLARK: -- but not for long in any
8 direction?

9 THE WITNESS: Not for long. Even in the
10 world's best one there is -- in Boeing time, we can
11 match the flight data recorder up to Boeing time about
12 135, 136. And if we drive it really hard, we can match
13 it almost to 137. The vertical motion simulator with
14 all its ability match it up to about 139.

15 MR. CLARK: These times are the --

16 THE WITNESS: These are Boeing accident times
17 in seconds.

18 MR. CLARK: Related to the Pittsburgh
19 accident?

20 THE WITNESS: To the Pittsburgh accident.

21 MR. CLARK: Both, I believe you and Mr.
22 Berven said that normally in this 190 knot range, you
23 operate without rudder input, commanded rudder input
24 from the pilot. Typically, is it likely that somebody

1 would get on the rudder pedals in a wake vortex
2 encounter -- when you were doing your encounters, would
3 it be likely that somebody would get on the rudder
4 pedals in that situation?

5 THE WITNESS: I don't know about likely. It
6 is a -- I've seen data where they do and I've seen data
7 where they don't. So is it likely? I don't know. We
8 don't know why. There's a wake turbulence event of the
9 737 landing behind the 757 at Denver and the crew uses
10 half available rudder. And there are other wake
11 turbulence events where they don't touch the rudder,
12 so.

13 MR. CLARK: Is there anything that you felt
14 in the wake vortex encounters that would prompt a full
15 rudder input in your estimation?

16 THE WITNESS: No.

17 MR. CLARK: Anything in the -- you were in
18 the VMS simulator, the M-CAB simulation that went
19 through the motions of Pittsburgh. Are there any
20 visual cues or motion cues recognizing the limitation
21 and the motions that you feel would prompt somebody to
22 put in full rudder?

23 THE WITNESS: Not in the classic sense. In
24 the classic sense, the only time you use the rudder

1 pedal is when you have a definitive yawing moment,
2 i.e., an engine failure or something like that. Or you
3 have a very -- you have a high rolling moment is the
4 other case that we find out that pilots use rudders.

5 So from the classic sense of using the
6 directional controls to control the direction of the
7 airplane, no.

8 MR. CLARK: But even in the sense of the
9 rolling direction, the cue would be to put in right
10 rudder, for example?

11 THE WITNESS: That is a question that I hope
12 the human performance group gathers data upon and can
13 provide the data for the NTSB to come up with the
14 analysis.

15 MR. CLARK: In one of your comments, you were
16 talking about sticking the tail into the vortex core at
17 about 190 knots. I believe you said it took full wheel
18 and opposite rudder. I think you said it --

19 THE WITNESS: Zero rudder.

20 MR. CLARK: Did you just say "rudder?"

21 THE WITNESS: Yes.

22 MR. CLARK: Okay. I understood that when you
23 were in the -- trying to hold in the core, I thought
24 you made a comment about equal and opposite for the

1 tail in the wake.

2 THE WITNESS: No. Oh, yes. Equal and
3 opposite for the rolling moment to correct, to keep the
4 wings level, but I didn't use rudder.

5 MR. CLARK: Just the wheel.

6 THE WITNESS: Just the wheel.

7 MR. CLARK: Oh, okay.

8 THE WITNESS: Initially, every now and then,
9 I started to use the rudder, but then you would
10 translate left or right out of the full effect of the
11 core and then I would be left with either putting -- I
12 had already taken out some wheels and have a little bit
13 of rudder in. So that you're left with the problem of
14 either taking the rudder out and putting the wheel back
15 in or leaving the rudder there and just playing with
16 the wheel.

17 So finally, to keep the engineers happy, I
18 put my feet on the floor and just tried it with wheel
19 off. If I couldn't hold it, I couldn't hold it. If I
20 could, I could.

21 MR. CLARK: I'm sure Mr. Jacky and Mr.
22 Kerrigan will appreciate that very much.

23 THE WITNESS: Yeah.

24 MR. CLARK: I have no further questions.

1 CHAIRMAN HALL: Mr. Marx.

2 MR. MARX: Yes. I may have missed this in
3 the video tape, but the encounter in which there was a
4 60 degree roll, what altitude was that at?

5 THE WITNESS: Six thousand feet.

6 MR. MARX: Six thousand feet. What was the
7 configuration of auto pilot? Was that on or off?

8 THE WITNESS: No, that is a hands-off event.

9 It's just putting the airplane -- making sure the
10 airplane hits square in the middle of the wake hands
11 off and let it roll.

12 MR. MARX: Could you account for why there
13 was a difference between a maximum of 60 degrees and
14 your event, one event compared to Mr. Berven's 30
15 degrees max?

16 THE WITNESS: I think that -- well, Mr.
17 Berven didn't fly under these conditions for one thing.

18 He wasn't on board the airplane the day we flew in
19 those conditions, at least at the two nautical mile
20 point. So he wasn't there.

21 The 30 degree bank, it's not much of a -- I
22 don't think it's as technical as it sounds. If you can
23 find a way to hit the wake vortex and situate yourself
24 such that you stay in it longer and then the rolling

1 moment has a bigger effect. So when the vortex is in
2 this three degree descent, instead of crossing it
3 through and getting some of the vertical, you actually
4 just get almost pure rolling moment out of it. And
5 it's tilted slightly. So you cross it at a little
6 different angle, a little broader angle.

7 Also, if you look in the tape, another time
8 we had the vortex was coming down and then it kind of
9 leveled out and then went down again. And if you just
10 hit it at this part where it's level, now what you've
11 really done is hit the original part of a wake -- of an
12 instantaneous start of the wake vortex.

13 So it's just a function of an event that you
14 can have that allows you to stay in the core longer.

15 MR. MARX: Has there been any consideration
16 made to the density of the air and how strong the
17 vortex would be if it is at different altitude?

18 THE WITNESS: That's out of my expertise.

19 MR. MARX: Thank you.

20 CHAIRMAN HALL: Mr. Schleede?

21 MR. SCHLEEDE: No questions.

22 CHAIRMAN HALL: Mr. Laynor?

23 MR. LAYNOR: No questions.

24 CHAIRMAN HALL: Well, let's see. Do I have

1 any questions? Mr. Carriker, I guess I do have a
2 question about this article. I guess this was written
3 in the interest of providing 737 line pilots
4 information on the 737 directional control system. I
5 guess there may be some -- well, some conversation in
6 the community of the people that fly that, because of
7 the tension on these two accidents. Is this
8 information, you think, every 737 line pilot would find
9 beneficial and should have?

10 THE WITNESS: I'd like to think so. I put a
11 lot of effort into writing the article and researching
12 and making sure that the numbers and the perceptions
13 are correct and got approved by aerodynamics people and
14 mechanical systems people and human factors people to
15 get that information out there.

16 I guess another reason I should have stated
17 that we gave an airline a brief about yaw dampers and
18 what happens when they fire. The first time they had
19 one of these events, it was a fairly big happening.
20 And after the crew had the brief and another one
21 happened, it was if the yaw damper failed, turn it off,
22 continue on to the next point.

23 CHAIRMAN HALL: General, does USAir get this
24 magazine and would this be something you would

1 distribute to your line pilots on the 737? How many
2 pilots do you have that fly that, do you know offhand?

3 I know in Pittsburgh we mentioned that number, but I
4 can't remember what it was.

5 GENERAL ARMSTRONG: Yes, sir. We did receive
6 the article. We did, in fact, reproduce the article
7 and distribute it to all 2700 people.

8 CHAIRMAN HALL: Well, good. The Airline
9 Pilots Association would have to make their own
10 decision, but if you look at it and think it's
11 something that's appropriate, I would encourage you to
12 get it out. And internationally, this American
13 passengers fly this plane worldwide. I assume that
14 this information goes out internationally, as well.

15 Well, I applaud your efforts in putting this
16 together. On page 6 of this exhibit, which is page 29
17 of the article, you get into -- you say apparent
18 uncommanded yaw or roll not caused by yaw damper
19 malfunction. And then you list some non-normal events;
20 wake turbulence, adverse weather, flight control
21 malfunctions, split throttles, engine power loss, auto
22 pilot malfunctions. Any other malfunctions of the
23 rudder are not here. Is that because there would not
24 be any or you all don't have the experience with --

1 THE WITNESS: It's because you could possibly
2 have almost the same indications and not be the same
3 fault. So we didn't want to tell people -- to give
4 people the idea that every time you roll, you had a yaw
5 damper malfunction. You may have hit a wake. You may
6 have hit just a regular turbulence in a thunderstorm
7 activity.

8 Flight control malfunctions are such if
9 things like asymmetric flaps or asymmetric slats,
10 whether you get a rolling moment split throttles,
11 there's a possibility that on the auto throttles, one
12 throttle can come up and the other one doesn't. And
13 that's a heck of a rolling moment. Engine power loss
14 is pretty easy and auto pilot malfunctions and we
15 talked about those.

16 CHAIRMAN HALL: Well, I found the article
17 very interesting and I hope it gets wide distribution.

18 I guess you have, what, how many hours on the 737?

19 THE WITNESS: About 1400.

20 CHAIRMAN HALL: Fourteen hundred. And Mr.
21 Berven had what, 5,000?

22 MR. BERVEN: My total flight time is 7,000.
23 About 3500 hours are in engineering testing. And my
24 total time in the 737 --

1 CHAIRMAN HALL: I apologize. I'm causing
2 problems here.

3 MR. BERVEN: I said my total flight time is
4 7,000. About 3500 hours are in engineering testing.
5 And my time, total time in the 737 is about 450 to 500
6 hours.

7 CHAIRMAN HALL: Well, we got a lot of
8 experience here and you have participated with us in
9 this investigation, as you mentioned, representing
10 Boeing on two of the groups. In this public setting,
11 is there anything else that you think we should be
12 doing in this investigation or other tests that should
13 be run or other things, suggestions you would have or
14 comments for us?

15 THE WITNESS: I would like to see the
16 continued activity and a broadening of the scope of the
17 human performance group. We're at a bit of an impasse
18 because we're only allowed to look at this event. And
19 they're bringing up -- there's NASA studies, FAA
20 studies, university studies involving all these
21 different parameters, and we have not assimilated,
22 incorporated, analyzed, or even brought forth from a
23 team -- and I am a member of the team -- brought forth
24 to highlight sections, paragraphs, and present that

1 data to the NTSB for the NTSB's analysis.

2 CHAIRMAN HALL: And finally -- I meant to ask
3 Mr. Berven this question -- we made a decision to
4 extend some taxpayer dollars in terms of this test. We
5 also were fortunate that USAir and Boeing contributed
6 to this test. But we, FAA and the National
7 Transportation Safety Board, dipped into our emergency
8 fund. Do you think that that wake vortex test that we
9 took at Atlantic City will advance the knowledge in
10 this area? I guess, did we spend the money properly,
11 in your opinion?

12 THE WITNESS: Yes. I honestly believe we
13 did. We've solved a couple of key problems with the
14 unknown points on the cockpit voice recorder. We now
15 have the absolute best chance of having a very valid
16 simulation. From that simulation, we hope from the
17 performance group to know where the flight controls
18 went and to aid us in trying to recognize what
19 happened.

20 I think it gave experience to John Cox and
21 Jim Gibbs and Les on what it is to flight test an
22 airplane, how the airplane can be flown, and not have
23 to fly it in the airline environment. And to
24 broadening all around through the members of the NTSB

1 that were there and observed the flight test, and
2 members of the FAA, members of ALPA and USAir to see,
3 one, how all these people can work together and
4 successfully complete a program in a very quick time.
5 And, two, gather as a group all this information and to
6 start processing it and using it.

7 CHAIRMAN HALL: Well, I'm sure -- I'll be
8 sure Administrator Henson hears that. I don't know
9 Mr. Cox and Mr. Berven may have different opinions, but
10 we'll find out from them. Well, thank you very much
11 for your time and your participation.

12 Unless there are other questions, we will
13 excuse you.

14 (Witness excused.)

15 CHAIRMAN HALL: We need to get to Mr. Cox
16 today, that's for sure, because -- right? Captain Cox.
17 I apologize, Captain, I'm sorry. I'll get in trouble
18 real quick that way. But I guess we ought to take a
19 break and then come back and have Captain Cox. Is that
20 everybody's pleasure?

21 So we'll come back here in 15 minutes. At
22 ten minutes to the hour.

23 (Whereupon, a brief recess was taken.)

24 CHAIRMAN HALL: We will reconvene this Board

1 of Inquiry. Captain Cox, I want to give you of all
2 individuals, a special welcome up here, because I am
3 the eighth chairman of the National Transportation
4 Safety Board and some have described me -- well, some
5 have described me -- some of my detractors have
6 described me in other ways, but I have been described
7 as an average chairman of the National Transportation
8 Safety Board.

9 (General laughter.)

10 CHAIRMAN HALL: And it's nice to -- I believe
11 you're here as an average pilot. Is that correct?

12 CAPTAIN COX: Yes, sir. That's what they
13 tell me.

14 (General laughter.)

15 CHAIRMAN HALL: Well, we'll get together and
16 celebrate after this is over.

17 (General laughter.)

18 (Witness testimony continues on the next
19 page.)

20

21 JOHN COX, CAPTAIN 737, USAir, AIRLINE PILOTS

22 ASSOCIATION, PITTSBURGH, PENNSYLVANIA

23

24 Whereupon,

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

5 CHAIRMAN HALL: Who's handling this one?

6 MR. SCHLEEDE: I've got to --

7 CHAIRMAN HALL: Oh, he's not been sworn? I'm
8 sorry.

9 MR. SCHLEEDE: Yes, I'm sorry. He's sworn.
10 I just want to qualify him for the record.

11 CHAIRMAN HALL: Okay.

12 MR. SCHLEEDE: Captain Cox, your full name
13 and business address, please?

14 THE WITNESS: My name is John M. Cox. My
15 business address is One Thorn Run Center, Corapolis,
16 Pennsylvania.

17 MR. SCHLEEDE: And your position with USAir?

18 THE WITNESS: I'm a 737 Captain.

19 MR. SCHLEEDE: Could you briefly describe
20 your experience bringing you up to that position?

21 THE WITNESS: Yes, sir. I've been a licensed
22 pilot for 25 years. I've flown professionally for 22
23 years. I've been with USAir for 16 years. I hold an
24 Airline Transport Pilot certificate with three jet type

1 ratings, including the Boeing 737. I have something in
2 excess of 12,000 hours flight experience, and of which
3 something over 8,000 hours in the 737.

4 MR. SCHLEEDE: And you're working on the
5 investigation of the USAir accident.

6 THE WITNESS: Yes, sir.

7 MR. SCHLEEDE: In what capacity?

8 THE WITNESS: I'm with the systems group.
9 I've also done work with the performance group and
10 participated in the wake vortices flight tests in
11 Atlantic City and the simulator validation tests in
12 Seattle.

13 MR. SCHLEEDE: Have you worked any other
14 investigations with the NTSB?

15 THE WITNESS: Yes, sir, several.

16 MR. SCHLEEDE: Thank you. Mr. Jacky.

17 MR. JACKY: Good evening, Captain Cox.

18 THE WITNESS: Good evening, Mr. Jacky.

19 MR. JACKY: You mentioned that you're a pilot
20 for USAir on the 737-300. Are you rated and do you fly
21 in the other derivatives of the 37?

22 THE WITNESS: I'm currently flying actively
23 the 737-300 and 400. We fly that as one type of
24 aircraft at USAir. I also have experience in the 737-

1 200.

2 MR. JACKY: But you're not actively flying?

3 THE WITNESS: No, sir. We currently fly that
4 as a separate type aircraft. But I flew it both as a
5 first officer and a captain on the 200 version.

6 MR. JACKY: Okay. And you have no experience
7 in the 500?

8 THE WITNESS: No, sir.

9 MR. JACKY: Does USAir fly the -500 airplane?

10 THE WITNESS: No, sir, we do not.

11 MR. JACKY: I guess, first off, if we could
12 turn to Exhibit 9X-I, please. Again, this is the
13 article that's taken from the Airliner manager. I was
14 wondering if I could get your assessment of this
15 article, whether or not you feel it is a good article.
16 Have you read the article?

17 THE WITNESS: Yes, I have.

18 MR. JACKY: Could you give me a
19 characterization of the article?

20 THE WITNESS: I think that it's -- overall,
21 it's a pretty good article. I did notice what I would
22 characterize as some carefully chosen verbiage. In
23 that way, that I think it's technically correct, and I
24 applaud the Chairman for his efforts to insure its

1 distribution. I know it was being distributed pretty
2 well around USAir. But it's sort of information with
3 the interest in the lateral control system in the 737
4 is something that I would think is advantageous to all
5 the line pilots.

6 Within the AirlinePilots Association, we
7 have also tried to distribute this sort of information.

8 So, it's an educational process that I think is good.

9 MR. JACKY: Have you had any discussions with
10 other pilots within ALPA and USAir on this article?

11 THE WITNESS: A few, a few people.

12 MR. JACKY: And any comments or thoughts
13 from --

14 THE WITNESS: Pretty much the same as mine.
15 That some of the verbiage was chosen a bit carefully,
16 but overall it's pretty good. It explains some things
17 pretty well. And it's a well-researched article. So
18 in that regard, I think it's good.

19 MR. JACKY: Does USAir have any sort of
20 method for getting information like this to -- I know
21 you said that USAir has distributed the article to the
22 pilots. Are there any other ways that they get
23 information to you?

24 THE WITNESS: Well, there are several

1 different ways. One of the company distributions is a
2 magazine called, "Safety on Line." It's about a
3 monthly publication from the Safety Department.
4 There's also specific aircraft issues that come up on
5 the 737. There's a publication ALPA publishes,
6 approximately a monthly magazine and safety articles
7 and airplane specific information. Our articles
8 probably constitute 60, 70 percent of that magazine.

9 So on an average month, USAir pilots are
10 getting quite a bit of material on current information.

11 And about once a quarter, we also get a publication
12 from the company called "Flight Crew View." And that
13 oftentimes has reprints of flight safety foundation
14 articles and other industry publications that are
15 applicable to line operations.

16 MR. JACKY: Are the articles sort of meant to
17 be refreshers to your training or are they just giving
18 new information to you or what are the purpose of the
19 articles?

20 THE WITNESS: Well, I think it varies from
21 article to article. Oftentimes, they are the events in
22 research that has come up in the industry. It's
23 serving to re-emphasize training that we've already had
24 on a variety of subjects. Sometimes as a refresher,

1 sometimes as new material is brought forward. And
2 sometimes, as is topical for the season. As an
3 example, in the late spring, you get the thunderstorm
4 articles and then as deicing season approaches, you'll
5 get the deicing articles. So it's a big seasonal in
6 what's going on in the industry.

7 MR. JACKY: I asked the other two pilots this
8 question. I'll go ahead and ask you. At a flaps 190
9 airplane configuration, normally how much rudder would
10 you expect to use while maneuvering?

11 THE WITNESS: In normal line flying, zero.

12 MR. JACKY: Zero. And per USAir operating
13 procedures, what would be the normal air speed range
14 that you would use while operating under flaps one
15 configuration?

16 THE WITNESS: Well, we would operate normally
17 between 210 and 190 knots with flaps one under the
18 current system.

19 MR. JACKY: And then would you -- then at
20 what point would you start going to more flaps or slow
21 down or --

22 THE WITNESS: If you were slowing below 190 -
23 - and I would probably need to clarify that. Previous
24 till about two months ago -- and that's an approximate

1 figure -- depending on the gross weight of the
2 airplane, that zero flap or flaps one maneuvering speed
3 could have been lower than that. So at times -- you
4 know, six months ago or for longer, we could have had
5 the airplane operating at a lower speed with the flap
6 setting of one, but that would have been normal. At
7 190 knots, flaps one would have been a normal setting
8 for us.

9 MR. JACKY: You mentioned when you were
10 talking about this, you said that's the current
11 procedure. Does that indicate by use of that word,
12 that there's some thought about changing that?

13 THE WITNESS: Well, there has been a change.
14 We have now gone to a less weight restricted, more
15 categorical, if you want to call it that, speeds of 210
16 and 190 as a range for the flaps one setting. And
17 that's on a much broader scale where we would
18 previously -- on the previous system, we would
19 incrementally adjust it for every 1,000 pounds of
20 weight or so.

21 MR. JACKY: So then you're just -- you're
22 basically -- or would that mean that you're using that
23 now all the way across the band of weights then?

24 THE WITNESS: Well, there are some weights in

1 there where the speed goes up further, but they are at
2 the heavier weights.

3 MR. JACKY: Okay. What was the reason or the
4 basis behind that change?

5 THE WITNESS: I'm not absolutely sure. I
6 know that there was some thought. This process was
7 used some years ago. The speed schedule was used some
8 years ago. And the engineering folks came up with the
9 idea of flying the airplane at the slower speeds, I
10 think in an effort for fuel conservation. But they
11 were Boeing approved -- it was a Boeing approved
12 procedure. And then USAir, as I say three or four
13 months ago, decided to go back to the newer speed
14 schedule.

15 MR. JACKY: In the course of your flying
16 experience in the 300, what would you believe would be
17 about the maximum amount of rudder that you've ever had
18 to use?

19 THE WITNESS: Well, it would vary. I mean,
20 there are training scenarios where we've used it all.
21 In a simulator with an engine out event, heavy weight
22 conditions, where you need just about all the rudder.
23 As far as with a non-instrumented airplane in line
24 operations -- for example, in cross wind landings, I

1 really don't know that I could characterize in degrees
2 how much you use. You use what you need, if that makes
3 sense, as you align the airplane with the runway.

4 MR. JACKY: So how many of your -- within the
5 737 fleet at USAir, how many of those airplanes have
6 some sort of indication of where the rudder is at in
7 the cockpit?

8 THE WITNESS: None.

9 MR. JACKY: None. And that can be said for
10 the 200 and the 500 also? Or, I'm sorry, the 200 and
11 the 400?

12 THE WITNESS: Yes, sir, that's true. The
13 only indication of any consideration with the rudder is
14 the yaw damper indicator on the forward panel.

15 MR. JACKY: Okay. And just for
16 clarification, could you tell us how big and where on
17 the cockpit panel the yaw indicator is?

18 THE WITNESS: It's approximately the diameter
19 of a quarter and it's fairly far up on the forward
20 panel underneath the glare shield almost.

21 MR. JACKY: And does it give you -- is it a
22 gage? Does it tell you exactly where the yaw -- where
23 the rudder is and the yaw damper position in degrees?
24 Or how does --

1 THE WITNESS: It's only -- it's a white
2 needle with an indices that the center moves, tracks
3 left and right in relation to the yaw damper. And it's
4 not marked in degrees. It's just -- if you had to
5 describe it, the only definition you could use is
6 needles widths. That's the only measurement you could
7 use.

8 MR. JACKY: Could you give us a
9 characterization of your participation in the simulator
10 calibration flight tests, please?

11 THE WITNESS: I was on the aircraft first as
12 an observer. When Mr. Berven and Mr. Carriker flew, we
13 were in the back of the aircraft with the videos and
14 the flight test engineers. Then Captain Gibbs and I
15 exchanged flight crew duties on the second flight. He
16 flew a portion of the flight and I flew a portion of
17 it.

18 MR. JACKY: In the course of your flying with
19 USAir, have you had the opportunity to perform the type
20 of maneuvers that were performed during those simulator
21 validation flight tests?

22 THE WITNESS: In some respects, part of my
23 history with USAir, I was a simulator instructor, an
24 aircraft instructor check pilot, check airmen, and also

1 an acceptance test pilot. So in doing some of the
2 acceptance test work on the different aircraft -- not
3 the 737, I have had some experience in this type of
4 work before, but not quite to the extremes and not in
5 this airplane, but it's similar in nature.

6 MR. JACKY: Did you perform any of the steady
7 heading side slip maneuvers?

8 THE WITNESS: On the 737 in Seattle, yes,
9 sir.

10 MR. JACKY: Yes.

11 THE WITNESS: Yes, sir.

12 MR. JACKY: Which of the two flights was that
13 on?

14 THE WITNESS: The second one.

15 MR. JACKY: Did you perform any of those
16 maneuvers were you in Atlantic City?

17 THE WITNESS: Yes, sir.

18 MR. JACKY: Could you give us your
19 impressions of -- there's been -- I'm sorry. There's
20 been a lot of talk about the lateral stability and the
21 control and the cross-over point and whatever. Could
22 you give us your impressions of what you saw there?

23 THE WITNESS: The thing that I think probably
24 stuck with me the most was at speeds right around 190

1 knots, in a full rudder condition, the airplane would
2 start to roll and did. It had insufficient lateral
3 control to stop it. As you accelerated back, you had
4 to go several knots above that, before the lateral
5 control system could again over power the rudder.

6 It surprised me a little bit, because once
7 the roll started, it was pronounced. It's something
8 that you could definitely see. I was a bit surprised
9 at that. I didn't expect the cross-over points, quite
10 frankly, to be quite that high. I was -- I had never
11 taken the airplane before into that regime of flight.

12 So from a line pilot perspective, I think
13 that I would have expected more padding under the
14 maneuvering speeds that we were flying in the case of a
15 full hardover rudder than in the cases as we observed
16 it.

17 MR. JACKY: Would you have any sort of
18 assessment as far as the -- we talked about the two
19 degree offset in the rudder at the full rudder blow
20 down condition. Would you have any sort of assessment
21 of that?

22 THE WITNESS: My opinion is that after flying
23 the M-CAB simulator in Seattle and then also having
24 flown the flight simulator at USAir, that the aircraft

1 exhibited the cross-over point at a higher speed than
2 the simulators. So in that regard, I was pleased to
3 hear that they're going to update the simulator model
4 to more accurately represent the airplane.

5 MR. JACKY: Do you think that the airplane
6 that was used in the flight test was fairly
7 representative of 300?

8 THE WITNESS: Yes, sir. I would guess that
9 I've flown every 737-300 and 400 that we have, which
10 is, I think, some 235 airplanes. And it was what I
11 would call very definitely an average airplane. It was
12 rigged pretty well, which is normal for a USAir
13 airplane, and it flew, I would characterize it, as
14 average. Average or better.

15 MR. JACKY: Could you tell us about your
16 participation in the wake vortex test?

17 THE WITNESS: Yes, sir. Once again, on the
18 first couple of flights, my function was that as an
19 observer in the back of the aircraft with the engineers
20 and the video monitors. On four of the flights, I
21 believe, I participated as a flight crew member flying
22 the aircraft. I flew several of the wake turbulence or
23 the wake vortex encounters from a variety of the test
24 condition.

1 MR. JACKY: Could you characterize for us the
2 behavior of the wake vortices?

3 THE WITNESS: It was consistent with pretty
4 much things that we see on the line. Operating in and
5 out of the east coast, which is where USAir is a
6 predominant airline, we go into high density airports
7 with great frequency.

8 I mean, on a three-day trip, three or four-
9 day trip, it's normal to come across wake vortex of
10 traffic. The word routine is probably not descriptive,
11 but it's certainly not unusual. And this was -- it was
12 consistent with the experiences that I've had
13 previously.

14 Now, the only difference was I've never
15 before tried to find the center of a core and stay
16 there. So the control inputs necessary to do that were
17 larger than what I -- certainly larger than what I had
18 seen in previous line experience. But where Mr.
19 Carriker referenced hitting a vortex two or three
20 times, I've experienced that, both with the auto pilot
21 on and off where I was hand flying the airplane.

22 The Atlantic City test was no different.
23 It's not that disruptive a condition.

24 MR. JACKY: Two of the earlier witnesses were

1 talking about the amount of time that you would spend
2 within the effect of the wake vortices. Could you give
3 us your characterization of that?

4 THE WITNESS: In normal line operations, it's
5 a couple of seconds. I mean, you're in and out of it.

6 The one or two times that I had experienced what I'd
7 call repetitious encounters, which I now understand to
8 be the same core as it maneuvered around with us
9 holding a track over the ground as going back through
10 it. That whole thing is lasting just a couple of
11 seconds per encounter and then you're gone.

12 One of the things is it's very difficult to
13 stay in the core. The aerodynamics are such that it
14 wants to spit you out and away from the center of the
15 core quite quickly. So if you're not deliberately
16 trying to stay there, it's going to move the airplane
17 away from the center of the core.

18 MR. JACKY: During the flight test in
19 Atlantic City, what were some of the representative or
20 maximum amounts of roll angles or upsets that you saw?

21 THE WITNESS: Depending on the test
22 condition, with any kind of pilot intervention, they
23 were, I'd call it, in the mid 20s. A good bit of the
24 time you spent looking outside because you're trying to

1 align the airplane visually with the core and you
2 glance back inside as you went through it, and I don't
3 recall seeing anything much above 20, 25 degrees. I'd
4 certainly characterize it as normal.

5 For example, an auto pilot will oftentimes
6 make a 30 degree bank, and this would be what I would
7 call within the realms of normal for passenger service.

8 Now, the video describes 60 degrees of bank, and I was
9 a cockpit crew member when some of those tests were
10 done. Those were set up quite carefully to examine the
11 airplane's free response.

12 So we would set the airplane up to hit the
13 maximum portion of the core and remain there as long as
14 it could with no pilot intervention at all. Literally
15 we were sitting there with our feet on the floor and
16 our hands up to let the airplane have maximum time to
17 respond until it dampened out and then we'd set up the
18 next test.

19 So the 60 degrees is what I would
20 characterize as a special test condition, that's not
21 representative of line flying.

22 MR. JACKY: And during your experience with
23 wake encounters and line flying, if you can remember,
24 what would be like the maximum amount of roll rate or

1 roll -- I'm sorry -- roll that you would see in any of
2 those encounters?

3 THE WITNESS: I don't recall seeing any much
4 over -- about the same amount, 20, 25 degrees. And
5 that's very usual. Typically, more often than not,
6 what we'll hit them is at a fairly acute angle. So
7 you'd get just one or two pretty good bumps and not a
8 lot of roll.

9 On the cases where you're going in behind a
10 lot of traffic, is the cases where I've -- the
11 strongest memories are of encountering the roll. And
12 even then, it's 20, 25 degrees. Not much more than
13 that.

14 MR. JACKY: And during the flightest in
15 Atlantic City, did you notice any encounters that
16 resulted in a large yawing moment or heading change?

17 THE WITNESS: No, actually, we did several
18 tests with both the yaw damper operative and switched
19 off. We had the vertical fin in the vortex. We put
20 several parts of the airplane carefully in the vortex,
21 looking for yaw, and it was less than I had expected it
22 to be, because I had -- particularly with the fin only
23 in the core and with the yaw damper off, I had expected
24 a fair amount of yaw and it wasn't there.

1 MR. JACKY: When you were flying through the
2 wake during the flight tests in Altantic City, did you
3 happen to notice if the yaw damper was active?

4 THE WITNESS: It was active. Yes, sir, it
5 was active, but I don't know that I could characterize
6 it in magnitude. I was sort of busy doing other
7 things, but it was moving. Yes.

8 MR. JACKY: During your experiences as a line
9 pilot, have you had any sort of wake encounter that
10 would result in a large heading or a yaw change or yaw
11 moment?

12 THE WITNESS: No.

13 MR. JACKY: Let me ask you, when you are
14 doing line flying and you have a wake encounter, what
15 are the sort of cues or what tells you that you just
16 had a wake encounter?

17 THE WITNESS: There's an abrupt movement in
18 the airplane that was -- that the pilot didn't put in.
19 The airplane is flying along in a steady state, if you
20 want to call it that, even in light choppy air. And
21 then the airplane begins a roll that was not instigated
22 by the crew or the auto pilot and there's usually
23 little bit of vertical moment with it. And it has a
24 distinctive characteristic, a fingerprint, if you want

1 to call it that, that you come to know pretty quickly
2 as that was the wake of another airplane.

3 MR. JACKY: Over the past several days or
4 past two days, we've had a lot of conversation about
5 some of these uncommanded roll events that have been
6 happening in the industry. Do you see any way that
7 what you term as being a wake encounter, could that
8 have been some sort of roll upset with the auto pilot
9 or something?

10 THE WITNESS: I think that in some cases,
11 that's probably true. One of the things that after the
12 accident in Pittsburgh everybody began to look and had
13 some concern surrounding the 73. And as the education
14 came out and the people and USAir put out a lot of
15 information saying that if there is anything unusual in
16 roll or whatever, to make sure that you go ahead and
17 get reports, and that way that the diagnostics could be
18 applied to it.

19 So what we found pretty quickly was that
20 reports that two years ago would have been written off
21 as well that was probably a wake turbulence encounter,
22 now generated paperwork and became the -- the term as
23 uncommanded roll event. So I think some of them are
24 maybe wake encounters. But some of them, based on the

1 information that I've got, I don't think are.

2 So I think that we've got a very sensitive
3 pilot group that are reporting events in an effort to
4 try to do what they can to assist this investigation
5 and also the issue of the 737 uncommanded roll events.

6 MR. JACKY: But you haven't had one of these
7 blue water or uncommanded roll events while you were
8 flying the airplane?

9 THE WITNESS: The airplane is a -- the
10 airplane has an FMC in it, that the airplane spends
11 quite a bit of time flying in. So I've had the auto
12 pilot do things to me that I didn't expect. And
13 oftentimes, you write that off to you -- or lateral
14 navigation, making adjustments.

15 So if you want to characterize that as
16 uncommanded roll, I've seen it, because I've had the
17 airplane surprise me when it rolled in an area that I
18 didn't initially expect it to. But with the amount of
19 experience that our 737 crews have, you rapidly learn
20 what's FMC induced. And if you -- as you watch the
21 airplane, it will settle down and go on about its way.

22 So in that respect, I've had the airplane do
23 it. But as far as anything of significant magnitude,
24 no sir.

1 MR. JACKY: You were talking about some of
2 the wake encounters that you had while acting as line
3 pilot. Were you hand flying the airplane any time
4 during these encounters?

5 THE WITNESS: I've had them with the auto
6 pilot on and when I've been hand flying.

7 MR. JACKY: And when you've had these wake
8 encounters, have there been any times that you have
9 been startled or surprised?

10 THE WITNESS: In a line operation, you never
11 know they're coming. So as far as -- I don't know if
12 it's surprise, because it rapidly goes to identifying
13 what it is and going on. You have no idea that it's
14 coming and it startled the turn that -- it doesn't
15 cause a reflex action or grave concern, but it's
16 unexpected. I guess, is a better term for it.

17 MR. JACKY: During any of the wake encounters
18 you've had while line flying or during the flight tests
19 in Atlantic City, did you have any encounters that you
20 thought were disorienting?

21 THE WITNESS: No, sir. As a matter of fact,
22 one of the things when we're flying and the tests in
23 Atlantic City, when you flew into the core, you lost
24 all outside visual reference. So you would transition

1 from flying the airplane visually to having to fly it
2 by instruments and then back visually again.

3 There was clearly no disorienting cues to me
4 at all in regard to which way the airplane wanted to
5 roll or what control should be applied to counter that
6 roll.

7 MR. JACKY: A a line pilot, have you had any
8 sort of training as far as wake vortices, both
9 encounter and recovery from?

10 THE WITNESS: No, sir. As I say, they're
11 pretty common. It's something you learn early in your
12 flight training experience. So, I mean, you deal with
13 it as a student pilot forward. So particularly with a
14 jet transport airplane, the experiences is clearly all
15 you need.

16 MR. JACKY: Did you see anything either of
17 the two flight tests that would, you believe, help
18 train or help better train pilots?

19 THE WITNESS: I'm very hopeful that the tests
20 will help rewrite some of the books on wake vortices
21 and how pilots are trained with them, because I think
22 that there's a lot of information. They are not, as
23 Mr. Carriker made reference to, the steady state 300
24 feet a minute diverging cores in the sky that he

1 described quite accurately. And that's what's in the
2 book. They are not that.

3 They move both horizontally and vertically.
4 They'll come together. They'll burst open. They will
5 snake, for lack of a better term, both -- particularly
6 vertically. And at one point, we had the opportunity
7 to have the FAA 727 fly over in Atlantic City and you
8 could actually hear them. We were out near the runway.

9 And you hear the vortices as they blew over towards
10 us. There's quite a bit of energy there. And I think
11 that if those videos can be brought forward,
12 particularly for pilots of light aircraft, that they
13 need to be respected, particularly in a small airplane.

14 But I think that there's a lot of education and a lot
15 of research that I hope NASA and others will do.

16 MR. JACKY: Would you be able to characterize
17 any sort of difference in the way that the 300 would
18 react to a wake encounter as opposed to a 400? Are
19 there any differences?

20 THE WITNESS: Probably not. The airplanes
21 fly very, very similarly. Probably not. I don't know
22 that I could characterize the two as having any
23 difference.

24 MR. JACKY: Would you say that the airplane

1 that was used for the purposes of flight tests had more
2 rudder used on it over a shorter period of time than
3 any average airplane in the USAir flight?

4 THE WITNESS: In flight, yes, sir. Now,
5 maneuvering the airplane around on the ground,
6 particularly before flight -- every flight, the
7 controls get a full lock-to-lock control check prior to
8 flight, and that's done before every leg. And an
9 average 737 probably makes in the neighborhood of six
10 legs, maybe seven a day.

11 So the controls get a pretty good full
12 deflection workout. But in flight, you don't use that
13 amount of rudder.

14 MR. JACKY: During the flight tests, did you
15 see anything that would lead you to believe that any of
16 your training simulators needed to be changed?

17 THE WITNESS: The simulators pretty closely
18 represent the airplane. I did notice and as has been
19 previously stated here, I did notice that the aircraft
20 has what I'll call a higher cross-over speed than
21 demonstrated in the simulator. So in that one area, in
22 my opinion, there could be some modification made to
23 more accurately represent the airplane.

24 Also, from what I understand that Boeing has

1 made that adjustment in the M-CAB. I would certainly
2 hope that they would get that correction out to the
3 industry.

4 MR. JACKY: Did you get a chance to fly
5 through the vortices as modeled on the M-CAB?

6 THE WITNESS: No, sir.

7 MR. JACKY: I believe I have no further
8 questions.

9 CHAIRMAN HALL: Other members of the
10 Technical Panel? Mr. Haueter?

11 MR. HAUETER: Just a couple here quickly.
12 You mentioned that flying in the east coast, the number
13 of flights you do, that you're fairly used to vortex
14 encounters.

15 THE WITNESS: We see a lot of them.

16 MR. HAUETER: Would you think that experience
17 would cause you to delay getting on the controls?

18 THE WITNESS: No, sir. It's virtually
19 instinctive. When the airplane starts to move and do
20 something you didn't want it to do or expect it to do,
21 you're on the controls quite quickly, and it's
22 instinctive.

23 MR. HAUETER: On the steady heading side slip
24 data and the cross-over point, as an average pilot, if

1 you hit a dynamic rudder input, do you think you could
2 -- based on, well, I guess prior experience, recover
3 the aircraft?

4 THE WITNESS: I think it would very much
5 depend on where you got it. At the higher speeds, if
6 you're well above a cross-over point, I think the
7 airplane -- you could probably control it. I think if
8 you were right at that speed or below it, I'm not as
9 nearly as confident or even sure that that's possible.

10 The airplane roll rate, it appeared to me,
11 seemed to be significant. As the roll in degrees, the
12 bank angle would increase, the problems would get
13 worse. As the airplane would have more and more
14 difficulty holding altitude and it resulted lift loss
15 and so forth. So things would deteriorate quite
16 quickly from a flight crew perspective.

17 MR. HAUETER: Do you believe your training to
18 date would prepare you for such an event?

19 THE WITNESS: Here again, if this happened at
20 250 knots, I think that it would be a very bad roll
21 rate. It would be very uncomfortable. We would
22 stabilize the airplane and look at each other and try
23 to figure out what we're going to do next to try get
24 the thing on the ground or how we could resolve it

1 after we diagnosed it.

2 If you were at cross-over speed or below, I
3 think the problem solving window would be pretty short,
4 and I don't know that you could get to satisfactory
5 answer before you would run out of time.

6 MR. HAUETER: Do you have aerobatics training
7 in your background?

8 THE WITNESS: I have a limited amount
9 aerobatics's training. Primarily when I was doing work
10 on my commercial license, there was an aerobatics -- a
11 limited amount of aerobatics there, but it's too many
12 years ago. We're talking quite a few years.

13 MR. HAUETER: Based on your experiences on
14 this test and working on the investigation, do you
15 believe there should be more unusual attitude training
16 to look in areas like this?

17 THE WITNESS: Training is something the
18 pilots are always thinking you should get more, because
19 you can never have enough. In this particular area, I
20 think that it will provide some help in certain areas,
21 but I'm not sure -- I think it needs to be very
22 carefully crafted.

23 I've been through the United Airlines unusual
24 attitude training. And I think that it has some merit

1 in some areas. But in the case we're talking about
2 here with a deflected flight control and not having
3 full authority on all three axis of flight, I think
4 you've got apples and oranges.

5 MR. HAUETER: One last question, have you
6 ever had a yaw damper failure in any of your flights or
7 went hardover?

8 THE WITNESS: I've had a yaw damper, but it
9 was passive.

10 MR. HAUETER: How was that?

11 THE WITNESS: It just ceased to function.

12 MR. HAUETER: Okay. It didn't increase.

13 THE WITNESS: It didn't hardover. It just
14 ceased the function.

15 MR. HAUETER: Thank you very much.

16 THE WITNESS: Yes, sir.

17 CHAIRMAN HALL: Questions from the parties?
18 I see the Boeing Commercial Airplane Group, the Airline
19 Pilots Association. Anyone else? If not, the Boeing
20 Commercial Airplane Group, Mr. Purvis.

21 MR. PURVIS: Thank you, Mr. Chairman. Good
22 afternoon -- good evening, Mr. Cox -- Captain Cox.
23 Sorry.

24 THE WITNESS: Good evening, Mr. Purvis.

1 MR. PURVIS: You were just talking about your
2 feeling on crews getting unusual attitude training.
3 Some of these courses are now being offered by United
4 and others. And I think you said you had taken the
5 United course. Is that correct?

6 THE WITNESS: Yes, sir. I was invited at
7 United to evaluate the course.

8 MR. PURVIS: Do you know in that course why
9 United and the other airlines are providing training
10 that shows or demonstrates how to respond to an upset,
11 especially from a wake vortex?

12 THE WITNESS: I wasn't aware that it was
13 specifically for a wake vortex. That's certainly not
14 anything that I saw. There were specifically designed
15 flight maneuvers that I would characterize as expanded
16 from what we normally see in line operations. But they
17 were expanded in a variety of areas. For example, we
18 did full stall in the simulator. We don't see that in
19 the line operation. But there was nothing specifically
20 geared for a wake vortex encounter.

21 MR. PURVIS: Do you personally believe that
22 it's a good idea to collect and study crew's responses
23 to -- and I'll use your word -- unexpected upsets,
24 including wake turbulence upsets or wake vortex upset?

1 THE WITNESS: I would -- anything that
2 regards study of flight crew performance in pretty much
3 any arena, fatigue for being one, startled, as you
4 characterized it, would be another. I mean, there's a
5 multitude of research that I would like to see done for
6 flight crews in an effort to generally improve and
7 better understand the working environment where I work.

8 MR. PURVIS: That would include then upsets?

9 THE WITNESS: Yes, sir.

10 MR. PURVIS: Have you personally evaluated
11 crew's reported reaction in which unsuspecting crews
12 were startled by wake encounters?

13 THE WITNESS: I'm sorry. Could you rephrase
14 it? I'm not sure I understand what you're asking mean.

15 MR. PURVIS: In your work or in part of the
16 accident investigation that you've participated in,
17 have you been able to evaluate crew reports where there
18 were reported reactions from the crew in which the crew
19 was startled by wake encounters, by an unsuspecting
20 crew, in particular?

21 THE WITNESS: I think your question is have I
22 interviewed and evaluated crews that have unexpectedly
23 encountered a wake vortex and evaluated the actions of
24 that.

1 MR. PURVIS: Either crew interviews or crew
2 reports?

3 THE WITNESS: Yes, sir, I had done that. And
4 what I have found that typically the responses are --
5 the trend of responses is correct. The magnitude that
6 they report is sometimes amplified. But in general, if
7 for example, they say the airplane rolled right, and
8 when you look, the airplane rolled right. So as I say,
9 the trend of information is correct. I have seen, on
10 occasions, sometimes when the magnitude has been
11 amplified a bit.

12 MR. PURVIS: In the reports?

13 THE WITNESS: Yes, sir.

14 MR. PURVIS: During your just concluded
15 testimony, you said that you would get right on the
16 controls during a wake encounter?

17 THE WITNESS: Yes, sir.

18 MR. PURVIS: What sort of a delay would you
19 consider to be normal?

20 THE WITNESS: I don't know that I can
21 characterize that, because, as I say, it's virtually
22 instinctive. When the airplane starts to move in an
23 area in a way that either myself or the first officer
24 didn't command, you get right on it. It's instinctive.

1 You reach for the airplane to find out what's going
2 on.

3 MR. PURVIS: So, no delay?

4 THE WITNESS: I don't know. We're all human.
5 There is a delay involved, but it would be in my
6 estimation, quite short.

7 MR. PURVIS: Thank you. That's all the test
8 -- or all the questions I have.

9 CHAIRMAN HALL: Thank you, Mr. Purvis.
10 Captain.

11 CAPTAIN LeGROW: Thank you, Mr. Chairman.
12 Good evening, Captain Cox.

13 THE WITNESS: Good evening.

14 CAPTAIN LeGROW: You testified that you're a
15 captain with USAir. However, you represent the Airline
16 Pilots Association in this accident. Could you explain
17 to us the position you hold with the Airline Pilots
18 Association?

19 THE WITNESS: Yes, sir. I am the chairman of
20 the Central Safety Committee at USAir, which is the top
21 level at USAir of a group of pilot volunteers that deal
22 with safety issues from the line. So I've become a
23 focal point for the flow of information, safety
24 information and concerns that the pilots would bring

1 forward.

2 I interface with the company safety office on
3 a regular basis. In addition, I'm part of the accident
4 investigation team at USAir. And for ALPA National,
5 I'm the technical coordinator for the 737 airplane and
6 have been for about four years now.

7 CAPTAIN LeGROW: Thank you. Has the Airline
8 Pilots Association provided you with any training or
9 education in your endeavors?

10 THE WITNESS: Yes, sir. They initially sent
11 me to the ALPA Basic Accident School, which is a
12 requirement for participation in the ALPA accident
13 team. In addition, I've been to the University of
14 Southern California, through several courses there,
15 including their accident investigation course.

16 In addition, ALPA has also qualified me,
17 through the International Federation of Airline Pilots,
18 to assist and investigate accidents worldwide.

19 CAPTAIN LeGROW: Do you belong to any other
20 safety associations industry wide?

21 THE WITNESS: Yes, sir. I'm a member of the
22 International Association of Air Safety Investigators.

23 CAPTAIN LeGROW: You said that you interact
24 with the company in your duties with the Airline Pilots

1 Association. Exactly how does that interaction take
2 place and with whom do you interact?

3 THE WITNESS: I interact with probably my
4 counterpart, Captain George Snyder, who is the Director
5 of Corporate Safety, Quality Assurance. I also
6 frequently interact with General Armstrong, who is the
7 Vice President of Corporate Safety and Regulatory
8 Compliance. And also on operational issues, Captain
9 John Murphy, who is our Senior Director of Flight
10 Operations, and also with senior management from time
11 to time. It's a very close working relationship
12 between the airline pilots and USAir on safety issues.

13 It's a very open-door policy. So I interact
14 with an awful lot of people in a variety of departments
15 in dealing with safety issues. But it's a very open
16 exchange of information in both directions.

17 CAPTAIN LeGROW: Thank you. I believe that
18 Mr. Jacky asked you some questions about the Boeing
19 Airliner article that was offered as an exhibit. And
20 you said that ALPA and the company write articles. Do
21 you personally or have you personally written articles
22 to be distributed to the pilots of USAir?

23 THE WITNESS: Yes, sir. I generally produce
24 one article a month for the ALPA publication on some

1 issue of safety. And over the course of this 14 month
2 investigation, I have had several articles on the 737
3 and the progress of this investigation.

4 CAPTAIN LeGROW: On your duties on the wake
5 vortices tests, how many of the test flights did you
6 actually participate on either airplane?

7 THE WITNESS: I believe there were eight test
8 flights total. I was on six of them. There were two
9 flights in Atlantic City. There were only two flights
10 in Atlantic City that I was not on the airplane.

11 CAPTAIN LeGROW: How would you characterize -
12 - and I think this question was asked before, but I
13 really wasn't sure of the answer. But how would you
14 characterize those wake vortices events or how did you
15 characterize them?

16 THE WITNESS: They were about what I had
17 expected based on my experience from line operations.
18 It was something that a line pilot sees on a relatively
19 normal basis. And the magnitude was consistent with my
20 experience.

21 CAPTAIN LeGROW: On a normal month of flying,
22 how many hours is a line pilot flying?

23 THE WITNESS: Block hours, we're actually
24 away from the gate probably in the neighborhood of 70.

1 CAPTAIN LeGROW: In that 70 hours a month,
2 how many, on the average -- how many times would the
3 average, average pilot anticipate encountering a wake
4 vortices?

5 THE WITNESS: It's easier for me to
6 characterize it sort of by trip, because it's the way
7 you tend to remember things. I would expect one any
8 where between two or three times on a three or four day
9 trip to come across some form of a wake vortex going in
10 and out, as I say. It's more often in and out of the
11 high density airports. You know, Boston, New York,
12 Pittsburgh.

13 CAPTAIN LeGROW: In your 25 year career,
14 Captain Cox, have you ever encountered a wake vortices
15 under normal line operation that would be in the
16 vicinity of 60 or more degree bank?

17 THE WITNESS: No, sir, I have not. Not
18 anywhere close.

19 CAPTAIN LeGROW: Mr. Purvis asked you some
20 questions on the interviewing of some pilots. Could
21 you elaborate a little bit on exactly how that takes
22 place? Is that with your duties as the accident
23 investigator on this accident or as your duties as
24 Central Safety Chairman?

1 THE WITNESS: It's been as my duty as Central
2 Safety Chairman. It is -- it's not at all unusual if a
3 pilot has an event that in addition to contacting the
4 company, that he will call ALPA safety. So we get a
5 pretty early contact with the flight crew members.
6 It's a good exchange. It's very low key. So we get a
7 lot of information that we can then assemble and help
8 in determining what actually went on on that flight.

9 So it's very routine. It's something I've
10 been doing for seven or eight years now.

11 CAPTAIN LeGROW: Thank you, Mr. Chairman. I
12 have no further questions.

13 CHAIRMAN HALL: Thank you, Captain. Any
14 other questions from the parties?

15 (No response.)

16 CHAIRMAN HALL: Seeing none, we'll move to
17 Mr. Clark.

18 MR. CLARK: Captain Cox, with the experience
19 that you've had in the wake vortex flight testing, do
20 you think the separation standards in existence are
21 adequate for a 73 behind a 727?

22 THE WITNESS: Yes, sir, I do. As was
23 characterized by Mr. Carriker, I found the difference
24 in magnitude not real discernable between two miles and

1 three miles or between three and four, but between four
2 and two, you could tell it. So I think however the
3 number of three miles came up, that it's probably a
4 pretty good standard.

5 MR. CLARK: You said that in a one-week
6 period, you may encounter vortices three to four times?

7 THE WITNESS: On a three or four-day trip,
8 that's what I would characterize as an average trip.

9 MR. CLARK: What would be the nature of the
10 encounter, what kind of airplane typically would you be
11 following?

12 THE WITNESS: It could be anything. Where we
13 operated. It could be anything from a 747 to a leer
14 jet.

15 MR. CLARK: So in these three to four
16 encounters a week, does it seem reasonable that those
17 three or four times, you're operating at 300 or 400
18 feet below the flight path of the airplane ahead of
19 you?

20 THE WITNESS: It would depend -- I mean,
21 because oftentimes for example -- let me give you an
22 example of New York. If we're landing in LaGuardia,
23 there is a departure path from Kennedy. So you have
24 airplanes crossing in a variety of directions and

1 different altitudes.

2 So it's hard for me to characterize being
3 exactly 300 feet below, because it's a pretty dynamic
4 environment with the airplanes both descending and
5 climbing at pretty good rates.

6 MR. CLARK: But your understanding of the
7 motions of the wake vortex and what you saw at Atlantic
8 City indicate that the vortices descend.

9 THE WITNESS: They do descend, yes, sir.
10 Once they descend, though, if there's any kind of
11 atmospheric heating, they snake pretty well, and that
12 can be -- I don't know -- probably 50, 60, maybe a 100
13 feet. I don't know. It's hard for me to gage the
14 magnitude of that snaking, but it was quite noticeable.

15 So maybe 200 feet under certain conditions
16 and 400 feet others, they move.

17 MR. CLARK: So basically then if the FAA is
18 operating on the premise that the flight path for all
19 of these airplanes have to be equal or at least the
20 trailing airplane should be at a higher flight path,
21 then says operationally that three to four times a
22 week, at least hit the vortices, the trailing airplane
23 is below the flight path of the preceding airplane.

24 THE WITNESS: A preceding airplane, I don't

1 know that it would be necessarily the one directly in
2 front of you. Another airplane would be a better
3 characterization of it.

4 MR. CLARK: Okay. Do you believe this
5 encounter three to four times a week is typical of all
6 of your counterparts?

7 THE WITNESS: Yes, sir, I would think it
8 would be representative.

9 MR. CLARK: Mr. Jacky asked about flying at
10 190 knots and flaps one, asked if you would typically
11 use the rudder in that environment, and I believe you
12 said no.

13 THE WITNESS: No, sir.

14 MR. CLARK: Do you -- where would your feet
15 be? On the floor or on the pedal?

16 THE WITNESS: It would depend. If I'm hand
17 flying the airplane, I'll normally have my feet up on
18 the rudder. If the auto pilot wants -- once I've
19 engaged the auto pilot and assured it has engaged
20 correctly and is not going to present a problem and it
21 virtually never does, then I'll fly with my feet on the
22 floor.

23 MR. CLARK: In your line operation, you said
24 you've hit these vortices. I assume you've had some

1 pretty good jolts?

2 THE WITNESS: Yes, sir.

3 MR. CLARK: In any of those did you use the
4 rudder while you were flying?

5 THE WITNESS: I don't ever remember coming up
6 on a case where I've needed it. With swept wing jet
7 airplanes in that sort of flight regime, I would apply
8 a controlled wheel and if I wasn't getting a result
9 that I was comfortable with or felt that I needed more
10 roll, I would add rudder then. But it would be a
11 stepped process, first control wheel, trying to get the
12 airplane aligned with wherever I wanted it and
13 illustratively wings level.

14 If the airplane wasn't going there, then I
15 would add rudder in an effort to increase the rolling
16 moment to oppose whatever roll of force was applied to
17 the airplane.

18 MR. CLARK: Is the type of rudder you would
19 input, would that be consistent with the phrase of
20 stepping on the top rudder, top pedal?

21 THE WITNESS: I would be countering the
22 direction of roll, both with control wheel and rudder,
23 in that case.

24 MR. CLARK: You talked about in the flight

1 control demonstration where you were using full rudder
2 input and slowed below 190 knots and then you had to
3 increase several knots above that to effect a recovery.

4 Was that type of action intuitive in your estimation?

5 THE WITNESS: It was in a test regime. So we
6 were very -- trying to carefully record those
7 parameters. So instinctive in that environment, no,
8 sir, because we were trying to do everything very
9 deliberately in a research effort.

10 MR. CLARK: You talked about your encounters
11 in the vortex flight test. I think basically you said
12 there was nothing disorienting about the event. I
13 believe you also participated in the M-CAB events in
14 the VMS simulator.

15 THE WITNESS: Yes, sir. That's correct.

16 MR. CLARK: Was there any disorienting
17 effects in those?

18 THE WITNESS: No, absolutely not. That's --
19 the cues were very clear to me about which way the
20 airplane was trying to roll. And that's true of the M-
21 CAB, the vertical motion simulator at NASA-Ames and in
22 the flight tests. The cues were very clear.

23 MR. CLARK: What was the most powerful cue
24 available to you?

1 THE WITNESS: Roll rate. And it's
2 instantaneous -- it's simultaneous. There's the visual
3 recognition of roll and then there's the lateral g feel
4 as the airplane starts to roll and they come together.
5 So I don't know that I can separate them.

6 MR. CLARK: Now, you commented about it
7 surprised you that the cross-over speed was 190 knots
8 and that you had not seen that in the simulator
9 environment. My question is is that typically
10 demonstrated for a line pilot operation, a line pilot -
11 -

12 THE WITNESS: No, sir.

13 MR. CLARK: So all of this was a result of
14 the investigative process you were involved with --

15 THE WITNESS: Right, the flight test.

16 MR. CLARK: -- rather than anything going on
17 in training today.

18 THE WITNESS: Right.

19 MR. CLARK: The typical line pilot would have
20 no idea what the cross-over point is?

21 THE WITNESS: Before starting this test, Mr.
22 Clark, I had no idea what the cross-over points were.

23 MR. CLARK: Thank you.

24 THE WITNESS: Yes, sir.

1 CHAIRMAN HALL: Mr. Marx?

2 MR. MARX: No questions.

3 CHAIRMAN HALL: Mr. Schleede?

4 MR. SCHLEEDE: Yes, one question. It might
5 have been asked. During these encounters and on the
6 line, have you ever noticed the thumps that we've heard
7 referred to?

8 THE WITNESS: No, sir. The first time I had
9 -- that I remember hearing the thumps was in the flight
10 test, but you only hear them when you're virtually
11 aligned with the vortex itself so that your entry angle
12 is very low. You're almost parallel, I guess, and you
13 hear it then. That's a bit unusual. It's my
14 impression, it's a bit unusual to hit that close or
15 that low an entry angle in normal line operations.

16 You almost are sliding in there slowly,
17 intentionally.

18 MR. SCHLEEDE: So you've never heard them on
19 the line?

20 THE WITNESS: No, sir, I have not.

21 MR. SCHLEEDE: During the wake tests, did you
22 notice what Mr. Carriker mentioned about the wipers
23 jumping?

24 THE WITNESS: Yes, sir, I saw that.

1 MR. SCHLEEDE: You did. Did you hear it?

2 THE WITNESS: I don't remember hearing it as
3 much. Mr. Carriker commented. We talked about that a
4 little bit, but I don't recall -- I don't have personal
5 recollection of it.

6 MR. SCHLEEDE: Have you heard the voice
7 recorder on the 427?

8 THE WITNESS: Yes, sir.

9 MR. SCHLEEDE: Thank you very much.

10 CHAIRMAN HALL: Mr. Laynor?

11 MR. LAYNOR: No questions.

12 CHAIRMAN HALL: Well, Captain, first let me
13 thank you on behalf of the board for the excellent way
14 in which you represent not only USAir, but the Airlines
15 Pilot Association. Your participation in this
16 investigation has just as Mr. Carriker, and I think
17 anyone here would, I would think, be very impressed
18 with the level of experience and expertise that you all
19 are bringing in assisting us with this investigation.

20 I want to thank you. I'm going to ask you
21 the same question I asked Mr. Carriker. Do you think
22 this taxpayer dollars we spent to do this test was
23 worthwhile?

24 THE WITNESS: Yes, sir, I do. Initially

1 going in, I was unclear about how much results we could
2 really expect. In the end, the tests exceeded my
3 expectations significantly. I not only think that it
4 was -- we got our money's worth, I think we actually
5 got a bargain.

6 CHAIRMAN HALL: Thank you. Were you in the
7 part of the flight crew when you got the 60 degrees?

8 THE WITNESS: Yes, sir, I was.

9 CHAIRMAN HALL: Was that by turning into the
10 vortex and it was descending? Is that what I
11 understand?

12 THE WITNESS: Yes. Well, we did several of
13 those. When you set the airplane up where it drifts in
14 and we caught it just right, you could get that kind of
15 result, assuming that we made no intervention at all
16 and we just let the airplane rescind as it would with
17 no pilot input. As I said, literally, we had our feet
18 flat on the floor and our hands straight up to assure
19 the engineers that we weren't in some way affecting the
20 airplane. So it was what -- it's termed a free
21 response.

22 CHAIRMAN HALL: Did we recreate that type of
23 upset, if that's the proper word, with the vertical
24 motion simulator?

1 THE WITNESS: No, sir, we did not.

2 CHAIRMAN HALL: What was the -- well, what
3 was the worst angle we went on that?

4 MR. JACKY: The information that was used in
5 the vertical motion simulator was from the flight data
6 recorder.

7 CHAIRMAN HALL: At Pittsburgh?

8 MR. JACKY: Yes.

9 CHAIRMAN HALL: A similar profile. Are we
10 going to be reprogramming that, as well, or are we just
11 going to reprogram the 737, the engineering simulator?

12 MR. JACKY: At the present time, we plan to
13 model both or resimulate the wake vortices themselves,
14 as well as the 37, but on the Boeing engineering
15 simulator.

16 CHAIRMAN HALL: Captain, let me ask you a
17 question, because you represent a very important
18 population of people. Every party to this
19 investigation is important. But you represent the
20 individuals responsible for flying this plane. Is
21 there any information that you're aware of that has
22 been withheld by any of the parties to this
23 investigation that this Chairman and this Board of
24 Inquiry should know about?

1 THE WITNESS: No, sir. Absolutely on the
2 contrary. It has been my experience with this
3 investigation that the flow of information between the
4 parties and between the board -- to the board and back
5 from the board has exceeded that of anything that I
6 have ever seen before.

7 As the process has gone on month after month,
8 the dedication and the commitment to solve this
9 accident has been quite apparent in the willingness of
10 all the parties to share information and work in a
11 cooperative manner. So quite the contrary, sir.

12 CHAIRMAN HALL: Well, I'm pleased to hear
13 that, because I'm aware that there is concern in the
14 pilot community. And I want the pilot community, as
15 well as the American public, to know that we're doing
16 everything we can in this investigation.

17 THE WITNESS: The --

18 CHAIRMAN HALL: On that -- I'm sorry.

19 THE WITNESS: Well, I was only -- as I
20 mentioned earlier, I write an article on a monthly
21 basis. And that I have attempted, and I think to some
22 degree successfully, to convey that message to the
23 pilots at USAir and also across the seven carriers that
24 are represented by the Airline Pilots Association, that

1 the level of cooperation in this investigation is
2 unprecedented, I think.

3 CHAIRMAN HALL: Well, let me ask you then
4 finally the same question I've asked a number of
5 witnesses, intended to ask them all. And that is, is
6 there anything in this investigation that you think we
7 should be doing that we're not doing?

8 THE WITNESS: As a member of an active group,
9 the systems group is still quite active and under the
10 leadership of Mr. Phillips. We are -- we've got the
11 methodology in place to continue to evaluate the next
12 step in this investigation. I think the process is
13 fundamentally sound. I think it has proved itself over
14 a difficult 14 month period, and I think that we're on
15 the right track, particularly within the systems group.

16 That's really all I can speak to from
17 personal experience.

18 CHAIRMAN HALL: Well, I appreciate your
19 testimony. Mr. Haueter is putting together another "to
20 do" list. Tomorrow before we finish, we want to get --
21 if you can have a copy of that, like you did in
22 Pittsburgh, with our to do list printed up, then we
23 would like to follow that.

24 Captain, thank you very much. For an average

1 pilot, you certainly do well.

2 (General laughter.)

3 CHAIRMAN HALL: I feel a lot better flying
4 back and forth to Chattanooga now that I've met a USAir
5 average pilot.

6 THE WITNESS: Thank you.

7 CHAIRMAN HALL: Well, thank you. Thank you
8 very much for your testimony.

9 (Witness excused.)

10 CHAIRMAN HALL: We have three witnesses left
11 to cover. What the Chairman would propose and I would
12 appreciate it if any of the parties or the audience if
13 there are people that have an interest in these
14 hearings and have left, if you would please try to let
15 them know that in the morning, we will begin at 8:30
16 rather than at 9:00, to see if we can't -- we have some
17 long-winded fellows from Boeing, I think, to get
18 through --

19 (General laughter.)

20 CHAIRMAN HALL: -- but hopefully we can get
21 through by lunchtime. I know some people have planes
22 and things to catch, but we'll start promptly in the
23 morning at 8:30 and hear our last three witnesses.

24 (Whereupon, at 8:00 p.m., the hearing was

1 adjourned. To be reconvened on Friday, November 17,
2 1995, at 8:30 a.m.)

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