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NATIONAL TRANSPORTATION SAFETY BOARD

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APPEARANCES:

Members of the Board:

CAROL CARMODY, Acting Chairman
JOHN J. GOGLIA
JOHN HAMMERSCHMIDT
GEORGE W. BLACK

National Transportation Safety Board Technical Panel:

STEVE MAGLADRY
JOHN CLARK
JOHN O'CALLAGHAN
CAPT. DAVE IVEY
DR. MALCOLM BRENNER
ROBERT BENZON
LORENDA WARD, Hearing Officer

On behalf of American Airlines, Inc.:

CAPT. ROBERT AHEARN

On behalf of the Allied Pilots Association:

CAPT. DONALD W. PITTS

On behalf of Airbus:

DR. JOHN LAUBER

APPEARANCES: (Continued)

On behalf of the Federal Aviation Administration:

HAROLD DONNER

On behalf of the Bureau D'Enquetes et D'Analyses pour la Securite de L'Aviation Civile (BEA):

PIERRE JOUNIAUX

WITNESS SCHEDULE

NUMBER	NAME AND AFFILIATION
4 & 5	Captain Delvin Young A300 Fleet Standards Manager Mr. Asok Ghoshal Manager Simulator Engineering American Airlines
6	Captain Armand Jacob Experimental Test Pilot Engineering, Flight Operations Airbus
7	Dr. Fred Proctor Research Meteorologist Flight Dynamics and Control Division NASA
8, 9, 10, 11	Mr. Robert Jones Aerospace Engineer Mr. Don Stimson Aerospace Engineer Mr. Loran Haworth Human Factors Specialist Mr. Guy Thiel Flight test pilot FAA Transport Airplane Directorate FAA
12, 13	Mr. John Howford Chief Scientific and Tech Advisor Flight Loads and Aeroplasticity Mr. Henry Offerman II Aerospace engineer, Airframe FAA

W I T N E S S E S

E X H I B I T S

P R O C E E D I N G S

8:06 a.m.

CHAIRMAN CARMODY: I'd like to get started. Good morning. I'd like to resume the hearing. It's a few minutes after eight. Ms. Ward, would you call the next witness, that would be the fourth witness, please? Fourth and fifth I believe.

MS. WARD: Thank you Madam Chairman, I'd like to call Captain Delvin Young and Mr. Asok Ghoshal.

Whereupon,

CAPTAIN DELVIN YOUNG

and

MR. ASOK GHOSHAL

were called as a witnesses, and first having been duly sworn, were examined and testified as follows:

QUESTIONING OF CAPTAIN YOUNG

BY MS. WARD:

Q Please have a seat. Captain Young, can you please state your full name, your current employer, and your business address?

A My full name is Delvin Young. My current employer is American Airlines, from DFW Airport, Texas.

Q Could you state your current position and how long you've been in that position?

A My current position is Fleet Standards

Manager for the A300, and I've been there since July of 2002.

Q And what are your current duties and responsibilities, and the education and training that you may have received to qualify for that position?

A My duties and responsibilities involve oversight of training programs as well as standardization of those training programs, standardization of line pilots, as well as responsible -- sharing in responsibilities for revisions and updates and currency of flight manuals. And in the past year it's also been sharing in the responsibility of the accident investigation of Flight 587.

Q Did you also list under FAA certificate that you have, flight time, and the aircraft that you've flown?

A Yes, ma'am. I have flight time in everything from single engine propeller aircraft -- civilian, to multi-engine civilian aircraft including turbo-prop aircraft with commuter airlines. I have over 2000 hours of fighter time in the military and I was hired by American Airlines in 1986 and have flight time on the Boeing 727, the McDonnell Douglas DC-9 Super 80, and the Boeing 7576, The Fokker F-100, and Airbus A300, and I am rated on the Airbus A310, which is the A300 rating.

Q Thank you, Captain Young.

QUESTIONING OF ASOK GHOSHAL

BY MS. WARD:

Q Mr. Ghoshal, would you please state your full name, your current employer, and your business address?

A My full name is Asok Ghoshal. My current employer is American Airlines, and my address is American Airlines Flight Academy, DFW Airport.

Q What is your current position and how long you've been in that position?

A My current position is Manager Simulator Engineering, and I have been in this position since 1992.

Q And what are your duties and responsibilities, and the education and training that you may have received to qualify you for your position?

A I received my Bachelor's Degree in Aeronautical Engineering in 1971 from India Institute of Technology, Karapool (ph) India. I then worked for two years in the aerodynamics department in Indian Space Research Organization. Indian Space Research Organization is somewhat like India's NASA. I came to England, got my Master's Degree in Air Transport Engineering from College of Aeronautics Granfield in

1974. I joined Link Miles, the manufacturer of flight simulators. I was an engineer in the systems engineering group for flight systems, while my duties and responsibilities included analyzing the data that came from the aircraft manufacturers, writing mathematical models, and in programming them for real time flight simulation.

In '79 I came to Link headquarters in Binghampton, New York. When I left Link in 1990 I was a manager of the flight group, responsible for flight, autoflight, and control loading simulations for all our commercial simulators. There were 34 engineers in my group that time.

I joined American Airlines in 1990 as a senior simulator engineer. In '92 I got promoted to my present position. In American, our duties are to insure that the simulators stay current with all the changes that happen in the aircraft, both hardware and software. We also assist simulator technicians as and when they need added expertise in maintaining flight simulators. I also am responsible for procurement of any new flight simulator that American Airlines purchases. I am also a member of the flight simulator working group of IATA.

Q Thank you, Mr. Ghoshal.

MS. WARD: Madam Chairman, I find these witnesses qualified and go ahead and turn this over by Captain Dave Ivey for questioning.

QUESTIONING OF CAPTAIN YOUNG

BY CAPTAIN IVEY:

Q Good morning, Captain Young and Mr. Ghoshal. My questioning will start with Captain Young, and just as a follow on to Ms. Wards' comments, prior to becoming the A-300 Fleet Training Manager, what was your position?

A Well, I'm currently the Fleet Standards Manager for the A300, and prior to that I was the F-100 and A300 Fleet Training Manager.

Q I misspoke. My apologies. And how long did you hold the Fleet Training Manager position?

A I was a Fleet Training Manager for slightly over two years, sir.

Q And you currently fly the A300 as well as the F-100?

A Yes, sir, I fly both aircraft currently.

Q It's my understanding that you have a presentation which basically follows along the first line of questioning, which I'd like for you to describe for me the evolution, development, and history of the advanced aircraft maneuvering program, known as AAMP.

A Yes, sir, Captain Ivey, with your permission, I'd like to go through that presentation.

Q That would be fine.

A Just a brief overview here and primarily will concentrate on the AAMP program, but American operates today about 819 aircraft of which 34 of those are A300 aircraft. We have slightly over 12,000 pilots currently -- at one time much greater than that.

When a pilot checks out on the A300 for the first time, they receive about 225 hours, just slightly more, of initial training, and then they come back every nine months for around 25 hours of training, of which some of that is ground school, some of it is simulators. The FAA, when we developed training programs -- the FAA requires that the manufacturer provide us with some information, and you can read those out of the Part 25 there, but our training programs are based, primarily, on that information, and we develop our own operating manuals from those flight manuals and operating manuals from the manufacturer. We depend on those to develop procedures and techniques to support those training programs.

The FAA approves our training programs and they're involved throughout the entire process. They monitor it on a regular basis, in fact go through training themselves with us, and they do that continuously.

The need for upset training, particularly as we talk about AAMP as we call that for African American, Advanced Aircraft Maneuvering Program -- the industry from '87 to '96, the loss of control was the leading cause of accidents, followed closely by control flight into terrain, and it was very significant. As the investigators, different agencies, and different groups looked at those accidents, they realized that some of those accidents could have been covered if the pilots had known better how to respond to those upsets.

So, over the years, the NTSB has issued multiple safety recommendations that talked about the lack of training in upset recovery should -- especially in transport category airplanes -- should the pilot find themselves there.

So in 1995, what initiated our AAMP program, or the AAMP as it's commonly called, the FAA issued a bulletin and it recommended that airlines develop training in excessive roll attitude as well as high pitch attitude. And the human factors team with the FAA, also in '96, issued a bulletin that stated that they thought that maneuvers, especially advanced maneuvers, should be integrated as part as -- integral part of training programs throughout. I will note, as we mentioned before, that we do depend on the manufacturer to provide us procedures and techniques in our operating manuals and things, and there was nothing provided as far as upsets goes, or procedures.

So the development of AAMP. We started it in 1995, and over the course of about two years, we developed it and we understood that there's a lot of expertise out there. We never once said that we were the experts in the industry, and so we tried to rely on that expertise to help develop this. We wanted to be the best program. The entire industry in 1995 was very concerned about loss of control. There had been some history of some large aircraft that had accidents, and so the industry was concerned, trying to address that.

We also found in our AAMP program, we looked into aerodynamic books, some of the widely, most recognized sources to build a foundation.

I don't like throwing out numbers, but American invested a great deal of money and effort and resources to develop this program, because it was an industry concern at the time, and we had -- by the time that we had rolled this program out, we had already spent over six million dollars presenting it to our own pilots, as well check airmen instructors from lots of different airlines operating around the world, as well as a lot of agencies.

When we rolled it out, the AAMP program included a full day of ground school training. We have six and a half hours there because by the time of breaks, and lunch, and this, that and the other, it ended up being actually six and a half hours of pure instruction, and then we included recurrent training also, and then we have some simulator exercises.

We also handed out at the presentation, or at the classroom, this -- this is the front cover of that AAMP book, and I think we saw it yesterday with mr. Hammerschmidt -- but we handed those out as a supplement, a place for someone to take notes as we were going through the program. It was never intended to be a stand alone document. It was just to take notes -- a place to take notes as we went through this full day course.

In 1997, after we had been developing it for a couple years, we had an industry conference in Dallas, and we invited over 200 people from around the aviation community, experts and those -- we did a two day session with them, and what we did was a full day of ground school, the same ground school that everyone had been receiving, and then we did a half a day of question and answer, and then a half a day in the simulator, demonstrating the exercises that we were conducting in the simulator.

At the industry conference, there's a -- a host of attendees there, and probably most notable was certainly the NTSB, the FAA, and the manufacturers -- Airbus, Boeing, and McDonnell Douglas, and other airlines. I will state that -- and a lot of these folks that were at the conference had already seen the presentation before, at least once, and many of them saw it afterwards too, and asked us for the presentations.

Some of the things that came out of that, some of the reviews -- I'll just -- overall reviews of the program has been overwhelming, positive. And it was an industry concern at the time, but one of the Board members for the NTSB thought it was "one of the best training experiences of any transportation mode I've ever attended". Another spokesperson for the NTSB said it was highly positive. The FAA applauded American for taking a leadership role in the Advanced Aircraft Maneuvering Program, and in fact one FAA individual, the air carrier training manager at the time, wanted to capture some of the material for an advisory circular. NASA thought it was an outstanding coverage from the pilot's point of view.

There's also many other airlines, and these are just a few of the examples of many of the things that we got. I think a notable one here was Avianca there at the bottom of the page was that a pilot claimed that it had helped him save his aircraft and crew, and it was right after this presentation when they had seen it, so -- The pilot's unions, APA as well as ALPA were very fond of the presentation and the course, and for American for taking the leadership role.

Now many of the airlines -- and it wasn't isolated to domestic airlines, it was also international carriers -- that had asked us for a program, and either utilized all or part of it to develop their training programs involved in upset. This wasn't just a domestic -- a US problem -- large aircraft upsets. Many airlines all over the world had experienced that.

The Flight Safety Foundation, in 2001, in November of 2001, had awarded Captain Warren Vandenberg -- Captain Vandenberg was responsible for oversight and developing the AAMP program, and he took a leadership role in that -- and the Flight Safety Foundation had recognized him in 2001 for his role in the development of AAMP. In that award it stated that five pilots had credited AAMP for saving their aircraft and passengers.

As we've looked yesterday and today, there was a lot of information put out about dates when and when we were doing things and who was doing what, when. And so I'll just highlight a couple here. We began development of AAMP in 1995. The industry training aid that you had heard about, started AAMP in 1996. We received final approval from the FAA for our AAMP program in August of 1997, and then the industry training aid was presented -- yesterday I think I heard August we had a letter that it was presented to us and sent to us in October of 1998. So those are probably the most notable dates. They're just kind of -- where the industry training aid as well as AAMP was kind of in development.

What is AAMP? And what AAMP was is it's advanced training for experienced aviators involved in upsets. AAMP was never a turbulence recovery training unless it ended up in an upset -- that's what we were specifically addressing there was upsets. Yesterday I think we heard the definition, as we talked about AAMP, but here's what the industry training aid says that an upset is. And as you can see, it's some extreme condition there, and not normal flight condition.

Most pilots won't ever encounter -- certainly at the airlines -- will never encounter an upset in their entire flying career, or we would not expect them to, anyway. And from everything that we've seen, Flight 587 was not in an upset until after the vertical stabilizer separated from the aircraft.

But we did talk about wake turbulence during the AAMP exercise and what did we say? We did recognize the fact, and so did the industry, that some situations involving wake turbulence could result in an upset. The data showed that between 1983 and 1993, that at least 51 accidents in the US and incidents, could be attributed to some encounter -- probably encounter with wake turbulence. So the FAA had issued a bulletin once again, in 1994, recommending that training programs incorporate heavy wake vortex awareness and containment into their programs.

This page right here is right out of that AAMP booklet that we talked about, the AAMP workbook, and as you notice kind of at the bottom of the page, it's got notes and that's the top half of the page. So the bottom was to take your own notes -- and this was more bullet statements and things -- that's what -- this supplement -- that this workbook was to be used for.

Now what we have here, and you can read the verbiage, but -- is a very, very large aircraft, MD-11 in this case in the picture, and a Fokker is what we represented there in the roll, that a short winged aircraft encountering a large aircraft wake turbulence might find itself in an upset. And how do we teach to respond to that?

Once again we're talking about very extreme conditions here, not just normal upset. Thousands of pilots all over the world every day fly and encounter wake turbulence, that's not what we're talking about. We're talking about a wake turbulence that results in some extreme condition and upset. And the airplanes that are really susceptible to that are airplanes with shorter wing spans.

At the time, over 50 percent of our fleet was comprised of McDonnell Douglas Super 80s as well as Fokkers and they have relatively short wing spans, and so they were susceptible, possibly, to an upset from an encounter with wake. We never thought that larger aircraft, at the time the DC-10, the MD-11, 757, 76, the A300, would end up in an upset just from a normal encounter with wake turbulence. Once again, we're talking about when it resulted in extreme things like i.e., 90 degrees of bank, once again, in an upset.

What we taught was that if you find yourself in an upset, apply the appropriate procedure -- the upset procedure. And the only time we really talked about using rudder was when we were using high AOA maneuvering, and I'm sure we'll get to that later in our questioning.

So what did we teach in AAMP about rudder? We taught that ailerons/spoilers are primary roll controls, and that's intuitive to every pilot from the beginning, when you first start flying. And I have a video here -- the significance of the video, and I think Mr. Brenner brought it out yesterday, that this film was actually filmed in 1997, in the March-April time frame of 1997. These are actual film clips from a class. We didn't have it set up in a studio. It was filmed in a classroom environment and there was somewhere over 200 students at the classes, and this is the actual presentation.

(Audio from video presentation:)

"The next thing then, says, roll. Well, since you've unloaded what are you going to roll with? Well, you're going to roll with ailerons and spoilers aren't you? The rudder won't roll this plane rolling on ... the back. Ailerons and spoilers roll it. 90 degrees of bank, nose low. Looks like this. Well, this is where the neutral part comes. Neutral. You're going to unload toward about zero G, "neutral". About zero G. Then, back to bullet one. Roll the shortest direction towards the sky pointer. What are we rolling with? We're rolling with yoke, with ailerons and spoilers because we have no alpha on this plane.

"And since we're rolling full forward on the yoke, we've actually got a negative alpha on this airplane right now, but that's what's going to roll the plane, it's going to be yoke. The ailerons and spoilers. So as we hold full forward, we roll the yoke, and which way? Back to bullet one, we roll towards the sky pointer. So we're rolling full forward, and we're rolling towards the sky pointer."

There was mention of the industry training aid yesterday, and so there's a slight comparison here. I wanted to compare the industry training aid with what we were teaching in AAMP, and they were basically in development about the same time, although AAMP was out in front, there was some crossover there. AAMP taught that the primary roll controls, which you just saw from the film clip, they're effectiveness decreased with increased angle of attack. And the industry training aid stated that ailerons and spoilers become less effective -- and talking about high angle of attack there.

We also stated that -- in AAMP -- that at high angles of tack, the rudder becomes an effective roll control, and the industry training aid talked about ailerons and spoilers, if they're ineffective, then rudder inputs may be required.

We also talked in AAMP that rudders should only be used in coordination with other roll controls, and you can see there that we had some cautions about it, that it must be applied smoothly, and that, once again, I have a video clip, and that's from 1997, as we stated, in a classroom environment.

(Audio from video presentation:)

"Bullet number four has a whole bunch of nuances in it. It says, 'As the aircraft symbol approaches the horizon' -- well, that's the issue we just talked about, you've got to lead the roll. You've got to lead the roll out in order to get the lift vector up in time. Then it says, 'Make a coordinated roll' -- and I have that word coordinated underlined, and the reason that I do is because I want to get it straight between us today what I mean by that. Because, rightfully, there's a lot of different meanings for that word out there. But in everything we do today, when I say coordinated rudder, what I mean is that we will apply rudder in the direction we are trying to roll the plane. Left rudder, left roll; right rudder, right roll. And just the amount of rudder that it takes to get the desired roll response. And these are very powerful rudders. It might take smooth, small applications to get the desired results in most of our fleet."

The industry training aid talked about that coordinated use of rudder may be required, and it said that in more than one place.

Also, AAMP talked that the rudder was a very powerful control and it can generate excessive side slip -- it can generate side slip and lead to loss of control.

(Audio from video presentation:)

"The next thing then says, roll. Well, since you've unloaded, what are you going to roll with? Well, you're going to roll with ailerons and spoilers, aren't you. The rudder won't roll this plane at rolling ... the back, the ailerons and spoilers roll it. So we come in with ailerons and spoilers and we roll towards the nearest horizon, i.e, if you're right wing low, roll right.

"Now some of you out there might say, well, I'm going to use a roll coordinated rudder to help the nose come down. Fine. That's fine. That's good technique. A little, smoothly applied. I mean understand right here, if you jam full right rudder, that's the spin entry procedure.

"To complete this unusual attitude recovery procedure segment of the Advanced Aircraft Maneuvering Program, I'd like to briefly review the proper use of rudder at high angles of attack. As I stated in the aerodynamics segment, smooth application of small amounts of rudder, coordinated with the aileron will significantly improve the roll response at high angles of attack.

"I'd like to reemphasize that we have very large, powerful rudders on our aircraft. We do not want to introduce high side slip angles with high angles of attack by either kicking the rudder or applying the rudder in excess at high alpha. It only requires a small amount of smoothly applied, coordinated rudder to achieve the desired results. This coordinated rudder will significantly improve the roll response at high angles of attack."

Note the little tag there at the end, that was in response to a feedback letter that we've received from four signatories that had attended this conference, and we put that on the end of the tape in 1997, and sent that out to each and every American Airlines pilot. But the industry training aid talked about the rudder being very powerful, the same thing that we were saying in the AAMP.

And we talked about that use of returning the aircraft to proper attitude, that it might take the use of rudder, and we talked about some cautions there, but in coordination with the ailerons and spoilers, full speed recovery and preserve altitude. And the industry training aid, it spoke specifically of primary flight controls as being ailerons, elevator and rudder.

In the industry training aid, they also talked about -- and I think this is very notable -- talked about pilots must be prepared to use full control authority when necessary. The tendency is for pilots not to use full control authority because they are rarely required to do this.

There's been a lot of talk about the simulators and some questions yesterday involved simulators and what we taught in AAMP. We had two upsets that we performed in the simulators in relation to AAMP exercises. And we did one, an uncommanded roll to at least 90 degrees. A bulletin that had come out that initiated a lot of this talk about upset recovery training from the FAA, the 9510 HBAT, recommended uncommanded roll in events of at least 90 degrees. The industry training aid recommended at least 120 degrees of bank angle with 20 degrees nose low.

We also had a pitch, an uncommanded pitch exercise between 20 and 40 degrees. Once again, the bulletin, the HBAT 9510 recommended a nose high event of at least 35 degrees, and the industry training aid recommended an exercise in at least 40 degrees.

We understand there's some simulator limitations. We never once suggested that the simulator is exactly 100 percent perfectly replicate an airplane, but they're the best tools that we have available. The industry was concerned about upsets at the time, and we were trying to use the best training aids and the best tools we had available to teach this, and the FAA agreed with us on that.

The NTSB has sent out several safety recommendations and so it was a concern, and our objective in AAMP was clearly, pilot recognition to try and avert an upset condition, but if you found yourself in an upset condition, to apply the proper and correct procedures to recover from that upset. We know that the fidelity of the aircraft was not perfect, but we thought there was something to be gained. There had been accidents where we had talked about, or we had investigated and once the crew got beyond 90 degrees that they had failed to push on the yoke to help preserve altitude, and in fact, they had actually pulled and decreased their chances of recovery. So although the simulator can't replicate negative G, we think there's some value to be learned from learning and systematically learning to push instead of pull and help yourself to recovery.

Yesterday we talked about full stall exercise. Captain Rockliff mentioned that. The simulators did not replicate that, and we took their advice, and we listened to them, and we didn't incorporate full stall series into our simulator exercises. We do approach to stalls, but we do not do full stalls for that very reason. We understand there's some fidelity issues with that.

We also invited the manufacturers to come and look at our packages and what the exercises we were doing in AAMP.

Yesterday, the Tenth Performance Conference came up and -- in September of 1998, Airbus conducted the Tenth Performance Conference, and Captain Wainwright from Airbus had written a letter. Quite frankly, we were a little surprised at some of the comments, and it's included in the Exhibit list on this particular accident, and so that's why I address it here, because we don't think it reflected what we were teaching in AAMP.

These are just a few examples that we just ran through, and I won't belabor the point, but we talked about thrust effects on under wing mounted engines were ignored -- and speaking of the airlines there -- and talked about -- Captain Wainwright talked that had a significant influence on recovery. And this is a page, again, out of that supplemental work book, and also Captain Vandenberg during his presentation at ground school, talked about it. But we clearly talked about the thrust effect, and specifically we talked 7-5, 7-6, and the A300 had a powerful moment to pitch axis.

At the Tenth Conference Airbus also stated that training that was already being done considered upsets as being due to momentary inattention to fully serviceable aircraft, that was in trim when it was upset. And once again, here's a page out of that workbook, and this is just a bullet statement to an instruction that Captain Vandenberg was talking about during that time, so clearly, we did talk about that.

It also talked about emphasizing excessive nose pitch up attitudes, emphasizing rapidly Rolling to 90 degrees of bank, and in fact we never taught that. Once again, here's a video clip from

1997.

(Audio from video presentation:)

"We've got this next bullet that says normally limit banking to approximately 70 degrees. I hate a number. Whenever I put a number up, a pilot sees a target. So listen, that's not a target. It's kind of a limit. What am I saying there? Well, as I started doing this in our larger transport airplanes, I initially reverted to my other life. In my other life, you know, I just rolled the 90 degrees of bank and just came on down. Well, when I did that in the big transport simulators, I learned something kind of surprising, that shouldn't have been, but it was. When you come to the horizon with 90 degrees of bank on these big puppies, you don't have adequate roll rate to get the lift vector pointed back up before you end up with a nose way down here. Now you have to do one of those nose low recoveries, see. You know, you can't -- the good news is you can get them both done on the same maneuver. But it's not ideal. We really don't want that to happen. So the reason that 70 degree bullet is in there is to say in these big guys, we've got to keep our lift vector up a little bit as we approach the horizon, so we don't have so far to go with it, to get it turned up the rest of the way because of our roll rate.

"The other way of looking at that -- because I want to kind of get this clear -- is you don't need to go to 70 degrees of bank, that's not what I'm saying. If you're at a 45 degrees climb, then maybe you only need 45 degrees of bank, and that'll be enough, see. But don't go to the horizon like this in these guys, it doesn't work."

Okay, and I will add that you saw the 70 degrees in there. After the industry training aid came out, they had recommended 60 degrees, and we subsequently changed that and updated that.

At the Airbus conference, it was always stated that the training managers were all in the habit of demonstrating the handling characteristics beyond the stall. And as I mentioned before, we didn't teach full stalls in the simulators, as a result of that, and here's a film clip.

(Audio from video presentation:)

"In conclusion, let me reinforce that AAMP emphasizes keeping the aircraft inside its flight envelope at all times, regardless of attitude. Likewise, in your simulator training, you should never increase the angle of attack above the onset of stickshaker alpha -- that angle of attack that we know as CL-max."

And we also had a page in the workbook that stated that we did not do full stalls, as you can see here. So we clearly addressed that issue.

One of the things that was stated there was that airlines were accustomed to teaching, and through their backgrounds, fighter pilot background or whatever, that we were accustomed to teaching scissors-type maneuvers. And clearly we never talked about doing scissor-type maneuvers of anything. Through the film clips so far, you can recognize that we never talked about that, and we always talked about exercising caution when using the rudder, and particular with small, appropriate amounts.

Once we held the industry conference in 1997, our Vice President of Flight had requested feedback from every attendee there and specifically, the aircraft manufacturers and the FAA. We solicited their input and feedback, once again recognizing that we were not the only experts out there in the industry in this, and we wanted to draw on that expertise that was other places.

Now, the August letter that came to us was from Airbus, Boeing, McDonnell Douglas and the FAA, had some things in it that -- I'll just bring up a few examples here I wanted to correct. But it says "Although the simple rule about rudder usage cannot be stated, a more appropriate standard is to first use aileron control. If the airplane is not responding use rudder as necessary to obtain the desired airplane response." Here's a video clip once again, from 1997.

(Audio from video presentation:)

"Well, as highly experienced aviators, I want you to think about this with me. I'm going to suggest to you that as we're out there flying along in our airplanes somewhere, someplace -- could be anywhere -- let's say flying somewhere entering the traffic pattern of the approach or whatever, our airplane starts to roll. I'm going to submit to you that I, for myself, and I think if you think about this too, at this instant, probably don't have any idea why it started to roll. I mean it could be rolling because as I configure my flaps and slats went asymmetric. It could be rolling because I hit the vortex of the guy ahead of me. It could be rolling because of an engine failure. At this instant, I doubt I'm smart enough in most situations, and certainly in the weather, to understand clearly at this point, why it's rolling. All I know is it started to roll. It's an uncommanded roll. My job is to stop it. Right.

"So I come up with some yoke and say, come on, stop rolling. But it doesn't. So I come up with some more yoke and say, come on, stop rolling. And it doesn't. Well, what control would I go to now if this isn't stopping a roll. Yes. Rudder, sure. So I come in now with coordinated rudder, right rudder in this case, trying to roll right."

So clearly that demonstrated that we talk specifically about if the aircraft was not responding to aileron and spoiler control, that you use smooth application of coordinated rudder.

Now after we sent our response, our Vice President of Flight sent a response letter back to that feedback letter from August of 1997, we didn't receive any response back from any of the signatories, once Captain Muell (ph) had responded to that, and in fact, one of the signatories later on advised Japan Airlines to contact us to get our program, our AAMP program.

We also, and you saw in one of the video clips there, where we had added a section at the very end of the video to reinforce the proper use of rudder, and that was sent out to each and every American Airlines pilot in 1997, December of 1997. And that tag, it repeated warnings about how powerful the rudder could be. It reiterated the fact that rudder generated side slips could lead to loss of control, and it reemphasized the fact that rudder must be applied in smooth, appropriate amounts.

In addition, we clarified some of our written materials and the workbook in particular, that what was already being taught, but sometimes the bullets may have been misworded or whatever, so we clarified. And example would be down there, as you see, on the right side there, where it says high AOA equals coordinated rudder. On the left side it had said high AOA maneuvering equals rudder. And we just -- we used that feedback letter to clarify some of our statements in our written materials there.

I know I've talked for a little while here, and I don't mean to belabor the point, so I'll just try to bring three of them home to you. We haven't seen anything in the 587 accident to indicate that it was an upset. It was not an upset until after the vertical fin separated from the aircraft.

Pilots all over the world encounter wake turbulence daily. That's not what we're talking about here in AAMP. AAMP was one of the most widely reviewed, and widely applauded training programs in aviation history. At the time, there was a great and genuine concern about loss of control of large aircraft, in particular, transport category aircraft, and we, as an industry, not American Airlines alone, but we as an industry, were trying to address that concern and prevent it from ever happening again. And AAMP always taught for the pilots to respect the power of the rudder.

And once again, here's a little small video clip, and this was from December of 1997, this little tag that we sent to all of our pilots.

(Audio from video presentation:)

"To complete this unusual attitude recovery procedure segment of the advanced aircraft maneuvering program, I'd like to briefly review the proper use of rudder at high angles of attack. As I stated in the aerodynamics segment, smooth application of small amounts of rudder, coordinated with the aileron will significantly improve the roll response at high angles of attack.

"I'd like to emphasize that we have very large, powerful rudders on our aircraft. We do not want to introduce high side slip angles at high angles of attack, by either kicking the rudder or applying the rudder in excess at high alpha. It only requires a small amount, smoothly applied for a coordinated rudder to achieve the desired result. This coordinated rudder will significantly improve the roll response at high angles of attack."

And that concludes my presentation, sir.

Q Thank you, Captain Young. Just a couple of questions that relate to the presentation that you made.

A Yes, sir.

Q You stated in the presentation that American invited Boeing, McDonnell Douglas and Airbus to review the AAMP simulator data.

A Yes, sir.

Q Did any of those organizations accept your invitation?

A Not to my knowledge.

Q And so no one reviewed your simulator data to either add or subtract or modify what you had at that time?

A Of the aircraft manufacturers?

Q Yes.

A There was dialogue between the manufacturers at the time, and I -- I don't know whether they modified the simulator data or not, sir.

Q And one other comment, just for the audience and everyone here. You mentioned in the presentation a scissors maneuver. Would you mind describing what scissors maneuver is?

A Only through previous experience do I know what that word means, through being a fighter pilot, but a scissors maneuver was a maneuver where you had two aircraft that were fighting each other, and would find themselves in very close proximity, trying to outrate each other -- trying to outrate each other, and you could get into what we call a scissors maneuver. That was very extreme, very specific to fighter aircraft only.

Q And lastly, regarding the presentation, it stated that American was aware of simulator limitations and encouraged Airbus to review the alpha and beta angles generated by the AAMP maneuvers. Did that ever occur?

A Not to my knowledge, sir.

Q Regarding the AAMP program, were there any major changes made to the program since the inception of AAMP?

A At the very inception, -- the changes that were made, the ground school was extended. Initially it started out as -- it was planned to be four hours, and we realized once we got into it, the foundation of which you build for this particular maneuver, upsets, that the foundation wasn't there, and so we had to extend it to a full day of ground school. So that changed, and there's been modifications to it all along the line, so I'm not sure if you'd consider those major or not.

Q Is the AAMP program generic, or is it specific to airplanes in the American fleet?

A The AAMP program itself is generic. The ground school is very generic, but each and every fleet has some specifics that apply to their particular aircraft, and they address those in the ground school as well as the simulator training.

Q Have you had the opportunity to compare the AAMP program, in particular the A300 program, to other airlines that operate similar sized airplanes, or A300 airplanes?

A Yes, sir, I have, actually.

Q And would you mind commenting on how your program compares with other airlines programs?

A As I reviewed the other airline programs, and primarily I stayed with domestic air carriers here in the US, but as I looked at their programs, I would say that some programs appear to be more aggressive in some of the maneuvers they conducted in the simulators in some of their training, and some programs were as little as point and click off a computer, and multiple choice. So, when you look at the airlines, there really didn't seem to be a standard for the AAMP or upset training, and if I had to guess, I would say we were -- I don't know if we were in the middle of the road, but we certainly use simulators with motion to train.

Q Just based on what you just said, is it all over the place? Some use simulators, some don't use anything but classroom? Some use interactive TV screens, computer based training?

A I think that's a correct statement from what I've seen, yes, sir.

Q So the industry training aid was being developed as your AAMP program was being developed, and my question to you is, did the AAMP program incorporate many of the features of the industry training aid, and/or did the industry training aid incorporate many of the features of the AAMP? Was it a combination of both or did it go more or less one way or the other?

A I don't know if we can state it went one way or the other. As you look at the industry training aid, it has very, very similar characteristics to the AAMP program. Now the AAMP program started development about a year prior to the industry training aid starting it’s development. We did incorporate some changes to our AAMP but I mentioned where we changed them from 70 degrees to 60 degrees but the ITA had recommended 60 so we updated our program after the ita came out. The ITA seems very reflective of the AAMP program.

Q In your review of the AAMP program, did Airbus Industries provide any guidance to American concerning the AAMP program as it related to the A300?

A Outside of the industry training aid, we never really received anything from airbus concerning upsets.

Q You certainly are familiar with the FCOM, the Flight Crew Operating Manual.

A Yes, sir, I am.

Q Is there any guidance in that manual that relates to upset training or wake turbulence encounters in the A300?

A After the 587 accident, we received a bulletin from Airbus and it incorporated some, not procedures, but it incorporated some guidelines or techniques that addressed recoveries. But prior to that, no, sir.

Q And so Airbus never incorporated any FCOM procedures into their manual, based on what you just said that might have been discussed in the industry training aid.

A Not to my knowledge. I don't want to give you the wrong impression here that -- there was dialogue between the airlines and the manufacturers, so -- but in the formal written communication or specific upset procedure in the FCOM, no there was not.

Q And you just testified about receiving something post-accident from Airbus.

A Yes, sir.

Q And do you recall what information that was about?

A The information that came to us from Airbus for the operating manual, was a bulletin that spoke about some of the concerns that came out of 587, upsets, and it talked about rudder usage, et cetera. And that was after a response to a safety recommendation from the NTSB.

Q Have there been any changes since the accident made to the AAMP program by American Airlines?

A Yes, there has. Well, what we've done is once this accident happened and as I stated, that normal encounter with wake turbulence, we did not expect that to be AAMP unless it resulted in an upset of some type. But there were certainly some questions coming to us about our AAMP program and our training, and we're committed to making sure this never happens again, and we have been reviewing our AAMP training program and the changes that we made so far, and it's still under review, is that we had some preprogram simulator buttons in the simulator to address rolling maneuver and a pitch maneuver. And we removed those preprogrammed buttons from the instructor, but other than that, AAMP has remained basically the same.

Q Well, thank you because you led very aptly to my next question -- and this may be in Mr. Ghoshal's area -- would you mind describing how a pilot was placed into an unusual attitude in the A300 simulator?

A I can, and then I'll hand it over to Mr. Ghoshal. The instructor in the simulator has a panel just behind the two pilot seats, and they would go to a page on the computer screen there, and they would select either pitch maneuver or roll maneuver, and that would put them into an upset condition. So the specifics of that upset, Mr. Ghoshal can address.

QUESTIONING OF MR. GHOSHAL

BY CAPTAIN IVEY:

Q Okay.

A Yes, Captain Ivey, I have a small presentation I would like to make that might explain how the simulator works and how we do these upsetting maneuvers in the simulator. Is that okay?

CAPTAIN IVEY: That would be fine.

MR. GHOSHAL: This particular presentation is about how the software programs are modified in American Airlines flight simulators in support of our AAMP program. American initially started with two upset events. One was upset rolling event, and the other one, upset pitching event. And I would like to briefly describe what the upset rolling event was.

In the upset rolling event the simulators simulates a significant rolling moment that overpowers the crew's control authority and rolls the aircraft past 90 degrees. This upset rolling event was not intended to simulate an encounter with turbulence from which either the recovery was routine, or one that could be arrested before the aircraft was in upset.

The simulation was intended to replicate a significant uncommon dead roll event from an unknown source. It could be an engine problem. It could have been a flight control malfunction, or even some air mass anomalies. It would probably be helpful at this stage to explain in a sentence or two how the flight simulator works. A flight simulator uses computers where we solve complex mathematical equations that presents the different systems and subsystems to replicate actually how the aircraft flies.

Now let me explain how the actual simulator was programmed in support of the upset rolling event. First, a rolling moment is induced, as Captain Young said, the instructor presses a button and this is what happens in the background. First a rolling moment is induced to roll the aircraft in one direction, approximately ten degrees. The direction it rolls is random. Second, a rolling moment is then induced to roll the aircraft in the opposite direction past 90 degrees. For example, if the aircraft rolled first right wing down ten degrees, it will now roll left wing down 90 degrees. The aileron, the spoiler, and the rudders are ineffective until the aircraft reaches a bank angle of 50 degrees, or maximum of ten seconds.

After the aircraft reaches the bank angle of approximately 50 degrees, the yaw and the roll control are phased back in over the next 1.3 seconds. The phasing in of the control authority in the next 1.3 seconds, and the moment of the aircraft is what takes the aircraft past 90 degrees. The roll rate after approximately 50 degrees, and the final bank angle depends on how effectively the pilot responds. The software changes that we made in the flight simulators do not favor the rudder over ailerons. The pilot can recover from the upset without using the rudder.

Now let me discuss how the upset pitching event was. The upset pitching event was an event that simulates a pitch up of the aircraft between 20 and 40 degrees nose up. This simulation was again intended to replicate a significant pitch up event from an unknown source.

I'll now explain how the software programming was done. First a pitching moment is induced to drive the aircraft pitch angle to 37 degrees minus half the roll angle. During the time, the horizontal stabilizer is driven up, the elevator and the horizontal stabilizer are ineffective until the aircraft reaches the final pitch angle or maximum 11 seconds. Pitch control authorities then phase back in over the next 1.3 seconds. The final pitch angle of the aircraft depends how effectively the pilot responds. The software changes that we made in the simulator do not favor rudder over ailerons. The pilot can recover from the upset pitching event without using any rudder.

A common issue, when you talk about flight simulators is a simulator's fidelity. In laymen's terms, simulator fidelity merely means how the simulator replicates the flying aircraft. To accomplish this goal, we have physically a cockpit with instruments, seats and the pilot, along with powerful computers in which we run the software for the actual aircraft.

Simulators are built by manufacturers like Link, the company I used to work for, CAE, but these simulator manufacturers, however, do not create the mathematical models or the data that are used in the flight simulator to recreate the flight. Those come from aircraft manufacturers. Consequently, in the airplane upset recovery training aid which are referred to the industry training aid has it right when it states, "simulator fidelity relies on mathematical models and data provided by airplane manufacturer."

The industry training aid contains a number of recommended training exercises for using the flight simulator. According to the industry training aid, these exercises are designed to keep the simulator within the mathematical models and data provided by airplane manufacturers. From a aerodynamics modeling point of view, there are two key parameters to consider here as to how an aircraft flies. This is angle of attack, alpha, and angle of side slip, the beta. Although it may not be intuitive, the actual pitch angle, roll angle, and the heading angle are not that important. The industry training aid recognizes that the angle of attack and side slip angle are the key factors when it cautions us to "Ensure that the combination of the angle of attack and side slip angle reached in the maneuver shown in the flight simulator do not exceed the range of the validated data or analytical extrapolated data supported by the airplane manufacturer."

What you are looking at now is an alpha-beta block. This chart was provided by Airbus for industry training aid. The vertical axis here is the angle of attack, alpha, the horizontal axis is angle of side slip, beta. There are three types of data in this chart. Right in the center is something called flight data, surrounded by wind tunnel analytical data, and then the data extrapolated for the simulator used by Airbus engineers.

However, when this aircraft manufacturer provides this data to the simulator manufacturer or to an airline, these data is not separated into this neat, three boxes. Instead, the variable that the data tables that the Airbus provides for building a flight simulator, do not make any difference among the three types of data. As an aerodynamics engineer, however, providing all the variables in the same table is not a problem, as we saw from the highly accord (ph) from the industry training aid says, "As long as the flight simulator is using any of these three types of data, the simulator should be accurate in presenting how the real aircraft will fly."

The industry training aid actually agrees. It explains that the key to consider here is angle of attack and side slip angle, even if the airplane is flying upside down. It says, "For example, a full 360 degree roll maneuver conducted without exceeding the value range of angle of attack and side slip angle, will be correctly replicated from an aerodynamic standpoint." In other words, even when the aircraft has rolled 180 degree, i.e., the aircraft is upside down, it is still the angle of attack and side slip angle, and not this 180 degrees of roll angle, that determines how accurately the simulator represents the aircraft from an aerodynamic standpoint.

This point can be further illustrated in the industry training aid by looking at some of the training exercises it recommends. For example, industry training aid includes a recommended exercise for a nose high event of at least 40 degrees. A higher pitch angle than the one would reach during the AAMP pitch maneuver. It also includes an exercise for a rolling event with 120 degrees bank angle and 20 degrees nose low. Again, a greater bank angle than the one reached during the AAMP rolling event, along with a much lower pitch angle while inverted. But, as I stated earlier, angle of attack and angle of side slip are the key factors, not the pitch angle or the roll angles. The angle of attack and side slip during AAMP exercises are similar to those in the industry training aid exercises.

In conclusion, first, side slip and angle of attack were monitored during AAMP exercises when we developed it; second, each AAMP exercise in the rolling and the pitching event, was flown and evaluated in each simulator type before being rolled out to other simulators of the same type; third, the AAMP pitch maneuvers and roll maneuvers stay within the valid data; fourth, these were not major changes to the simulators; fifth, the aerodynamic coefficient data tables provided by the aircraft manufacturer for the simulators used, were not changed; and finally, as Captain Young told you, both domestically and internationally, the AAMP program was widely applauded and other carriers and training centers, not only requested the data for the ground school, but they also requested the software changes and implemented simulator changes to their simulators. Thank you for your time.

MR. IVEY: Thank you, Mr. Ghoshal.

FURTHER QUESTIONING OF CAPTAIN YOUNG

BY CAPTAIN IVEY:

Q Captain Young, you've been in the simulator, and I'd like to ask you if you think the simulator adequately represents the airplane.

A Specifically to the AAMP maneuvers, is that what you're speaking to?

Q Yes, sir.

A Well, I've never been in an upset in a large aircraft before, so I can't speak to that directly, but what I do know is that when pilots go into simulators, I mean we know right away that, although simulators are the best tool available and they're wonderful machines, they are not an exact replication of the airplane. But as it pertains to this AAMP maneuvers, we never really stated that it was an exact replication of the airplane. We were working more with procedures and how to recover should you find yourself in that position. So I don't know if that answers your question or not.

Q It does, and I think based on that answer, do you still believe that a simulator provides an adequate means of training to recognize and to recover an upset training as opposed to using computer based training or ground school presentation outside the simulator?

A I do because I think there's some value. As you look around, I don't know of a better training aid, shall we say, to teach some things. And through the accident history there have been some very definite trends in the mid-nineties that the industry was trying to address with accidents as a result of loss of control. And we think it's far more important that just to read out of a book. We're not for sure you gain the skills necessary to recover from an upset from just reading it out of a book, and so we think that the simulator is the best tool available for training those skills.

CAPTAIN IVEY: And Mr. Ghoshal, you stated that the manufacturer had provided a data package and there had been no changes since the original submission to you, is that correct?

MR. GHOSHAL: Yes, sir.

CAPTAIN IVEY: So since the accident, there's been no changes in terms of data or modification to the information?

MR. GHOSHAL: Yes, sir.

CAPTAIN IVEY: Has the FAA required or requested any additional changes since the accident?

MR. GHOSHAL: Not for any simulator software.

CAPTAIN IVEY: I don't know who might answer this question, but is there any simulator recording of data accomplished either during a student going through the program of upset recovery, either to observe simulator activity or the individual pilot's recorded control inputs, either for modifications to simulator, or for debriefing to the pilot upon concluding the simulator period?

CAPTAIN YOUNG: Maybe that might be a question for myself. The instructor -- we don't record any data during the upset recovery maneuver, and there's nothing presented to the student, nor the instructor pilot.

CAPTAIN IVEY: Is there a means or a way in which the G loads, since it is a simulator and you can't replicate the G loads that would be in an airplane either positive G or side lift, is there any recorded information related to G loads which can either be debriefed with the pilot or looked at for comparison as to how they're being generated by the student?

CAPTAIN YOUNG: I'll answer the first part, and then I think maybe some of it applies to Mr. Ghoshal, but the first part, in positive and negative G, certainly a positive G, the simulator, if you exceed some parameter, it will crash, so if you exceed that parameter, you would get a crash possibly on the simulator, but as far as lateral or negative G excedence parameters -- and I don't know what these numbers are, but you can knock it off of motion, and then it will settle down off of motion, and you have to reset the motion on it. Maybe Mr. Ghoshal can speak to the parameters.

MR. GHOSHAL: As far as the vertical load factor goes, yes, you can -- it is a variable in the simulator, it can be shown or recorded, same as the side slip angle, it can be recorded. We do not have the simulation for side loads, and we do not -- the simulator data doesn't show what side loading might do structural damage or something, if that's what you are asking, sir.

BY CAPTAIN IVEY:

Q Earlier I'd asked questions pertaining to the modificatIons in the AAMP program, have there been any modifications to the ground school portion of the AAMP program since the accident?

A Well, there has. We have spent a great effort after the accident, after 587, Flight 587 accident of teaching our folks about maneuvering speed and what that means and what they thought about before that. Also rudder limiter system, and the sensitivity of the pedal -- rudder pedal, as well as the restrictive movement or limited displacement of the rudder pedals. So that's a good time to talk about it is during our AAMP discussions because it talks about aircraft maneuvering. So I guess that was a change. The basic, core program, though, has not changed.

Q Regarding the AAMP booklet that was shown on the screen and Member Hammerschmidt displayed yesterday, is that still being used and distributed?

A As of right now, and I do have to qualify this, that we're not in a position of expanding and hiring pilots right now. That full day ground school and that workbook is given out during that initial ground school for AAMP. We don't hand it out for recurrent. That's a one time supplement material, and so we haven't conducted a full ground school of AAMP in a long time, other than to review it recently.

Q If today good fortune were to allow you to have a new hire class, would that booklet be used today?

A To my knowledge, yes, sir.

Q And I'd like to talk about a few of the terms that you just brought up. For example, the rudder limiter systems. How much, in your opinion, does a pilot know about rudder limiting and what its function is?

A Prior to 587, I would have thought that the pilots knew quite a bit, but after 587 it became apparent that the industry as a whole, and the NTSB safety recommendation addressed that issue in February, but the industry as a whole, I think, pilots didn't know much about rudder limiter system and in fact, possibly had wrong perceptions. Most pilots think that a limiter on some system will protect you in that system, protect the pilot from exceeding whatever parameter that limiter is limiting. And in this case, in particular the rudder, I think pilots, and it's not unique to the Airbus aircraft, it's all aircraft that the pilots think that the rudder limiter will protect the aircraft, structurally, and if it can't they -- they think, and we have limitations in our operating manuals, that there would be a limitation or a warning, or caution or a note that would indicate that -- indicate that the rudder limiter couldn't protect them, structurally.

Q I asked Captain Rockliff yesterday the question about the use of rudder on a normal flight from the time the wheels are retracted until they are extended. I'd like to ask you the same question. Do you believe that the amount of rudder that you use during the climb, cruise, descent, approach portion of flying is limited or is it used extensively by pilots?

A I don't think pilots use the rudder very much at all -- cross wind take off and landings, and then if you had some type of malfunctions, i.e., engine failure or a control malfunction that might induce some yaw or side slip on the aircraft, then they would use it, but for your question in normal flight, taxi out, taxi in, they're probably going to use a little bit, rudder checks, things like that, and then for cross wind take offs and landings. I think that would be the majority.

Q Do you think most pilots fly with their feet on the rudder pedals once they've gotten into the climb regime or have engaged the autopilot?

A I think that pilots --- the pilot flying would fly with his or her feet on the rudder pedal while they're hand flying, but I think once they turn the autopilot on that they would not fly with their feet on the rudder pedal.

Q I'd like to ask you the same question I asked Captain Rockliff yesterday, and I'd like your definition of what coordinated rudder means to you?

A I thought Captain Rockliff's answer yesterday was appropriate. I think it is without -- flying the airplane without side slip or yaw on the aircraft, and pilots are taught this from the very beginning, the first hour of flight, regardless of what airplane they fly is to fly the airplane coordinated, and it's certainly very easy to detect when it's not coordinated.

Q Moving to another area, there's been

discussion about the trapezoid or the side slip indicator.

A Yes, sir.

Q How much of that device is used during normal operations by a pilot?

A I think when you get side slip on the aircraft that the first thing you're going to notice, and what draws your attention to side slip or yaw on the aircraft, is what you feel in your butt, in the seat, and you'll make the big adjustments from that, and then the fine tuning of yaw or side slip is done with the side slip indicator, in this case, the trapezoidal index, that trapezoid you're talking about. So to use it for gross corrections, or large corrections, I don't think it's used very much, until you kind of get the airplane back in coordinated flight, and then you'll fine tune it with that trapezoid.

Q So you don't think during an upset recovery demonstration or being involved in one in the simulator, that that particular indication would be used much by pilots?

A Not during the upset recovery itself, not until you get back to a normal flight regime and you're fine tuning the yaw and side slip, is when I think it would be used.

Q Another definition we talked about yesterday was the maximum maneuvering speed. Could you give me your definition of what the maximum maneuvering speed is?

A Vmax, is that what you're speaking of?

Q VA.

A Maneuvering speed. Maneuvering speed, pilots are always taught from the beginning when they start flying that below maneuvering speed that you have use of full controls, primary flight controls -- that's ailerons, elevators and rudder, and that below that speed that using full controls that you would not damage the aircraft, and if there's a possibility of damaging the aircraft, that the manufacturer would put a limiter or even put a limitation in the book, or something to alert your attention to that.

Q Is there any limitations that were provided to you by Airbus, either through their FCOM or through other communications, that would have made you place a limitation of sort in your operating manual?

A In relation to the rudder?

Q Yes, sir.

A No, sir, not prior to the 587 accident.

Q And since the accident, has there been

communication or warnings or cautions?
A Sir, since the accident, since the 587 accident, we've had communications with Airbus as well as many other aircraft manufacturers -- Boeing, primarily -- and the NTSB and a lot of agencies about this whole concept of maneuvering speed and rudder reversals, rudder doublets of which there was a lot of new information coming to us from that. So Airbus did send us a bulletin addressing some issues with the rudder post after the 587 accident, yes.
Q What is your opinion of the knowledge, just general knowledge, that American pilots might have had concerning terms such as doublets, singlets, triplets, Dutch roll?
A I think Dutch roll they heard of before because we address that in the simulator -- very early in the simulator phase, we do an exercise with that. As far as the term doublet and singlets and triplets, et cetera, I don't think it's isolated, in my opinion, I've talked to lots of pilots, many, many pilots from other airlines as well as ours, American Airlines pilots, and most had never heard of the term before, unless they were involved in the test business. That's the only people that I found that actually knew what the term meant. So I don't think they were aware of

the terms at all prior to the 587 accident.

Q In your experience, do you think that there's ever a time that full aileron or full rudder would be required on an A300 to control the airplane?

A I have never experienced that. When you fly the A300, I mean the controls feel very powerful, and a small amount will get you a lot. They feel powerful. But if you found yourself in an upset and the aircraft was rolling and you had exhausted all of your roll controls, then I would expect to use some rudder if I needed to avert that roll, and it could possibly end up being up to full rudder, yes, sir.

Q Did American Airlines ever train their pilots on the fact that the rudder pedals become restricted as increased air speed occurs?

A Specifically to address that prior to 587, no, sir.

Q Did you have knowledge that the rudder pedals would be restricted?

A Not prior to 587, no, sir.

Q And why was that?

A You don't push the pedal to the stop on a normal basis. The only time that I really experienced getting the rudder pedal to the physical stop was during simulator training with an engine failure, high gross weight, high altitude -- high, hot and heavy, if you will -- and then it would require maybe to the physical stop of the rudder limiter. But outside of that, I had never experienced touching the stop on the rudder pedal before. I've shut down an engine on the A300 before during a functional check of the aircraft, and you don't -- at 250 knots and a descent, so the power's back, and so it didn't require much rudder at all with the power being back.

Q Did you happen to see stop on the rudder pedal at 250 knots?

A No, sir, I did not.

Q Have you ever hit the stop on the rudder pedal, either in a flight test airplane or in a real airplane?

A No, sir.

Q In flight, I mean, obviously. When you're on the ground taxiing out, doing a flight control check --

A Right.

Q -- certainly allows the rudder pedals to go full travel in both directions to insure the system is contiguous and is operating normally.

A Correct, on the ground we do the check, and so you do take it to the stops. But never in flight. I have never experienced the rudder pedal to the stops in flight.

Q We talked yesterday somewhat about the landing gear procedure that is incorporated in your A300 manual, and is also in the FCOM. You had a procedure that attempted to extend the landing gear that was not locked down and the procedure called for alternating side slips.

A Yes, sir.

Q What do you think that that meant, based upon the original -- or the latest revision 25 of the FCOM, which was in place at the time of the accident?

A As I read the FCOM and we incorporated that procedure into our operating manual, alternating side slips -- prior to 587 -- I would have thought that you would have conducted alternating side slips to try and get the gear down, and that would have been extreme rudder movements from left to right, to try to get the gear down and locked. That's how I would have read that prior to 587.

Q And having read the revision that came out post-accident that provided additional information as to what alternating side slips mean, what's your opinion of that revision?

A I thought they tried to explain something that was already in there through some method that didn't really explain the procedure, and so we chose not to do that procedure. We have eliminated the alternating side slip part of that procedure for the landing gear unsafe procedure and we do not follow what Airbus said there.

Q So they had, in their revision, they extended -- I think there was about 12 lines of information basically describing what alternating side slip means, and it's my understanding that American now has eliminated all that alternating side slip from their procedure.

A That's correct. When we got the alternating side slip explanation -- alternating side slip was excessive from left to right and right to left -- as we read it prior to 587. After 587 there was information that came out about side slip and issues involved with that as well as rudder reversals and rudder doublets, et cetera, and we put a pink bulletin, which is an immediate nature, in our operating manual that states -- and I don't have it right in front of me -- but it states that do not do the alternating side slips, that if you have a landing gear unsafe procedure that you're working down that check list, to conduct turns of 45 degrees and that'll give you some G's available to maybe try and get the gear unlocked, or excuse me, down and locked. Is that clear? I'm not for sure I -- we disagreed with their explanation -- Airbus' explanation of alternating side slip and we're not going to do that, based on our knowledge today that we didn't have before. And so we do 45 degree turns one way, 45 degree turns another way to try and get the gear down and locked, and that is what our procedure is now, today.

Q Do you think that prior to the accident that most airline pilots, and you certainly should be able to speak for the American A300 cadre, that most airline pilots believe that if you were below the maneuvering speed that you could exercise the rudder to its full authority in alternating side slips, and if there was to be any potential problem, that a rudder limiting device would protect you and preclude any kind of a disastrous effect, such as we had in this accident?

A I do believe that very statement. I think that pilots, prior to the 587 accident, thought that if you were below maneuvering speed that the rudder limiter would protect the aircraft, structurally, and that you could move the controls as necessary without risk of damaging the aircraft. Yes, sir, I do.

Q And was maneuvering speed ever provided as a limitation or a speed that was incorporated in your manual in any shape, form, or fashion, or provided to you by Airbus?

A Yes, sir. In the flight manual -- the Airbus flight manual -- it does have maneuvering speed, and we saw that chart yesterday, and some of the verbiage that is in it. We incorporated that into our operating manual -- American Airlines' operating manual as turbulence penetration speed, and that was 270 knots, and that was the minimum speed on that maneuvering speed chart. And so -- I don't think airline pilots -- my personal opinion is I don't think airline pilots specifically fly around thinking about maneuvering speed. No, that's not what I think at all. But, there is no limitation or restriction in the book that would bring your attention to the fact that they didn't have full use of the controls at those speeds. Certainly at high speeds, we know there's some restrictions, but not at the lower speeds, no, sir.

Q My last question, do you believe that the AAMP program meets the needs of the American Airlines pilots in training them sufficiently for recovery from upsets and wake turbulence encounters in its present state?

A I think that in the mid-90's there was a lot of concern about this, and there has been examples of this type training saving aircraft and passengers. So I think it's valuable training, and I think we need to continue training in upset recoveries, yes, sir.

CAPTAIN IVEY: Thank you, Captain Young, Mr. Ghoshal. Madam Chairman, I'd like to turn the questioning over to Dr. Malcolm Brenner.

CHAIRMAN CARMODY: Please proceed.

QUESTIONING OF CAPTAIN YOUNG

BY DR. BRENNER:

Q Following up on Captain Ivey's questions. Are there some statistics or trends that we can monitor? How do we judge the effectiveness of the program?

A I don't have those statistics available to me right now, but I'm sure that if you look at the accidents -- certainly in the mid-90's there, the Pittsburgh accident with the 737 was high profile and it had been the second one of that particular type that generated some of these bulletins and the industry concern over that. So if we went back and looked from 1995 or 1996 to date, I think we could validate some of those concerns.

Now, there have been specific examples of pilots attributing this type training to saving their aircraft and passengers. Statistically, I think we'd have to go back and look.

Q When you receive these types of reports from pilots about the program saving them, how much follow up is there or informal contact to guarantee the way the way they use the techniques and to guarantee how it affected the situation? Is there a follow up on that?

A And I'm talking as an industry as a whole, not necessarily American Airlines, if another carrier -- if they contact us and talk to us about a save or something with an aircraft as a result of this training, certainly we'd ask some of the details. But to go and interview the pilot or something like that, probably not.

Q Do we learn enough to improve the program?

A We try and validate what they said that was useful for them in the recovery of the aircraft and the upset. But we do try to look and get some validation of if we're teaching the right thing, and do we need to address any other issues that may be lessons learned from whatever they experienced at the time.

Q Yesterday we discussed the in flight upset involving flight 903, American Airlines 903 from 1997.

A Yes.

Q And in that case, I believe, that the pilots involved had recently completed an AAMP a few months before. Did they correctly apply the guidelines that they received in the program?

A I wasn't on the accident investigation of 903. I've read through some of the materials, quite extensive as you would know. I think the aircraft was in an upset condition, regardless of how it got there, it was in an upset condition, and they recovered the aircraft. And from what I understand, reading the reports, was that it was in a right bank and was 56 degrees and continuing to roll right with full left roll controls, and the aircraft was continuing to roll right, so they applied some rudder to help avert that roll and get upside down, so in that case, yes, it sounded like -- AAMP always taught to use your roll controls first, and then apply rudder if you need some additional -- so in that context, yes, sir, I think so.

Q And was it appropriate for them to apply an escape maneuver?

A As I -- as I understand, after reading through some of the context, that they thought that they were in some type of a microburst or wind shear condition at the time, so if they thought that, yes, sir, it would have been appropriate.

Q Did American Airlines make any changes in its AAMP training program as a result of that event? Were there any lessons learned?

A The lessons learned, and specifically to the A300, we -- the SGUs or displays that display your attitude and air speed and some other things, navigational things -- they blanked, or they went into computer mode that it was no longer available to the crew there for a few seconds, and so we did incorporate that into our training and we talk about it, because it would make recovery more difficult without having some instrumentation available to you. We did incorporate that. But as far as some of the other updates, no, that was about it.

Q And I think yesterday we talked about Captain Tribout's letter which was shortly after the 903 event, that he wrote to Airbus. He was very concerned about the AAMP training on rudder use was inaccurate and potentially hazardous and asked for guidance. Can you put that in context? Can you tell us about that letter and what may have come out of that?

A I can, and I've spoken to Captain Tribout recently. At the time -- this was a May 1997 letter, and he was looking at a book that we had produced in 1996, and there was a statement -- and I think Member Hammerschmidt brought it forward yesterday -- about the rudder being a primary roll control. And that concerned him. He had not taken the full class. He had not taken the class at all, he had just looked at the workbook. And as you look at the workbook -- and once again, as I spoke earlier, it was not a stand alone document, and by the time the 1997 workbook came out, we had update that verbiage to say, instead of primary roll control, the most effective roll control. And we're speaking specifically to high angles of attack.

His letter to Airbus might -- as I read through the letter, and I had not seen it prior to I suppose a week or two ago when it was entered into the Exhibits -- but as I read through the letter, what I saw was a dialogue between our technical group and Airbus, the technical people on the airplane there. And I would expect that. As a standards manager, we develop training programs in the training department, but we rely on technical expertise from the technical department, and that's where he was. He's not responsible for developing training programs, but he is responsible for advising us on technical issues. So as I read through it, I saw dialogue between the aircraft manufacturer and the user.

Q Do I understand that there were changes then in the guidance on the use of rudder during that time period? Is that what you said, or --

A No, what we did was we clarified verbiage in the workbook which was not -- it was supplemental material. It was not a stand alone document. The full eight hour course -- one of our concerns, even to put the workbook out, and quite frankly, it's still a concern today, is that someone would get the workbook and only read through the bullet statements. There was a full day of ground school that we would teach, and sometimes those single bullet statements we'd talk about for ten or 15 minutes, perhaps, and instruct it -- and one of our concerns was that initially, even with the workbook, and it still is today that someone could get that workbook, didn't take the class, and didn't understand fully the concept from that single bullet statement and -- and that's what we saw there, and that's -- there have been several changes to the workbook over the years, not so much in course content, but in clarifying what we were already teaching and putting it in bullet statement format in the workbook. Does that answer your question?

Q I think so, I tried.

A I'm sorry, it's a little long.

Q In the middle of 1997, is when the accident crew took their ground training in AAMP, had there been changes in the guidance or the material around use of rudders, specifically, from then to now? Is the guidance still accurate or have there been modifications in it? Can you help me on that?

A The guidance is still the same. I think you saw from the video clips, and that was from 1997, and in fact, First Officer Molin took the class in March of 1997, and he very well could have been in one of those film clips, or in the class when one of those film clips were being filmed, and Captain States took the AAMP class in May of 1997. So what you saw in the film clip there is what they saw, and that's what we teach today.

Q We have a report in our docket I'd like you to, again, help us put that in context. This is the interview with Captain LaVelle, it's Exhibit 2-B. He reports in 1997, he experienced with the acting First Officer, Mr. Molin, and although he says that Mr. Molin had excellent pilot skills in general, he had a strange tendency to be very aggressive on the rudder pedals, and specifically he reports that the First Officer responded inappropriately to a wake turbulence encounter by commanding aggressive back and forth rudder inputs, and further, that when he admonished the First Officer, the First Officer insisted that the AAMP gave him directions to use rudder pedals in this fashion. Is it possible that this one pilot received negative training?

A The short answer to that is no. I think you clearly saw from the video clips that that's not what we were teaching. Captain LaVelle came to me and talked to me about this during the course of this investigation, and I then forwarded it to the NTSB, to Captain Ivey. We're committed to making sure this never happens again, so we are going to forward all the information as it comes in.

I need to put the whole Captain LaVelle thing into context. We, as a group, as the NTSB group, have interviewed pilots, several pilots that had flown with First Officer Molin subsequent to Captain LaVelle. Captain LaVelle was speaking of an incident in 1997 on the 727. And we spoke to several pilots that had flown with First Officer Molin as recent as a month prior to the accident, and some of those pilots -- if you add them all up together, there were hundreds of legs. Captain LaVelle had flown a total of six. So -- but even if that did happen, I mean as you saw the video clips which was actual class instruction, clearly that's not what we said on how to use the rudder. And even Captain LaVelle states in his testimony that

that's not what AAMP taught. He debriefed First Officer Molin on the spot and by testimony by pilots since that have flown hundreds of legs, there's no evidence that he did that again at all. Does that answer your question. I'm sorry I'm a little long winded, there, but --

Q No, that's very well. I would like to acknowledge Captain, you did come forward with Captain LaVelle. We appreciate that support in the investigation. As an industry, we're all trying to figure out what happened and we appreciate the airline's cooperation in this, and as in many other events, especially in coming forward with that.

A Well, thank you. We're committed to finding out what happened. Facts are the facts, and make sure it never happens again, to any carrier, much less American Airlines.

Q I wanted to ask about the simulator exercise. In the case of the roll exercise, how do you introduce that to the pilot?

A As I've stated, the instructor will select and this -- we have recently disabled that button, and we put them into an upset into a different manner now -- but they select the roll maneuver on the simulator panel -- instructor panel -- and the simulator will do the exercise that Mr. Ghoshal talked about.

Q And I understood that there was an introduction that you're taking off behind a heavy airplane that was often used by instructors. Is that accurate?

A That is often used, that you're taking off behind a heavy jet and oftentimes the instructor will even say a 747. Normally they have the weather in the simulator clear or certainly good weather to where there's a horizon and some other things, some visual clues available, although primarily the student, or the pilot, will use the instruments inside the cockpit. But many times, yes, the instructor sets it up by saying you're behind a heavy jet, a 747, cleared for takeoff, and then after they get airborne and they start cleaning up the airplane, then we'll initiate the roll maneuver.

Q About what air speed are they going when you initiate it?

A It would vary with instructors, and it depends on the altitude and things and what they're trying to do. The roll maneuver, although the instructors mention wake behind a heavy jet or something like that, as we stated earlier in the presentation, we had very specific reasons of why we initiated this roll maneuver the way we did, and part of it was our investigation of accidents that once pilots had gotten beyond 90 degrees, sometimes they continued to pull. It was a very unnatural act for transport category pilots, in particular, to push and help them in their recovery, so we were driving to a specific point. We wanted our pilots to get beyond 90 degrees so they were forced to systematically push on the yoke to help them recover from this upset. So although -- it was a convenient way to introduce this maneuver, saying you were behind a heavy jet or something, but I don't think any pilot would ever think, certainly on a large aircraft like this, that, unless you have short wings or whatever, that you'd find yourself in an upset from wake turbulence.

Q Would the pilots experience the upset at 250 knots? Did that ever happen?

A Once you get to 250 knots, the preprogrammed button was removed, and it was no longer selectable by the instructor. So up to 250 knots you could have -- they could have selected it.

Q And in general, how much simulator -- would pilots have simulator training using the rudder in the area of 250 knots? I know you talked about ground school training, but is there any simulator training where they experience it?

A Outside of maybe getting an engine failure at that speed or something like that. We conduct engine failures at critical phases of flight and the majority of time, in most pilots' experience over the years, have been down in -- at lower speeds than 250 knots, but an instructor could introduce an engine failure at that or control malfunctions or something like that at that speed, but -- that would be probably the extent of the rudder experience at that 250 knot range.

Q In the training, the pilots are trained to use the rudder in the amount the crew feels is necessary to obtain the desired roll, and I think the training is, to use a smooth application of small amounts of rudder coordinated with aileron. Is that appropriate? Is that accurate?

A If you're not getting the desired roll response at high angles of attack -- now, we're speaking about very specific conditions here -- at high angles of attack, you're not getting the desired roll response from the roll controls, then a small amount of rudder to arrest that roll that you're trying to do would be appropriate, yes.

Q I guess the concern is that if the pilot has very limited experience or no experience with rudder properties at these high air speeds, how can they judge what would be an appropriate amount to apply?

A At the higher air speeds, and this is probably beyond this discussion here, but the higher air speeds, you are not going to be at a high angle of attack, because you just don't have the G available to put yourself at a high angle of attack, and we always taught at low angles of attack, utilize your roll controls. I would expect that at low angles of attack, that the roll control should get you what you need in response to an uncommanded roll.

Q In terms of the simulator exercise, a possible criticism is that the A300 is such a large transport that a 90 degree roll in response to a wake turbulence may be unrealistic, and perhaps that the exercise should be graded according to the size of the fleet. Is this a concern, that there is possible negative training, it may give unrealistic expectations of the effect of a wake.

A I know that's been brought up during this accident investigation, and like I said, we were driving to a very specific point. We wanted to get, regardless of the airplane, we wanted to get them to 90 degrees. Now, some of the instructors over time have utilized the wake turbulence because, as I said, the weather was typically pretty good in the simulator. They would set the weather where it was good, and we didn't want to give a multiple failure, i.e., some type of a control malfunction in order to get them to 90 degrees because then they have something else to deal with. We just wanted to teach them that once they got beyond 90 degrees, that they needed to push. That if they continued to pull, they could find themselves in a very nose low attitude, possibly reducing the chances of recovery. And we base this on accident investigations, specifically the US Air 427 in the mid-90's there, was -- addressed that. So, if it's negative training -- pilots all over the world experience wake turbulence on a regular basis, so I don't think for a moment that an airline pilot, certainly, when they encounter wake, certainly on a large aircraft, think that they're going to get upside down. No, I do not think that at all.

Q There was a -- I'd like you to comment on another interview in our Exhibit, also Exhibit 2-B, this is the interview with Mr. McHale, and he also reports a 1997 event with First Officer Molin, who was involved in the accident, in which he reports that First Officer reacted aggressively to wake turbulence encounter by executing an immediate escape maneuver when the airplane experienced the wake from a smaller airplane. I think they were following a 737 or a 727. Could this be an example of negative training for this particular pilot?

A Could what be an example? I'm sorry.

Q In terms of expectations that this is perhaps an example of what we're talking about, that to him, perhaps, experiencing wake turbulence, he's learned in a simulator exercise, perhaps --

A Right, I understand.

Q -- as an example, to experience that he may, without effective controls, end up in a 90 degree angle unless he's very aggressive. Is that possible that he overreacted?

A Without being there in that situation, in that airplane, I think it's difficult for me to judge on that, but what I do know is that -- we don't criticize pilots for making a decision to go around. If you're not in a position to make a safe landing, then to go around or to execute a missed approach would be the proper procedure. And if -- if there was some question about the flying capabilities of that aircraft, and to land safely in this case he was on final, to go around or execute a missed approach, I think would be appropriate. But without specifically being in that airplane and knowing what went on exactly, I think that's difficult for me to make a -- a decision right now on the spot.

Q And I think there was another possible criticism of the simulator training program again, that it may have an unintended side effect that by rendering the controls ineffective for several seconds, it might encourage pilots to respond very aggressively on the controls, especially if the pilot finds that the main roll control is ineffective during that period, to come back very aggressively on the rudder. Would that be a fair criticism?

A I don't think so. I mean, I don't think any pilot that walks into a simulator thinks that they're going to fly from point A to point B and have a normal flight. We just don't have that flight time available in the simulator. So to say that they're conditioned, if they experience wake turbulence to immediately go to full control, I do not think that that's a fair criticism, and I don't believe that. If the aircraft was starting to do something strange, i.e., roll over or do some type of extreme maneuvering, then maybe they would get to that. I don't think the simulator preconditions people to responses like that of which you speak.

MR. CLARK: Let me ask a couple quick questions while you're still in that area.

THE WITNESS: Yes, sir.

MR. CLARK: As I understand it, how often do these pilots get this roll mode type of failure in the upset training?

THE WITNESS: In the simulator, they'll get -- for recurrent training, we have four days of training -- two days of ground school and two days of simulator, of which the simulator periods are four hours each with --

MR. CLARK: Well, how many times do they get this particular mode? Once a year? Twice a year? Once a career?

THE WITNESS: They'll get it once every nine months now.

MR. CLARK: Okay, then my question is, I think Mr. Ghoshal talked about it -- it takes about ten or 11 seconds for this thing to develop -- if you introduce the roll mode and you lock out the controls for what? ten or 11 seconds, something like that?

THE WITNESS: No, it's to 50 degrees.

MR. CLARK: Okay, to 50 degrees. It takes about that time to develop it. The question is, once I start rolling, what is a pilot's first appropriate response?

THE WITNESS: To use the roll controls.

MR. CLARK: Up to the maximum.

THE WITNESS: Up to the maximum, yes, sir.

MR. CLARK: What's the second response?

THE WITNESS: If they're not getting the proper roll response that they want from the aircraft, then they would probably apply, and what we see, is they apply some rudder.

MR. CLARK: As much as necessary, I think is some of the language?

THE WITNESS: That's what it says, as much as necessary.

MR. CLARK: And then some of these controls move on beyond 50 degrees before the roll is stopped and the recovery actually starts.

THE WITNESS: Yes, and once again, I mean I refer back to we were driving to a specific point of 90 degrees, to address this whole elevator --

MR. CLARK: But over this amount of time, and I still think -- it's not a time-based thing, but it takes ten, 11 seconds for all of this to develop, first step is to get in the wheel, the second step is to get in the rudder. Doesn't that set you up to use a lot of wheel, a lot of rudder each and every time you go through this maneuver?

THE WITNESS: Well, in this particular maneuver, I think that it does teach that we exhaust the roll controls and then we use the rudder. This is very small -- out of eight hours of simulator once every nine months, the maximum time that they would spend doing all of this stuff, which would include not only the roll maneuver and upset, but it would include controlled flight into terrain, enhanced GPW training, TCAS training -- all of that would be a total of about 15 minutes in the simulator. So do I think doing this maneuver once every nine months, pre conditions pilots to expect to use full roll controls every time they get into some turbulence or some wake turbulence, absolutely not.

MR. CLARK: Okay, but it would appear that they need to use full -- or almost full control each and every time this mode is introduced.

THE WITNESS: No, it's -- it depends on the pilot reaction of what happens. As I said, we're driving him to a 90 degree bank -- and different pilots will do different things. Some pilots don't use the rudder, and other pilots do to arrest the roll control. So -- do we drive every pilot to use the rudder because the roll controls are ineffective? No, we don't do that, but through the AAMP ground school instruction, they do understand the concepts that the rudder can be used as a secondary roll control -- or the secondary effect of the rudder is roll if the roll controls are not working.

MR. CLARK: And then I'll just jump in one more and I'll give it back to Malcolm. In the 587 scenario, you're familiar with the data and following through on the lead in. Is there anything in there that would -- is there any training that you provide that would encourage a pilot to simultaneously use the -- a lot of wheel and a lot of pedal, based on what is happening in this 587 scenario?

THE WITNESS: From what I've seen in the data, I haven't seen anything that would indicate that the aircraft was ever in any type of upset. Specific to the rudder, if a pilot doesn't need to roll the airplane, at a high angle of attack and has exhausted the roll controls, in this case, the only time I would expect a pilot to utilize the rudder outside of that is if you end up with some yaw or side slip on the aircraft and you're trying to get it back to coordinated flying. Does that answer your question?

MR. CLARK: Yes, that's fine. Sorry, Malcolm

DR. BRENNER: Okay.

BY DR. BRENNER:

Q In the simulator exercise, I understand you do not record the pilot's inputs on the rudder. How do you evaluate their use of the rudder?

A It's really an individual instructor and -- to just watch the pilots of how they execute this upset procedure, so that's really how we evaluate it.

Q And in wake turbulence maneuvers, what's the guidance, or when would it be appropriate to respond with a full wheel?

A A full aileron or roll controls?

Q Yes, that's right.

A If you were getting some kind of a roll, and you put in a roll control, and the roll on the airplane continued -- an unintended roll -- continued, then I would expect the pilot to use all the way up to the full roll controls, to arrest that unintended roll.

Q And when would it be appropriate to use full rudder?

A Well, first of all, prior to 587, I don't think any pilot in the world thought that full rudder could be gained from an inch and a quarter of movement at 250 knots with ten pounds of pressure. But, if there was side slip on the aircraft, I think the pilot would put in the rudder to the amount to arrest the side slip and pull the airplane back into coordinated flight.

Q And would the guidance be to apply the rudder -- what would the timing be in terms of -- would the rudder come simultaneous with aileron, or after, or before?

A If you're in a low angle of attack, and you get roll, I'd expect him to roll with roll controls, and there would be no reason to use the rudder. But if you're at a low angle of attack, and you get side slip, then I would expect him to use the rudder. Now, whether that's at the same time or close together, I can't say. But at high angle of attack, if they exhausted their roll control, then I would expect them to come with the rudder, so I would expect the roll controls to lead in that case.

Q In the CVR transcript, the First Officer called for max power during the event. Is this a normal call out or a nonstandard call out?

A For an encounter with wake turbulence?

Q Yes. What is he doing? What is he calling?

A Most of my experience with wake turbulence, and as I talk to pilots, it's very short, it's just -- you hit the wake turbulence and you're through it. And so you don't really -- are in there very long to react. In this case, as I've read through, just yesterday when I looked through the CVR transcript, I think he was asking for power to get out of something that they were in, whatever that was.

Q Under the company guidance, is max power an escape maneuver? Is that correct?

A It could be part of the wind shear microburst, yes, procedure, which is the only time that you would use the word escape.

Q I see. Or is there any -- when is the command max power used? Can you help us out on that?

A During the wind shear microburst procedure, you would ask for max power during that procedure. Not necessarily an upset procedure, and we talked about the thrust vector effect during my presentation. You would not necessarily, categorically, just ask for max power, and certainly if you were in a nose low condition, you wouldn't ask for max power.

Q And according to the CVR transcript, the Captain replied, "You all right?" He did not, and according to the FDR data, did not change the power setting. Why did the Captain not provide full power as the First Officer requested?

A If you ask for max power, my personal opinion is that that could be two different definitions. One, is the normal max power that you use during climb out. And another max power would be to the firewall of the aircraft, where you're no longer concerned about overtemping the engines and taking them outside of their parameters, you're concerned more about getting power to recover the aircraft. So those two -- I can't sit here and say what Captain States was thinking at the time, nor First Officer Molin, what they were actually -- what he wanted and what he was asking for. But those are the two definitions that I would think of as max power.

Q Thank you, that's very helpful. And you talked about the Safety Board recommendation that came out in February regarding pilot training and the operation and the human factors of rudder systems, is American Airlines instituting actions as a result of the recommendations?

A Yes, sir, we are. Right after the recommendation came out, and of course we've had dialogue with the NTSB as well as the party members involved in this accident, we issued a technical bulletin to our crews. We've issued revisions and what we call our pink bulletins to our crews. We sent out two separate packages of information to our crews to address these issues of which we included the safety recommendation as well as the Airbus response letter to the safety recommendation, and the Boeing response letter to the safety recommendation. We talk about it now during ground school. We talk about it, we illustrate during the simulator program, we illustrate the restrictive rudder pedal movement and how sensitive that is, and the force of the rudder pedal. We have done several things. We've issued messages through our electronic thing. We've posted information on our pilots web site. I personally have, for the A300 in particular, I have made base visits to field questions from the pilots that they had, and it didn't always center on just some of the issues in the safety bulletin, but to field questions and get the information out there on the street. Because I think there was some issues in the safety bulletin that were clearly misunderstood or not well understood by pilots all over the world.

DR. BRENNER: Thank you.

CHAIRMAN CARMODY: I understand that Mr. O'Callaghan has some questions after you, Dr. Brenner, is that correct?

DR. BRENNER: Yes, Madam Chairman.

CHAIRMAN CARMODY: Was that your last question, Dr. Brenner?

DR. BRENNER: That's correct.

CHAIRMAN CARMODY: Okay, I just wanted to clarify, after Mr. O'Callaghan, will there be more from the tech panel, or -- possibly there will. I'm debating whether to take -- why don't we go ahead. I'd like to finish with the tech panel before we take a break, so maybe we can aim for 10:30 or so. Thank you.

MR. O'CALLAGHAN: Madam Chairman, I'll try to be quick.

QUESTIONING OF MR. GHOSHAL

BY MR. O'CALLAGHAN:

Q Good morning, gentlemen, thank you for your presentations. My questions have to do with the simulation, and also a little bit about the training. Dealing with the simulation first. Mr. Ghoshal is the upsets that you describe in your presentation, do they apply to all aircraft operated by American or to just a few?

A Yes, all American and American Eagle also.

Q Then, I'd just like to clarify something, Captain Rockliff in his testimony yesterday said that when he experienced the roll upset in the MD-11 simulator with the McDonnell Douglas pilot, it was his impression that the roll control was inhibited as you described, but he seemed to indicate that he thought, or both pilots thought that the rudder was not. Were they looking at a different version of the scenario, or do you have any opinions on that?

A From day one that we developed it, this is the way it was. Roll and yaw control were both phased out and phased in at the same time.

Q Okay, thank you. Now, in your presentation you mentioned that during the development of the roll upset profile that the angles of attack and side slip were monitored.

A Yes, sir.

Q And these were found to be within the valid range of the database report?

A Yes, simulator alpha/beta plot that I showed you.

Q Okay, thank you. And now, is alpha and beta monitored for each student going through the program for each run?

A No, sir, we don't.

Q But wouldn't the alpha and beta achieved during the recovery depend on what each individual student happened to be doing?

A Absolutely. When we developed it, we flew it with quite a few pilots and looked at it, and it looked pretty reasonable.

Q But for an individual student, it's not monitored.

A No.

Q And you mentioned that the simulator is capable of recording data.

A Yes, sir.

Q But is it in fact recorded and then used to debrief pilots during the training?

A Not this alpha/beta pitch angle, bank angle, no, we don't do that for AAMP.

Q And I think Captain Ivey asked this, but also load factors and things like that are not recorded and are not reviewed either, is that right?

A That's my understanding.

Q Thank you, that's --

MR. CLARK: Let me ask a follow on right there, John. How do you know that it would have been a successful recovery if you don't track those particular elements? What is your basis to determine that the exercise was successful?

CAPTAIN YOUNG: The basis for determining whether the exercise was successful or not was recognition to start with, and the second, proper execution of the procedure. And we understand -- and this is a limitation where, I mean, certainly if you get the sim upside down, you don't go to negative G, you don't hang in the straps, you don't have books flying all over as you would in the airplane, and this is just part of the limitation we live with the simulator. But in this particular case, we're trying to teach a specific procedure to an upset condition, and so if they apply the proper procedure, then that would be a successful.

BY MR. O'CALLAGHAN:

Q Mr. Ghoshal, going back to your presentation again, you mentioned that plot that shows the range of alpha and beta, and I think I heard you say that the data that feeds that comes from flight test, wind tunnel and perhaps extrapolation by empirical methods, and my question was -- what I heard was as long as there's a number in the database for a given angle of attack and side slip that means that one can expect the simulator to be representative of the real airplane. Did I hear you correctly? Is that what you intended to say?

A Yes, sir, and in reality, the data comes from the aircraft manufacturer. We, as the simulator user, or when I built simulators, we do not know which part of the angle of attack is flight test, which is wind tunnel, which is extrapolation. There is no way to know it. All we know is it is given by the aircraft manufacturer and their stability and control people have looked at it and deemed it accurate enough for use in simulators.

Q So, can I take that to mean, then, that if there is, indeed, then a number for an angle of attack or a side slip, then as far as American Airlines is concerned, that number has been blessed by the manufacturer and therefore is representative of the real airplane.

A Yes, sir, and also I quoted industry training aid, it says the same thing also. Just a -- okay, the industry training aid actually quotes the similar thing, that it could be analytical data, extrapolated data, anything you can use.

Q I think I saw in that chart, -- those databases went out to some 30 degrees of side slip, and possibly over 20 degrees of angle attack. Would you expect, knowing your knowledge of simulators, that the simulator would actually duplicate a real airplane in that kind of condition?

A Some of the high side slip angles, yes, if it is wind tunnel -- you know, wind tunnel is one of the best to get high side slip angle data. But it is very important to remember that most of the flight is done inside the box, even when the aircraft is in an upset maneuver, within that flight test box. The data that we recorded in the simulator will always be in the middle box -- most of the time, even in upset maneuvers.

Q I understand the latter, but at the extremes, though, you're giving separated flow conditions and these sorts of things, do your simulators account for that properly?

A The data come from aircraft manufacturers.

Q Okay, thank you. One second here.

QUESTIONING OF CAPTAIN YOUNG

BY MR. O'CALLAGHAN:

Q Moving on then to the pilot training, then, I guess, Captain Young, yesterday Mr. Chatrenet described for us how the rudder produces roll by first yawing the airplane and inducing a side slip, and then how it's actually the dihedral effect and the side slip angle that produces the roll. Can you explain what the significance of that mechanism is from a pilot's point of view?

A I'm not for sure I completely understand your question.

Q Well, the -- yesterday, Mr. Chatrenet described how it is aerodynamically that the rudder causes the airplane to roll --

A Right.

Q First thing it does is produce a yaw.

A Correct.

Q Which will create a side slip angle, and then the dihedral effect of the airplane through the side slip angle, produces the rolling moment that banks the airplane. And he mentioned, you know, that there's a delay -- first there's a movement in yaw, and then there's a roll, so there's kind of a delay --

A Right.

Q And I was wondering, does that have any bearing or any significance from a pilot's point of view?

A From a pilot's point of view, I'm not an aerodynamicist, but you know I understand some basics about why an airplane rolls with rudder at high angles of attack, or even for that matter, if you put in enough rudder at low angles of attack and you wait long enough, it could induce a roll. But when you first put in the rudder initially, you're going to get some adverse yaw, probably imperceptible to the pilot, and then as the oversweep on swept wing airplanes, as the oversweep takes effect, basically you have one wing that's more effective than the other, and it induces a roll as a result of that side slip, that causes one wing to get out into the airstream more effectively, should I say. And so -- but from a pilot's point of view, if I needed some roll and I've exhausted my roll controls, I'm going to put in a little rudder, possibly, and it depends on the situation, but possibly put in a little rudder to help that roll control if I need that. So I don't sit there and think about am I in a side slip, am I not in order to induce this roll at that point in time. I'm trying to arrest an uncommanded roll.

Q Now, in the presentation, the classroom presentation of the AAMP that we saw saw some clips of, is the mechanism that I described and that you reworded, is that gone through in the presentation -- this mechanism, the physics of how the different roll is applied?

A In detail. There's a -- the tape in the mechanism -- the full class of the AAMP program, the ground school presentation, that's full day of classroom instruction, the very first part of it spends a great deal of time building a foundation in aerodynamics and how airplanes move through the air and what they do, and the effects of the control surfaces on that movement through the air. And so during that time, there's a great deal of effort and instruction spent on the subject, yes.

Q So then you, I assume, feel that many of the pilots who have been through the program have the same understanding of the mechanism by which the rudder produces roll as you just described, verbalized for us?

A I think the pilots understand that the rudder can induce roll, yes. I can't speak for what they retain as far as being an aerodynamicist, you know, the exact nature of why that rolls, but I think they know that the rudder can get them roll, I do believe that, yes.

Q But do you think there's an understanding, though, that the rudder is not just a power boost for the wheel, that there is a difference in how it produces the roll, or do they think that well, it's like getting a boost on the wheel and you get more effect from a wheel by adding rudder?

A I think that their first instinct is to use, if they're trying to roll the aircraft, their first instinct is to use the roll controls, the aileron/spoiler. Do I think that they think that's a power boost for that, no, I don't think that's it. I think most pilots realize it's a secondary effect of what the rudder can do.

Q Hold on a second. Also, yesterday, Captain

Rockliff testified that it was his understanding or idea that the pilots flew or maneuvered aircraft by feel more than numbers -- I'm paraphrasing what I understood him to say. And I'm sure you heard his testimony. Would you agree with that characterization?

A I think we have very precise -- well, I don't think, we do have very precise roll instrumentation in the aircraft, and we have very precise pitch instrumentations in the aircraft. As it relates to rudder, I would agree with his statement that I think pilots do, once again, it was what I spoke to earlier, that they feel a side slip or a yaw acceleration on the aircraft first by feel, and correct for that by feel, because we really don't have any exact instrumentation until you kind of get the airplane back into coordinated flight, and then you can fine tune it with this trapezoidal index we talked about, or the ball in most airplanes, as it's called.

Q So I guess at least for the type of maneuvers we're talking about, that certainly by feel or the -- I think he also used words like the gain of experience over time -- that that's how one flies, more than reference to instruments or precise numbers. Is that right?

A In particular in reference to an upset, it's more of a procedure. Certainly we can't teach the pilots how it feels to be in an upset. We're not going to take an airplane up there and do that with our pilots. So do they apply that particular procedure by feel? Probably not. They just execute it as the procedure is written. So I don't think they fly that part of it by feel. But I think under normal flight conditions, that they do fly, and particular with yaw accelerations, by feel, yes.

Q Thank you. I guess since we've -- since the large part of the yaw or these maneuvers are flown by feel or experience, and I may have understood that the initial kind of instinct response might be the proper procedure, but then the -- in the degree or amount of rudder sort of like Dr. Brenner was talking about, and the amount of rudder to apply and these sort of things is learned by feel. I guess the question would be what opportunities do pilots have to acquire a feel for the roll response of the airplane to the rudder?

A Probably not that great of an opportunity. They do, as they fly on a normal basis, maybe have one engine that's producing a little more power than another one and so you'll get some side slip or some yawing in the aircraft, and so you do trim that out, and the other times that they really use the rudder is doing cross wind take off and landings, and I suppose that's really the only time that they get the chance to feel what the rudder does.

Q And those examples ... eliminating side slip and actually rolling the airplane?

A Yes.

Q I think you mentioned that the roll upset training was I guess maybe a total of 15 minutes once every nine months or so. Is -- I guess two questions in one, is that the opportunity for pilots to get a feel for the roll response of the airplane to rudder? And is there anything beyond that -- beyond those -- the roll upset training -- where they would have the opportunity to experience the response to the airplane rudder?

A In relation to rolling aircraft with rudder?

Q Yes.

A Obviously, the simulator is very difficult to simulate feel, accelerations, on your body, so that's not a very good tool, but it is the best tool that we have available to simulate those type conditions. For a pilot to experience what the airplane does or how it rolls with use of the rudder, there's just not many opportunities to do that.

Q I think the simulator can be used for

training for proficiency, I believe is the term used, is that correct, for some maneuvers?

A Some maneuvers it is training to proficiency, and it is used for that.

Q Like cross wind landings or landings, period.

A There's a long list of things such as that, and engine failures, and control malfunctions, and instrument approaches of different types, precision and non-precision, et cetera.

Q These train for proficiency maneuvers, there's a large exposure to the maneuvers -- and in these maneuvers, I guess when we say pilots are trained for proficiency, they are trained to acquire a feel for the aircraft for those maneuvers, is that correct?

A I don't know that they're trained to the feel of the aircraft or not, but there are some standards of what the FAA has established which those pilots must meet those standards in order to continue on in training, or they receive additional training to meet those standards. I don't know that we have a simulator available to us anywhere in the world that can simulate the feel of an aircraft as it pertains to Gs or et cetera.

Q I understand in terms of G loads, but for example, like the landings, I understand that a pilot can, you know, his first landing in a new airplane can be with passengers on board because they -- they have a lot of practice landings in the simulator.

A The FAA comes to our facility and they validate and approve our simulator, and in certain maneuvers, of which landing is one of those maneuvers, they validate it and say that the simulator replicates the airplane close enough that your previous statement is correct.

Q So my final question then, to kind of bring this into focus, that is comparing the amount of experience pilots have, say, in training for proficiency for landings or other maneuvers, compared to the amount of experience they get to experience the airplane's response in roll, what's the -- what's the difference there? Is there a large quantity of difference in the amount of exposure they get to those two types of maneuvers?

A There is. For certain malfunctions and certain maneuvers, we give them a great deal of time in the simulator. In this particular case, with upsets, obviously, it's not a great amount of time. We don't ever expect our pilots to find themselves in an upset, and we hope that they wouldn't. But the simulator, our primary focus on upsets is recognition -- to avert the upset before it ever happens, and then of course, if they do find themselves in an upset, then to apply the procedure. But -- long winded to say no, some of the maneuvers that we conduct in the simulator we spend a great amount of time on, and others we do not.

MR. O'CALLAGHAN: Thank you very much, that concludes my questioning.

CHAIRMAN CARMODY: Thank you, Mr. O'Callaghan and I know there may be a couple more questions on the technical panel but I think I'll go ahead and have a break now. I think the witnesses need it. I know we need it, and the parties would appreciate it. So let's come back -- before we get up, though, let me make a few announcements, please. When we return, I'm changing the order of the parties because traditionally the last questioner will be those whose witness it is, so at this time American will be last. Why don't we start with Airbus, FAA, Allied Pilots, and American in that order after the break.

Two more things: we're going to move some witnesses order. We'd like to move Mr. Rackers (ph), who is currently number 11 to a position between witnesses 15 and 16, which is Kurbit Kubian (ph) and Curlin and 17, Ilkowitz (ph). So this will put Mr. Rackers (ph) between those two. This would put all the composite witnesses in one group, and we understand this is fine with Mr. Rackers (ph). We're also proposing to move Mr. Proctor who is currently 14 to position following witness 6. Now we're looking for Mr. Proctor, but we understand he is prepared. Mr. Proctor is okay with this, so we'll get a new witness list, but I just wanted to make you aware of that.

Also, those parties who made -- or those witnesses, rather, who made presentations today and yesterday, please be sure we have copies of those for our hearing record.

And last, I understand we have some visitors here from the Korean Air Accident Investigation Board, so we'd like to welcome them, and we're very glad they're joining us. Thank you.

Fifteen minutes, please, quarter to eleven.

(Whereupon, a 24 minute recess off the record was taken.)

CHAIRMAN CARMODY: Let's resume the witnesses from American who had a break, so I trust we're all refreshed, and I understand there were just a couple more questions on the technical panel.

CAPTAIN YOUNG: Madam Chairman, the witness, Delvin Young here.

CHAIRMAN CARMODY: Yes.

CAPTAIN YOUNG: I did want to clarify one line of questioning that Mr. O'Callaghan had asked me about -- use of the rudder and whether the students and the pilots in the simulator could -- if we did any exercises or anything to help them know how much roll control the rudder would give them. And outside of what we've already spoke to, we do an exercise where we do some turns with aileron and spoilers only, and then we do them with rudder and aileron and spoilers to show the effectiveness of those rolls. So I just wanted to clarify that.

CHAIRMAN CARMODY: Alright, thank you. Now, the technical panel, was it Mr. Jouniaux has some questions? Please proceed.

MR. JOUNIAUX: Thank you, Madam Chairman. So I would like to come back and go a bit further to address the actual simulator training exercises and techniques and the feel the pilots can have from that, which -- so which operated to the crews, especially with the wake turbulence,, and for that I will refer to the Exhibit 2-B and in particular, page 12, 17 and 19. So the interviews in the Exhibit are with American pilots -- airline pilots who had recently followed the AAMP program.

First, I would like to refer to the -- to page 17, which -- yes. I can read it, a small quotation. It says, "wake turbulence" -- one of the pilots says, "wake turbulence is used in the simulator to lead to an upset situation". So my question first go to Mr. Ghoshal --

CAPTAIN YOUNG: And you're on page 17, is that correct?

MR. JOUNIAUX: Page 17, correct.

CAPTAIN YOUNG: Okay.

QUESTIONING OF MR. GHOSHAL

BY MR. JOUNIAUX:

Q So my question to Mr. Ghoshal will be, does this wake turbulence scenario combine the pitch and roll event you describe or just one of those?

A As I explained earlier, we do not have wake turbulence as such. We have two separate scenarios, one for pitch upset and one for roll upset. They are separate.

Q Yes, but does -- when this pilot refers to wake turbulence, does they mean that they are pitch and roll at the same time?

A You cannot have two at the same time, so I don't know what he means, really.

CAPTAIN YOUNG: And I will further explain that is that there is a button on the instructor's panel, or there was at the time, to either select either the pitch maneuver or the roll maneuver. Now the roll maneuver, depending on how the pilot reacted, if it did get greater than 90 degrees, it could end up in a nose low condition.

QUESTIONING OF CAPTAIN YOUNG

BY MR. JOUNIAUX:

Q I will refer to page 12, then, it's the sixth paragraph. It says "wake turbulence training includes simulator training of some extreme unusual attitudes for wake turbulence encounters. For example, a nose down roll to an inverted attitude." And the next paragraph, about wake turbulence and this pilot mentioned that "the simulator ride included an unsuspected unusual nose high attitude" and then he describes the recovery, so that leads me -- "Recovery was to add power and ... relative to the horizon."

So this leads me to the next question, so from this interview, it seems that the feedback it seems like we have from the pilot is very different from what was presented in the AAMP ground course that say that for the wake turbulence has limited upsets on aircraft, but this it seems that these pilots associate wake turbulence with large upset. And the second is said in the ground course that in high pitch situation you train pilots to use aileron to roll the aircraft first towards the horizon. Here it seems that the understanding of the pilot is to use rudder to go towards the horizon. What are your comments about that?

Q The wake turbulence here -- and as I said that for the rolling maneuver in particular, we do not introduce any other type of aircraft malfunctions like hard over rudder, so, and the weather -- the instructor generally sets the weather fairly clear. So, to just be flying along and all of a sudden it just goes out of control or it goes into some type of upset maneuver, what the instructors do to kind of set it up is that they -- they don't always, but I'm sure many of them do say you're following a heavy jet, some use actually the 747, and you're cleared for takeoff and then they go and execute the roll maneuver.

Now -- and I know there's a lot of talk right now, certainly, about this roll maneuver exercise. Our objectives were to get them past 90 degrees, 90 degrees or greater is the exact of what we were trying to do, because of some accidents. There are several ways you can do that. You can have the instructor fly it there and freeze the simulator and put him there. You could have the other pilot put their head down and have the pilot not flying put it there, or have the pilot flying close their eyes and give it some turns and different things, and as a standards manager, and all along as an instructor, I'm always working with trying to standardize our training. We have -- at one time we had nearly 15,000 pilots -- 14,000 and some pilots is what it was, and so standardization is a huge issue. And so to -- we felt that this was the best way to standardize the training to make sure everyone got exactly the same thing, and we chose this method to put them in that particular upset. The fact that the instructors used the words wake turbulence or whatever -- and I don't think any pilot out there thinks that -- I mean they experience wake turbulence all the time. I'm not for sure that a pilot thinks because they get into wake turbulence they're going to end up upside down. I don't think this training predisposes them to that.

Q I mention that because we have around six interviews referring to the same scenario for upset exercise.

A Agreed, and I think that most of the instructors probably do say that, hey you're clear for takeoff, you're following a heavy jet or whatever it might be.

Q This is my last question, in the light of these statements, can you describe what type of guidelines were given to the instructors before they delivered this training program?

A There was a -- the instruction that you saw before, the instructor gave training to all our instructors -- ground school check airmen as well as numerous other instructors, not only from American Airlines, but from several airlines and agencies -- FAA, NTSB -- many in this room today have received that instruction. And then, obviously that one instructor, Captain Vandenberg, could not give all -- all of our -- every single pilot instruction in the simulator, so it cascaded down to them in the simulator. Does it make sense.

Q Do you use any guideline -- written or something given to the instructors to teach these kinds of exercises?

A The guideline is the procedure out of the operating manual for nose high and nose low, and so that's really the guideline. As far as the maneuvers, prior to 587, we had these preprogrammed buttons so we have a worksheet that requires the instructor to complete, and on one of those -- on the worksheet is these upset maneuvers, and so the instructor would just go to that page on the instructor panel in the simulator and select either a pitch or a roll maneuver.

Q And how do they teach to recover from this situation?

A They teach from basically the procedure, and if you follow the procedure step by step right down the line, it's an effective tool for how we recover from these upsets.

MR. JOUNIAUX: Thank you, Captain Young.

CHAIRMAN CARMODY: Thank you. Anything else from the technical panel. Alright, in that case we'll move to the parties and start with Airbus. Any questions of the witness?

DR. LAUBER: Thank you, Madam Chairman. Yes, I have several questions I'd like to ask Captain Young and Mr. Ghoshal.

QUESTIONING OF CAPTAIN YOUNG

BY DR. LAUBER:

Q Captain Young, yesterday Captain Rockliff testified that -- with regard to AAMP -- it was his opinion that in general, and in many ways the program was very good, and in fact, I think he commended American for taking the action to put such a program in place. But just to make sure it isn't the concept of AAMP that is of concern, but we do have some specific concerns, as he stated, about what was taught and what was learned with regard to use of rudder, and how that ties into simulation, and how that ties into wake vortex recovery procedures, and how it might be related to the accident. So that's what I want to explore with you a little bit further in my questioning.

First of all, with regard to the timing, do you recall when Mr. Molin took the AAMP program? When he took the course?

A Yes, sir, March of 1997.

Q And you testified earlier that changes were made to AAMP with regard to the -- to what was taught regarding rudder use when, Captain Young?

A No, I didn't testify that changes were made to the content of the program. I said the supplemental material, which was the AAMP booklet, workbook, that bullet statements in there, that the wording had been changed to clarify what was already being taught in the course.

Q And specifically it had to do with coordinated rudders, is that correct?

A It added coordinated rudder, and there have been other changes over time.

Q So that coordinated rudder as it's now used in AAMP is the conventional definition of coordinated rudder, is that basically correct?

A Well, I know on the video clip there, Captain Vandenberg said that today that's what he was talking about, coordinated rudder, and I think I've already answered what I meant by -- personally, what I meant by coordinated rudder. What Captain Vandenberg was speaking to was a very unique situation that involved high angles of attack, and what he was talking about there.

Q In any event, those changes and the warnings, by the way, that were added to the video, came after Mr. Molin took AAMP, is that correct? Changes to the supplemental material and the video?

A The clarification of what was already being taught in the class came -- I mean it's evolved over the years and that tag on the end of the video which was distributed in December of 1997 to every American Airlines pilot -- that tag was just to reiterate and to restate what had already been said in the program, as a result of the feedback from the four signatories on the letter there of August of 1997.

Q With the added caveat with regard to use of rudder. That was the tag on at the end.

A Well, there were other tags ons..

Q Okay, well, do we know whether Mr. Molin

actually ever looked at the video, saw the video?
A No, sir, I have no way of knowing that.
Q And in fact, his first exposure to AAMP was March of '97, he saw the full blown high test version, basically, is that correct?
A Yes, sir, he saw the full eight hour ground school.
Q And when would he have had his simulator exercise relative to AAMP?
A The simulator exercise.
Q Yes, when would he have experienced the roll upset recovery to be specific, or the wake vortex recovery procedure in the simulator? When would he have had his first exposure to that?
A It would have been during his normal recurrent training or if he was upgrading on an aircraft or transitioning to a new aircraft, he would have had the AAMP maneuvers or the AAMP training then in the simulator.
Q Would he --
A Wait -- vortex training -- I just want to make that clear.
Q Was he in transition training during this period?
A No, sir, I don't think so.

Q Are you familiar with the law of primacy as a training person? Does that mean anything to you?

A I've heard of it one other time as they spoke during -- for this investigation, or during this investigation I had heard that you had spoke of it at one of the meetings. And that's the only time.

Q Do you have a working understanding of what it means or do you have an understanding or a definition of what the law of primacy is about?

A I am not a psychologist, nor a psychiatrist, so --

Q So you don't recognize that the basic principle is that people tend to remember best that which they hear first?

A I know basically that pilots have a pretty short attention span, and so if you're going to say something important you'd better get it out early.

Q Right. Can't argue with that, Captain Young. Can't argue with that. I'm interested in what appear to be different -- I'm trying to understand exactly what was and what wasn't taught with regard to use of rudders, and I want to start with this notion of coordinated rudder. Could you look at Exhibit 2-B, page 45, please?

A Yes, sir.

Q Okay, specifically, page 45 if I didn't say that, sorry.

A I have it.

Q And starting right at the top of the page. This is an interview of Captain Landry. First of all, who is Captain Landry?

A Captain Landry, at the time of this interview was the managing director of training for American Airlines.

Q Managing director of training. Okay. Could you -- could you take the second paragraph, and just read for us, please, what Captain Landry said. First two paragraphs.

A The first two paragraphs?

Q Yes.

A From Captain Landry, and let me see what the question was.

Q I'm sorry, we have a discrepancy in the page here. What I have as Exhibit 2-B circled page 45, okay, let's go to the top -- that's still wrong, it doesn't -- I don't know how to resolve it here because this is the Exhibits that we have, 2-B, 45, Captain Landry interview, and it's Mr. Ivey doing the questioning -- it's page 284 of the original operations group interview notes if you have that. Try page 42.

I'm told -- yes.
A I think I have what you want here in front of me. I'm not for sure they can display it up there.
Q Okay, do you have the paragraph that begins "If you're talking about -- well, I think what Warren said..."?
A Yes, I do.
Q Okay, would you read that for us, please.
A It says, "If you're talking about -- what -- well, I think Warren said it well in his lecture when he talked about coordinated rudder. I think he gave a great caveat right off the bat and said that when he talks about coordinated rudder, he's talking about rudder in the same direction as the ailerons."
Q So would you continue down in the second paragraph, just read the last sentence in the second paragraph, please.
A The last sentence in the second paragraph is, "I think he gave a great caveat right off the bat and said that --
Q No, I'm sorry, in the -- down there, the last sentence --
A I'm not sure where there is, can you specify?
Q Where the arrow is on the display up there. "So my impression of what Warren has been saying ..."

A "So my impression of what Warren has been saying about coordinated rudder has to do with rudder in the direction that you want to roll, i.e., the same direction that the ailerons are going."

Q Okay, in that context, I know you played for us a number of excerpts from the video that had been made of Captain Vandenberg's lecture, there are some segments that you didn't show. In one of them he says, with reference to the recovery from an inverted nose low attitude, he says, "I'm going to tell you to put in coordinated rudder, put it fully in, fully, all of it, right now. As many of you know, the rudder in this portion of the roll becomes what acrobatic pilots call top rudder" -- and he goes on to talk about the idea that somehow during the recovery from an inverted turn, the little bit of rudder back there is going to hold the nose of this transport sized airplane up in the air.

But in any event, he goes on to say, talk about "When you pull back, what goes up? Angle of attack. When angle of attack goes up, what rolls the plane? Rudder. Exactly, and that's rudder all the way in and it will whack. It will try to snap roll. That's fine. Just neutralize the rudders real quick."

Do you have any reaction, first of all, to any of what Captain Vandenberg says in the video in this context?

A In the context of top rudder, that's a very, very specific, unique situation. I think getting a transport category airplane upside down is very unique in itself and it is an extreme condition that it needs immediate attention. I don't think there's any pilot in here that disagrees with that. And specifically, talking about top rudder, if you're concerned about the nose dropping through and getting nose low, then top rudder may help you preserve your nose up to assist you in this recovery, as it pertains to top rudder there.

Q But would you agree that his description about how to do it, right now, fully, implies certain aggressive input on the rudder?

A Would it imply aggressive? I mean as you state it right there, I would say yes, but to further that, prior to this accident, as a pilot, I didn't know you couldn't do that.

Q You couldn't do what? Sorry.

A Be aggressive with the controls at the speed that we're talking about, when you're slow and a high angle of attack.

Q I don't know what's in the record that says you can't be aggressive with the rudder with angles --

any normal flight angle of attack. I don't know where that comes from. You might want to share that. I don't understand what your reference is to you weren't aware of a prohibition about the aggressive use of rudder in flight.

A You made reference to whether I thought this was aggressive and whether that was appropriate or not.

Q Right.

A Prior to this accident, I had never heard anyone speak of, or never had -- we had never had official communication with the manufacturers about the aggressive use of rudders.

Q Well, we, yesterday, spent some time going over the record with regard to written communications on that and I won't pursue that further here. The point is, with regard to what Captain Vandenberg taught with regard to rudder, in this context as we just discussed it, is that basically he was advocating open loop control of the rudder. Would you agree with that, based on the discussion we had on open and closed loop concept yesterday?

A You're going to have to refresh my memory about open loop/closed loop -- exactly what you mean by open loop.

Q In closed loop control, you're using the control to achieve some desired aircraft performance objective. Maybe a yaw rate, it may be a bank angle. In open loop control, you're basically going to the stops, if you want, there's no specific performance objective in mind other than moving the control to some specified position. Based on what Captain Vandenberg has described as coordinated rudder, isn't that an instance of open loop control that he's advocating with regard to rudder?

A In what you just said in describing open loop, the objective in a very special case of where you're concerned about getting the nose excessively low, the use of -- if you will -- and I'm not that familiar with open loop/closed loop controls -- but in the context that you just explained, I would say that he did want to go to full control of the rudder, or to the stops on the rudder to help hold the nose up so that it did not get excessively low.

Q Fully and quickly was the way he advocated it in the video. His words.

A I don't have that available to me right now, if you say so, then I will trust your words.

QUESTIONING OF MR. GHOSHAL

BY DR. LAUBER:

Q I'd like to pursue the issue of simulation and the role that it played in all of this, including how rudder was taught and the issues of the roll maneuver and the function button that we've heard Mr. Ghoshal describe for us. Spent some time talking about the fidelity of simulation based on data packages provided by simulator manufacturers, is that -- that's part of what we spent time talking about. And the focus, I think, of your comments, Mr. Ghoshal, had to do with the aerodynamic part of the simulation, isn't that correct?

A All the systems, really. Not just aerodynamics -- hydraulics, pneumatics, auto pilot -- everything comes from the aircraft manufacturer.

Q Correct, as far as they can be replicated in the cockpit, correct?

A Yes.

Q So aerodynamic data would show up in the form of changes in aircraft performance, instrument readings, attitudes, air speed, altitudes, and similar kinds of things, right?

A Yes.

Q But in the real world, in the real airplane, what's correlated with any kind of motion of the airplane, are also accelerations experienced by the pilot as he's strapped in his or her seat in the airplane, isn't that correct?

A I'm really not a pilot, but yes, there are simulator limitations for acceleration detection, if that's what you're getting at.

Q And are those capable of replicating the full envelope of accelerations that could be experienced by the pilot in flight?

A There are limitations in flight simulators where both translational and rotational accelerations cannot be maintained.

Q In fact, basically because of the limited motion capability of simulator platforms, all you can really provide are the onset cues, the onset acceleration cues, and you can't sustain any lateral, vertical or longitudinal G forces for any period of time, is that correct?

A Yes.

FURTHER QUESTIONING OF CAPTAIN YOUNG

BY DR. LAUBER:

Q Captain Young, as a pilot, aren't those forces of particular importance in helping the pilot determine which direction his airplane is going and what his attitude is in energy state, and similar kinds of things? Isn't that an important source of information for the pilot?

A It can be an important source of information, but we've all probably experienced vertigo, certainly in jet aircraft, so those are not always the only cues that you get, and -- and there's no doubt, when we train pilots, there are simulator limitations where it is not 100 percent replication of the aircraft. There has not been one built on this earth that is 100 percent replication of the aircraft. So, of course it's not going to replicate it exactly.

Q I'm glad you brought up the question of vertigo because I was going to ask you if you've ever personally experienced vertigo, or "the leans", or it goes by a number of common terms among pilots. You were a military pilot at one time, I believe, is that correct?

A You are correct.

Q And you have or have not experienced vertigo?

A I have.

Q Spatial disorientation?

A I have.

Q And generally, what are the consequences of that?

A Consequences?

Q Right, what are -- how does it affect you in your ability to control the airplane?

A If you get "the leans" as you mentioned, or vertigo, you're taught to get back on the instruments and look at the instruments to regain situational awareness, and if you will, repage your own personal gyros.

Q So the point is that the precipitating event for vertigo or spatial disorientation is often a conflict between what the pilot is seeing and what the pilot is experiencing through the vestibular system that senses acceleration --

CHAIRMAN CARMODY: Excuse me, Dr. Lauber, I wonder if you might refine your questions a little bit. You're doing a lot of explaining and analyzing and the witness is just being asked to agree or disagree. I'd prefer you ask things he can actually comment on.

DR. LAUBER: Okay, fair enough, Madam Chairman, I'll do that.

BY DR. LAUBER:

Q You understand what causes vertigo?

CAPTAIN PITTS: Madam Chairman, if I might, this line of questioning -- this airplane was --

CHAIRMAN CARMODY: No, I'm sorry. It's not appropriate for you to object to anyone questioning. I did point out that I think Dr. Lauber needs to refine his questions and not testify himself, but as we agreed at the prehearing conference, objections are not part of this proceeding. This is an informal proceeding, not a courtroom, so we can talk at the break if you have any specific concerns.

CAPTAIN PITTS: Thank you, Madam Chairman.

CHAIRMAN CARMODY: Thank you.

BY DR. LAUBER:

Q Do you understand what causes vertigo?

A I understand, I had military training in what causes vertigo, to a certain extent. I am not a medical doctor, but my own personal experience with vertigo, it generally centered around, usually, weather, that there was no clear horizon, or you were in the weather to where you were depending on the instruments. Generally what I found was that, kind of, if you will, marginal weather was worse than very bad weather, because in very bad weather, you stayed on the instruments all the time, so you maintained your situational awareness. In good weather you had the sky and the ground, and the horizon, and some things -- visual cues outside, so my own personal experience is primarily during marginal weather was when vertigo was experienced.

Q Do you think it's possible that a pilot who's only experienced extreme attitudes, inverted attitudes in a transport carrier airplane, for example, in a simulator might be surprised or even disoriented by the different forces and accelerations that he or she would experience when that same situation occurs in an actual airplane?

A I think the forces experienced in an actual airplane, outside of the normal flight envelope where we normally fly, you know, with a very small amount of positive and less than one G, forces outside of that, I think, would cause a pilot to -- I think they would be -- I don't know if I would use the word surprised, I'm not for sure that's an accurate term, but it would be unfamiliar.

Q And that sometimes causes surprise, is that -- and that's your testimony, right?

A Are you telling me, or are you ==

CHAIRMAN CARMODY: Dr. Lauber, ask the witness, please.

DR. LAUBER: I'm sorry.

BY DR. LAUBER:

Q Well, let's move on to another area here. And we're still dealing with the issue of simulator fidelity and how it might affect the lessons that trainees take away from the simulator. Could you show Exhibit 2-B, and I hope the page numbering is correct -- the page I have is page 64, circle page 64. Now this is correct, right.

I'd like to -- we're talking here, this is an interview with Mr. Cook. Down in the middle, Mr. Cook is being interviewed by Mr. Ivey and would you read the paragraph that begins, "And I think what I see.."

A "And I think what I see is most pilots put in the correct amount of bank angle and rudder that I think the airplane would require, and then I have to -- I'm sitting in the instructor's seat, which is right behind the Captain, and I just, in a very calm voice tell them, more rudder, more rudder. And then I go through again, that I don't believe that the aircraft without some type of structural problem would require that much rudder."

Q Would you turn next to page 67, same Exhibit? And who by the way, is Mr. Cook?

A Mr. Cook is one of our simulator pilots for American Airlines.

Q Page 67, and it's Mr. Cook, "In the simulator" it begins. Would you read that for us, please?

A "In the simulator, it's difficult, I believe.

In the airplane, it -- I think it's easy to determine the amount of rudder necessary to keep the turn coordinated. We all learned it when we first started flying."

Q Okay, and could we next go to page 68, please? Okay, on page 68, Mr. Cook -- "The airbus requires more rudder" -- see that right down there near the bottom, right of -- kind of in the middle?

A "The airbus requires"?

Q Yes.

A "The airbus requires more rudder -- the simulator -- now that's only during the pitch up maneuver, the way it's programmed. If they get the nose high in another situation, then it reacts more like, I believe, the aircraft would."

Q Doesn't it seem in all of these that -- what's your take away from this with regard to Mr. Cook's view about the fidelity or the faithfulness of the simulator and the ability to deal with the situations or replicate the situations that are involved in this training scenario?

A I think Mr. Cook thinks there's some limitations to the simulator.

Q And with regard to the simulator and simulator data, Mr. Ghoshal you testified that the data package that you use is provided by the manufacturers, and you indicated -- one of you, it may have been you, Captain Young, indicated in your testimony that you had invited Airbus and the others to review the alpha and beta data with regard to that simulation, is that -- do I remember that correctly?

A Yes, sir.

Q In what form was that invitation extended to Airbus?

A In the response letter to the August 1997 letter, there was a statement in there by our Vice President of Flight at the time, in inviting the manufacturers to review -- or actually, the manufacturers and the FAA -- all four signatories -- to review the simulator data, and the exercises that we were performing at the time for AAMP.

Q Could we provide the witness with Exhibit 2-C, please, which is the letter in question.

CHAIRMAN CARMODY: Dr. Lauber, we did discuss this issue extensively yesterday as I recall, so I hope we're not going --

DR. LAUBER: Not this specific issue, Madam Chairman.

CHAIRMAN CARMODY: Alright. Well, let's not -- I would urge you to read the section you're concerned about rather than have the witness read all of this information.

DR. LAUBER: Well, I -- okay.

CHAIRMAN CARMODY: Thank you.

BY DR. LAUBER:

Q Do you have page nine in front of you?

A I'm looking at page nine, yes, sir.

Q Okay, in about the middle, it's the paragraph entitled "Use of simulators" and it begins, "The AAMP program" -- the very last sentence in that paragraph says, "On your next visit to our flight academy, we will be pleased to show you the beta readouts during this event." Is that the invitation that you're referring to, the reference?

A Yes, sir, and you have to understand that. I know these letters have been suggested that this was the only communication going on between the manufacturers and the users and all the other airlines. That is clearly not the case, that there was a lot of dialogue -- phone calls, letters, e-mails for sure, and there was a lot of dialogue because this was an industry concern at the time, and as I've heard in other statements, we didn't know the exact answer -- and I'm saying we as an industry, and we were trying to prevent what it -- there was a history of loss of control accidents. So -- yes, that was the invitation, but I am positive that there were other invitations afforded to the manufacturers through conversations, et cetera.

CHAIRMAN CARMODY: Excuse me, Dr. Lauber, I beg to differ, we did discuss this yesterday because my colleagues had highlighted that very section. So the point's been made. I think we need to move on to things we don't know already, and the time is getting late and this is our --

DR. LAUBER: Okay, I understand.

CHAIRMAN CARMODY: -- fifth witness, so let's move please. Anything new, please, and if not, we'll pass to the next party. Thank you.

BY DR. LAUBER:

Q With regard to the AAMP handout, Captain Young, you had a slide that you had put up that showed -- you said an F-100 basically, sized airplane, behind a larger aircraft.

A Yes, sir.

Q That is Exhibit 2-D, page 55.

A Yes, sir.

Q Would you go -- could we put that up on the screen please? The Exhibit handout we have is not page numbered, it just says page 55. It's page 55 from the original AAMP booklet.

CHAIRMAN CARMODY: Is this the correct Exhibit that's on the screen now?

DR. LAUBER: I don't see one, ma'am.

CHAIRMAN CARMODY: There.

DR. LAUBER: That is the correct one.

CHAIRMAN CARMODY: Alright.

BY DR. LAUBER:

Q Captain Young, is there a difference between this diagram and the one you had shown earlier?

A Yes, there is.

Q And what is that difference?

A The difference is -- the generating aircraft is still the same, the MD-11, the McDonnell Douglas 11, but the aircraft is further inverted to 120 degrees of bank as opposed to what appeared to be 45 on the earlier one.

Q Are you aware of any upsets involving a heavy transport like the A300-600 that takes -- took the airplane to extreme bank angle such as depicted here?

A I am not personally aware of any upsets of an A300 that took into extreme angles, but -- and you have to understand, and I mentioned this early in my testimony, that wake turbulence -- that this was a --

the AAMP was a generic program that talked about -- to all of our aircraft, which at the time, we were very concerned -- we had some aircraft that had shorter wing spans that were susceptible to upsets by large aircraft, and specifically the Super 80 and the Fokker. But we never suggested that a wake turbulence would absolutely put you in an upset condition.

Q But did you tailor AAMP at all to specific airplanes, take into account characteristics, differing characteristics such as the one you just talked about?

A The -- for wake turbulence? No, sir. There was a generic discussion during the ground school presentation.

Q Mr. Ghoshal, with regard to the data package that comes from the manufacturers that provides the basis for your simulation, with regard to the modifications that you made, that is basically the inhibition of all rolling moments as we understood it, and as you described it, was Airbus -- did Airbus -- were we asked to provide or did we provide any data with reference to that specific modification?

MR. GHOSHAL: No, sir. Does not need it.

BY DR. LAUBER:

Q Captain Young, has anyone told you in any of your base visits, or any of the other contacts that you've had subsequent to the accident involving flight 587, that if in fact the pilots of 587 had -- did make full rudder input to recover from upset, they only would have been doing what all American pilots had been taught in AAMP. Has anybody ever said that to you?

A Not to my knowledge. AAMP spoke specifically to high angle attack in reference to the rudder. As I stated earlier, I don't think airline pilots, or pilots of transport category airplanes are just going to categorically put in the rudder unless there is a reason for that, i.e., a side slip or a yaw acceleration. I think they will try and correct that situation, the yaw or the side slip, back to a zero side slip condition, back to coordinated flight, if you will.

DR. LAUBER: Thank you. Madam Chairman, I have no further questions.

CHAIRMAN CARMODY: Thank you, I'll move to the FAA, Mr. Donner, please.

QUESTIONING OF CAPTAIN YOUNG

BY MR. DONNER:

Q Thank you. I have just a couple of questions for Captain Young. Sir, you mentioned, I believe, that the flight controls of the A300 were -- I think your words were -- more powerful than other aircraft in the fleet. Is that correct? Did I hear that?

A No, it wasn't exactly. I said that when you fly the aircraft, the controls feel powerful and the way I described that is when you make a turn or something, it takes a very small amount to get a large or a reasonable output, if you will. If you put in a small amount of aileron, you'll get some roll associated with that, and it takes a small amount, that you feel that if you would put in a great amount, you would get a large rolling moment.

Q Would more sensitive be an appropriate term for that?

A Possibly.

Q My real question is, did you find in your experience in the training department that your pilots had a difficult time adjusting to this -- whatever we should call it -- power or sensitivity?

A No, I haven't seen that nor have the check airmen or instructors that I have working for me, have they indicated that pilots have had a problem transitioning from the simulator to the aircraft in that respect.

Q Thank you. You mentioned the turn demonstrations where you used aileron and spoiler, and then you did it again with aileron, spoiler and rudder.

What speeds were used for those demonstrations?

A I'd have to look at our training program, but it was relatively slow speeds with high angle of attack. I'm not exactly sure of an exact speed.

Q It was a high angle of attack maneuver?

A Yes, sir, it was relatively slow speed.

Q Thank you. In light of what we've said today and the mention that the simulator setup is to mention that you're following a large -- a heavy aircraft to prepare for this maneuver of the upset in your simulator, are you considering changing the words on that or creating a different scenario in light of what you heard here?

A The words on the instructor's panel say roll maneuver, and we took that right out of the HBAT, the 9510, and the same thing with the pitch maneuver -- that's what the instructor selects. Do we talk more about that? Yes, we do because we understand more now than we did a year ago about rudder and sensitivity of rudder and rudder reversals and doublets et cetera.

Q No, I meant more specifically your setting up the crew to anticipate a wake turbulence encounter, and then you give them a resulting upset. Are you considering making any changes to that scenario?

A Well, we have changed it right now. The preprogrammed buttons that we disabled after the accident, we disabled them from the instructor, and so we're in the process, as I mentioned earlier, there's several ways you can set up an upset maneuver, and we had chosen, and we thought for standardization reasons as well as others, that the preprogrammed buttons were the best method. We're in the process of evaluating another method now, of which they wouldn't have wake turbulence because what we do is reverted to kind of an old military way of doing it, of having one pilot close their eyes and put their head down, and the other pilot put them in that maneuver. At the end of some of this we will determine which is the best way. What we're concerned with in that is standardization, because we want every single pilot to get a very standardized training as they go through and if one -- and in the method we're using now, if the pilot didn't -- you can't always -- how should I say this -- you can't always assure that every pilot gets exactly the same thing.

Q Understand, and I think I'm still not making my point.

A I'm sorry.

Q My point is that you're preparing your crew for a wake turbulence encounter by saying he's following a heavy jet.

A We don't do that now. That's what I'm saying.

Q You don't do that now? You don't use those words any more?

A No, because the preprogrammed buttons have been removed from the instructor's panel so -- and there's no way to really induce it other than flying it into an unusual attitude or an upset procedure.

Q Okay. Another subject. Mr. Ghoshal spoke to the fact that the FAA has not required any changes to the simulator software since this accident. Have you become aware of any changes the FAA has requested or suggested since the accident, in your training programs, on the use of rudder? And I'm speaking specifically at FAA notice A428.

A I don't have that in front of me, so I'm not sure what it says.

Q I'll be happy to provide a copy at the break. Thank you.

MR. DONNER: That's all the questions I have, thank you.

CHAIRMAN CARMODY: Alright, thank you, Mr. Donner. Moving on to Allied Pilots, Captain Pitts, any questions?

CAPTAIN PITTS: Yes, ma'am, thank you.

QUESTIONING OF CAPTAIN YOUNG

BY CAPTAIN PITTS:

Q Good morning, Captain Young.

A Good morning.

Q Sir, do you think that vertigo had anything to do with the American Airlines 587 accident?

A As I said, I'm not a doctor, but my experience in the military with vertigo, as I understand and looked at the weather, it was fairly clear with discernable horizon, and I would not think that would have been a factor.

Q Thank you.

A And by that, I mean vertigo.

Q I'm going to use a model, ma'am, to help with this depiction here that we were talking about a minute ago. Now we're talking about an inverted situation, nose low, and we were talking about the use of top rudder -- Dr. Lauber mentioned this, so I'll use the model for this. Was 587 ever in a nose low, inverted position prior to loss of the tail?

A Not that I've seen on any data at all.

Q Do you think that the concept of top rudder had anything to do with the 587 accident?

A No, sir.

Q Now, in terms of how we're trying -- if we were to find a transport category aircraft in this position, would this be a normal, abnormal or emergency condition?

A I would consider it an emergency condition.

Q Alright, sir. And in an emergency situation, I'm going to ask you to think back on your Air Force training and what you're training to now. What's the first step in an emergency situation?

A First of all, you have to recognize it. And then maintain aircraft control.

Q Yes, sir. And would it be every pilot's expectation in maintaining aircraft control that he could use all three axes of his aircraft to in fact right it up?

A I think every pilot would use primary controls to always fly the aircraft.

Q Thank you. And was this the condition that was being discussed in the excerpt that was being pulled out by Dr. Lauber? An inverted condition?

CHAIRMAN CARMODY: You want to identify which excerpt so that we know.

BY CAPTAIN PITTS:

Q Well, there were so many, I'm not sure, but we moved through one, and I thought he was using a piece in the context of the training which spoke to an aircraft that was, in fact, inverted.

A Was it the picture of the AAMP workbook?

Q No, it was just in the discussion leading up to his questions.

CHAIRMAN CARMODY: Does the witness know what we're referring to? Because it's hard for you to answer if you don't.

THE WITNESS: I really don't.

BY CAPTAIN PITTS:

Q Okay, alright. Thank you very much. Yesterday we heard from the aircraft manufacturer that rudder use was appropriate to maintain coordinated flight. Earlier, you spoke of pilot's ability to sense through the seat of the pants, lateral accelerations and how they might first make an instinctive move, and then refer to the instruments for refinement. Would you agree that in an upset recovery, making the correct initial response is very important from the time to respond perspective?

A I think in an upset condition that a quick response is necessary to avert exaggerating that condition.

Q Would you also agree that the simulator is a procedural trainer to help us in training for making those decisions?

A In reference to upset training, absolutely, I think it is a very good and the best tool for procedural training.

Q There was a reference to upsets made by Dr. Lauber with transport category aircraft. Are you familiar with an Air Force KC-135 example where a wake vortices caused a violent enough roll to shed two engines off of one wing?

A I am somewhat familiar with it. I have seen some information about it, yes, sir.

Q And also possibly an Atlas Air 747 which was in cruise flight lost over 15,000 feet over Canada?

A Yes, sir. I've read some information about it.

Q As a training Captain, sir, is it your expectation that the manufacturer's duty is to inform operators of any flight maneuver or conditions that would jeopardize the structural integrity of the aircraft, and do that in the form of a prohibited maneuver or limitation?

A As I mentioned earlier, when Captain Ivey was questioning me, that I would expect, and do expect that if a manufacturer has a structural concern, or a safety concern, whether it be structural or not, with an aircraft, that they would provide us, through formal communication, whether it be by revision to the operating manual or our bulletins, et cetera. Now, there might be some communication other than that in the form of phone calls, e-mails, to give us some background information or give us a heads up that it was coming, but certainly I would expect that would be how they would communicate a concern to us.

Q Following the American Airlines 587 accident, who first communicated to the pilots with these concerns about lateral accelerations or alternating use of the rudders in side slip?

A Can you restate your question, please?

Q Who first communicated with the pilots regarding the concerns that were raised post-587?

A We did, as American Airlines, specifically our technical group and myself -- I was included in that, because of concern and information that we were learning as a result of the accident investigation.

Q Do you consider the instructions in the Airbus Flight Crew Operating Manual relating to landing gear in normal conditions and the use of alternating side slip to be conflicting with some of the concerns that have been raised post-November 2001?

A I do, and that's why we have a pink bulletin which takes precedence over a normal page in our operating manual, the American Airlines operating manual, and we have a specific bulletin that says to not conduct alternating side slips, and I spoke to that earlier about where we conduct 45 degree bank turns to try to get the landing gear locked -- down and locked.

Q And in that case, the advocacy is to make coordinated use of the rudders, is it not?

A To maintain coordinated flight, yes, sir.

Q And that's in confliction with the Airbus FCOM, correct?

A As we read it, yes, as we understand what the procedure is, yes.

Q Post-587 Airbus issued a recovery technique from upset situations which endorsed a similar use of rudder as in the industry training aid. Would you agree with both the Airbus procedure and the industry training aid which calls for use of careful or small, or coordinated rudder as needed?

A I agree with that concept that if you run out of your roll controls, and certainly if you're at high angles of attack, that if you are continuing to roll, unintentional roll, that you may need some small amounts of rudder, yes, to avert that roll.

Q I'm going to refer to Exhibit 2-I, page five.

You want to bring that up, please? Recommendation number two, if you'd like to highlight that, on the right side of the page. If you'd let me know when you have that, Captain Young.

A I have it in front of me.

Q Could you read to us recommendation number two, sir?

A "Recommendation Number 2." -- and this is from the Airbus Bulletin -- "Rudders should not be used to induce roll or to counter roll induced by any type of turbulence. Whatever the airborne flight condition may be, aggressive, full or nearly full opposite rudder inputs must not be applied. Such inputs can lead to loads higher than the limit, or possibly to ultimate loads and can result in structural damage or failure. The rudder travel limiter system is not designed to prevent structural damage or failure in the event of such rudder system inputs." And there's a note: "Rudder reversals must never be incorporated into airline policy, including so-called aircraft defensive maneuvers, to disable or incapacitate hijackers. As far as a Dutch roll is concerned, yaw damper action and natural aircraft damping are sufficient to adequately dampen Dutch roll oscillations. The rudder should not be used to complement the yaw damper. Note, even if both yaw damper systems are lost, the rudders should not be used to dampen the Dutch roll. Refer to the yaw damper fault procedure."

Q Thank you, sir. And we received that in March of 2002, is that correct?

A Yes, sir.

Q Had American Airlines ever received such specific limitations or prohibited maneuvers on the rudder use prior to the accident?

A No, sir.

CAPTAIN PITTS: I have no further questions.

CHAIRMAN CARMODY: Thank you, Captain Pitts. Now to American. Mr. Ahearn, please.

MR. AHEARN: Thank you, Madam Chairman, and because of the hour, I will attempt to be as brief as possible. Most of my questions have already been asked, but I do have a few.

CHAIRMAN CARMODY: Thank you.

QUESTIONING OF CAPTAIN YOUNG

BY MR. AHEARN:

Q Captain Young, in response to Dr. Lauber's question on what First Officer Molin saw in AAMP, isn't it true that First Officer Molin would have either seen the course that was taped in your presentation, or one virtually identical?

A Yes, sir.

Q Okay, moving on to simulators for a moment. Do you believe that line pilots understand that the simulator is incapable of recreating all the movements and forces that you may feel in flight?

A I don't think there's any doubt of any pilot in the world that when you walk into a simulator, this is not going to exactly replicate an airplane 100 percent. And in particular, its limits are Gs or lateral Gs or positive and negative Gs.

Q Okay, let me ask the same question with regard -- do you believe the FAA, which approves our training, has the same understanding?

A I think that the FAA has the understanding that there are limitations with the simulator, but we're also faced as an airline, and with the FAA is, that you have to use the best tools that you have available to train at the moment.

QUESTIONING OF MR. GHOSHAL

BY MR. AHEARN:

Q Question for Mr. Ghoshal. Mr. Ghoshal, based upon the technical panel's questions that were offered to you earlier, I want to clarify, in your presentation that you highlighted that you can recover in the roll exercise without the use of rudder. Isn't that, in fact, not a true statement? You're not required to use the rudder to recover from roll?

A It is.

Q I also want to clear up another issue that there seemed to be some confusion from the technical panel as well. There seems to be an impression that, from statements that in order to return to the roll control effectiveness, that it's always ten seconds. Could you just clarify that and expand upon the ten second phenomenon that was addressed earlier?

A Okay. The ten seconds phenomena was just a time in case we did not reach the angle, but in most cases, say for example it rolled right first ten degrees and then it rolled left, say 110 degrees, total of 120 degrees, approximately that would take four seconds, and initially when it rolls to the right, the pilot will try to control it opposing that, so by the time he goes over, at 50 degrees of bank angle, we start getting back both the yaw and roll controls back in. So it is not ten seconds, it is from peak to peak, it is maximum four seconds.

Q Thank you, Mr. Ghoshal.

FURTHER QUESTIONING OF CAPTAIN YOUNG

BY MR. AHEARN:

Q Just a few more questions for you, Captain

Young. Do you agree with Captain Rockliff that the simulator preconditioned a rudder response to wake turbulence?

A No, sir, I do not.

Q Can you tell me why not?

A As we talked that -- there's a lot of correlation here, or there have been people that have tried to correlate wake turbulence to our AAMP and upset training. They are two very different, distinct, differences with that. AAMP specifically was trying to teach to upsets which the industry was concerned about in 1995. Certainly we started trying to do something about training upsets as an industry. Wake turbulence, the only way that entered into the AAMP program was if it resulted in a upset condition. As I mentioned before, numerous times here, that no pilot out there ever thought that every time you get into wake turbulence you're going to end up in an upset. It just doesn't happen. We experience wake turbulence all the time.

Q Thank you, Captain Young. Just another point of clarification. In response to the technical panel's questioning, do you believe that it's up to the crew, that the crew has the authority to call for max power in an appropriate, or for that matter, any reason, and it doesn't have to necessarily be associated with escape maneuver?

A If they have concerns about power requirements, certainly I would expect the pilots to push the power up as long as they had shared those concerns, or had those concerns about the aircraft flying up to the firewall, or to the stops if you will, on the throttles.

Q Two final questions for you sir. One, do you agree with Captain Rockliff that AA flight 587 departed from control flight before the vertical stabilizer separated?

A I do not think it was in an upset. I do think the crew, from everything that I've seen, looking at the data, they were reacting to something, and trying to keep the airplane coordinated and flying. So I'm not exactly sure if an exact term of -- of -- did you say out of control or -- I forgot the exact words.

Q Departure from control flight, sir.

A Departure from control flight. I never saw anything that they had a departure from control flight initially, or certainly not an upset.

Q And one final question, now that -- you alluded to earlier that you had an opportunity to read the CVR transcript, is there any indication that the

Captain disagreed with First Officer Molin's response to the dynamic weight vortex that he was in?

A The CVR transcript that I received yesterday morning did not indicate any disagreement at along among the grew, between Captain States and First Officer Molin, no.

MR. AHEARN: Okay, thank you very much, Captain Young. Madam Chairman, if I might, there is an Exhibit 2-I that refers to another FCOM that I believe would be an appropriate part of the documentation. We've had much discussion about that. It is -- refers to the chapter procedures and techniques for upset recovery that's referred to the document itself, so if I might, I'd like to request that we add that to the documentation and that as an exhibit.

CHAIRMAN CARMODY: What is the document again? Would you repeat that? I didn't catch it.

MR. AHEARN: It's a document that is referred to in Exhibit 2-I, and the specific document is a procedures and techniques document, identified as Flight Controls, and specifically it talks about recovery techniques from upset training. It is a part of the FCOM, or the flight crew operating manual from Airbus.

CHAIRMAN CARMODY: Okay, I'd like to see a copy of it, if you could make that available, then we'll --

MR. AHEARN: I will, ma'am. Thank you very much.

CHAIRMAN CARMODY: Sure. Thank you. Moving now to my colleagues, Member Hammerschmidt. Questions.

MEMBER HAMMERSCHMIDT: Thank you. Just a comment or two and perhaps a question. To begin with, I just want to explore this first referenced issue for these witnesses, the Advanced Maneuvering Program, as we've been calling it, AAMP. And Dr. Lauber's questions, I believe one of his first questions, he was asking about something of the chronology of when some changes were made to the role or the use of rudder in this upset training. And I would just point out, if we could put up Exhibit 2-delta, I believe, page 13.

I'm interested in the left hand side, the aerodynamic definitions. I know last night I pointed this out, but the handbook that we received when many of us from the NTSB went to the training has a page -- this same page, page 16 in the workbook I guess we're calling it -- and it's essentially the same as referenced here except the only difference is where it says the rudder -- on the slide we have before us, where it says "the rudder becomes the most effective roll control", the book that we have or that was given to us says "the rudder becomes the primary roll control."

And then the second paragraph here beginning with the words "Smooth application" was not in the October 1, '96 workbook. So I would just point that out for clarification. In that three month span, American Airlines made that change.

QUESTIONING OF CAPTAIN YOUNG

BY MEMBER HAMMERSCHMIDT:

Q As you mentioned, Captain Young, and I might mention I certainly enjoyed your presentation this morning --

A Thank you, sir.

Q -- that this workbook was meant to be helpful material, it was not a stand alone training manual, I believe you said.

A That is correct.

Q And it was meant as an aid in the actual discussion which you showed many good video clips of this morning. It was meant to supplement the discussion.

A Yes, sir, and it was a booklet for people to take notes and to supplement the discussion, yes, sir.

Q Well, I would like to go to the notes that I took on that page, just very briefly, and I will read them just exactly as I wrote them down. Concerning -- we could put that slide back up, please, 2-delta, page 13. And I just want to get your take on what I wrote down.

A Yes, sir.

Q Okay. When we went to this particular page in the instruction, down in the notes, I wrote, "For example, coming in on approach, right wing drops down due to wake, vortex, or whatever. Instinctively one pulls back on yoke, dramatically increasing angle of attack, therefore, roll control is achieved with rudder, not ailerons, especially on MD-80." Is that a fair depiction of what would have been taught at that training session -- that ground school session?

A Right, I understand. I think that, and specific in this case here, where you're close to the ground, you're concerned about ground contact with an uncommanded roll in this case, and there was some discussion during that whole process about at increasing angle of attack, which I would expect the -- for me, I think that anytime an aircraft rolls and it's instinctive that a pilot will put in roll controls. Since you're so close to the ground, you would possibly pull back, increasing angle of attack. At that point in time, the rudder would become an effective roll control.

MEMBER HAMMERSCHMIDT: Okay, that's all I have.

CHAIRMAN CARMODY: Thank you. Member Goglia.

QUESTIONING OF CAPTAIN YOUNG

BY MEMBER GOGLIA:

Q Just one point, Captain Young, that I would like you to clarify since all of us use airline jargon here, and there are a number of folks here that may not be familiar with the terms that we use. You mentioned early on in your presentation about crashing the computer.

A Right.

Q And that's a term that we frequently use when we exceed the parameters of the simulator.

A Right.

Q And usually the screen goes blank, and we reset and start all over again.

A Right.

Q And I just want to make sure that that's what you meant, for the benefit of those here who do not understand the terminology that we use.

A Well, actually what I meant was -- displays to the pilot will not go blank, but the motion will be

-- as a simulator, the cab of the simulator is elevated on some hydraulic cylinders, and that's what gives you these initial accelerations as you're flying around, and inside the simulator it can give you the feeling that you're somewhat flying. It tries to make it more realistic. And what I was speaking to was that sometimes if you exceed those parameters, it will settle down off of those jacks and there will be no motion at all of the simulator.

Q Thank you. I just wanted to make sure that everybody understood what I think the rest of us understood.

A Yes, sir.

MEMBER GOGLIA: No further questions.

CHAIRMAN CARMODY: It's important to clarify. Thank you. Member Black.

MEMBER BLACK: Thank you, ma'am. Just a couple questions.

QUESTIONING OF CAPTAIN YOUNG

BY MEMBER BLACK:

Q You showed some video clips in your excellent PowerPoint presentation early on, and one of them was Captain Vandenberg -- and I also, like John did, I had this I believe -- this course at LaGuardia and I might have even been in the class with one of the accident pilots, by the way, and enjoyed the course. As a matter of fact, one of the quotes in your presentation might have actually been something I said. It looked familiar to me. But I did enjoy the course and I thought it had a lot of excellent qualities to it.

At time 9 minutes and 20 seconds into that video, one of the clips you showed, that's what was showing at the top, the Captain is talking about valid -- he's talking about things he had observed -- and I gather he was talking about observing them in the simulator about the qualities -- this is when he talked about "these big puppies don't respond the same as you would expect a smaller airplane".

A Right.

Q Do you think he's talking about the simulator or some other experience he might have had with a real airplane?

A I don't think he took an actual large transport category airplane and put it into 90 degrees of bank. I think he was speaking of the simulator.

QUESTIONING OF MR. GHOSHAL

BY MEMBER BLACK:

Q Okay, well, that begs this question, and I guess the next question would be to -- well, whoever wants to answer it -- this alpha and beta envelope that

-- the code that's supplied by the manufacturer of the aircraft or the manufacturer of the simulator, do you get any sort of validation document when you receive that? In other words, when you buy a simulator, do you get something with some sort of assurance about the validity of that simulator?

A Yes, sir, as a requirement for FAA qualification, the simulators are checked against flight test cases for like engine out take off, engine out landing -- there are defined cases where you have to actually match the flight test data within some tolerance parameters. Is that what --

Q That's exactly what I mean, and I don't know whether the staff would be interested. I might actually. If you have a copy of that, or could produce a document, I would like to see what that looks like, if that's producible, or if it's not some sort of proprietary document. If you can send me a copy, I would appreciate it.

A Okay, sir. I'll look into it.

FURTHER QUESTIONING OF CAPTAIN YOUNG

BY MEMBER BLACK:

Q And another question about -- in the interviews we had some of the transcripts here a minute ago -- I read in preparation for this the transcript of the interview with the OPS group, I believe Captain Young was in on that, were you not?

A Yes, sir, I was.

Q Of the AMP, the Aircraft Program Manager for FAA, I think the POI was interviewed also, and that's probably a fairly new POI, is it not?

A Relative, it depends on what your definition of new is.

Q Well, I think there was a change after Little Rock, if I'm not mistaken.

A There was, yes, sir.

Q So he would not probably have been there in '97, the current one would not have.

A No, sir, he was not.

Q Did they ever reference, or was there any evidence of communication between the gentlemen who signed the letter, as I call it, in capital letters, from the manufacturers and the FAA -- was there ever any evidence of the FAA group that signed the letter, Captain Emmick I believe his name was, and the POI about the concerns in that letter? Did you ever sense that the POI or the AMP was concerned about anything that was in that letter? This would be the letter from the manufacturers and the FAA to Captain Ewell.

A No, in fact, the FAA -- they had looked at our program and had approved our program, had been through our exercises and simulator, and we had dialogue with them before that, and they had never expressed concerns about simulator fidelity, if that's what you're speaking to, in relation to this. The FAA, as I think we've heard before, that it was a desirable training, and their HBATs, et cetera, and their bulletins -- they wanted this training and we were trying to put together the best program we could with extracting information and expertise from the experts out in the industry. So we didn't try to create this in a vacuum.

Q Thank you, sir. I would also congratulate you on your presentation. My personal opinion is you're the kind of guy I would like to think about teaching airline pilots. Thank you.

A Thank you, sir.

CHAIRMAN CARMODY: Thank you, Member Black. I have no questions, this is the advantage of being last. Everything's been covered. Are there any additional questions, new questions, from any of the parties, starting with Airbus, FAA, Allied Pilots, or American? Thank you for your cooperation.

I would like to go ahead and start with the next witness, if it runs too long, we will adjourn for lunch, but I would like to get going with -- that would be Captain Armand Jacob. So, Ms. Ward, if you'll call the next witness, please.

And thank you, gentlemen, Captain Young, and Mr. Ghoshal. Thank you for your testimony and your time. You've been very helpful to our inquiry.

CAPTAIN YOUNG: Thank you, Madam Carmody.

MR. GHOSHAL: Thank you, ma'am.

(The witnesses were excused.)

MS. WARD: I call Captain Armand Jacob.

Whereupon,

CAPTAIN ARMAND HENRY JACOB

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

BY MS. WARD:

Q Captain Jacob, could you please state your full name, your current employer, and your business address?

A My name is Armand Henry Jacob. I'm an engineering test pilot, address, Flight Test Department, and the address is Number 1 ... Beronte (ph), B..., France. Q How long have you had your position that you're in?

A I joined the test flight department in 1990.

Q And what are your current duties and

responsibilities, and the education and training that you received to qualify you for your current position?

A Responsibilities consist in flying all aircraft types in flight tests, development and certification flight tests, also flying production flights and any other flights; consist also in providing expertise to the design office or new development programs going on, or for modifications on existing products. It also consists in participating in the support department to operational conferences, airline visits, and so on. I've logged about 7,500 flight hours, most of them in flight tests. I'm holding a French test pilot's license, which is valid for all transport type aircraft. I'm also holding a French aircraft transport pilot license valid for all Airbus types, with a German validation, and special permit from FAA relative to all Airbus types.

I have been my whole career have consisted in running in parallel pilot and engineering activities. It started in 1970 when I got a Master's degree in Aeronautics, and I joined the French Air Force Academy, graduated as a test pilot -- as a fighter pilot, sorry, the following year. Then I spent about 12 years in the French Military Flight Test Center. Was involved in many military programs, many testing, was also - and during these years for a couple of years, I was teaching aircraft performance and handling at the French Air Force Academy.

I joined Aerospatiale in 1983 on the ATR-42-72 program, and I was involved in the development and certification of these two products. Eventually I joined Airbus in 1990. I forgot to mention that I'm also a graduate of United States Air Force Test Pilot School.

Q Thank you, Captain Jacob.

MS. WARD: Madam Chairman, this witness is now qualified and I'd like to pass it over to Dr. Malcolm Brenner.

CHAIRMAN CARMODY: Yes, please go ahead.

BY DR. BRENNER:

Q Captain Jacob, a question came up yesterday, can you fly the A300-600 without a stabilizer rudder?

A The answer, sir, is no.

Q Thank you. Yesterday also Mr. Chatrenet indicated that in testing the airplane, he said test pilots flew hundreds of maneuvers with the rudder in normal service situations and in extreme conditions, and said that many involved precise closed loop response. Could you please describe the testing that he was talking about?

A Yes, he was referring to the testing which is done in development and certification, and this would include typically, performing minimum control speed tests, either on the ground or in the air. It would involve side slip -- steady state side slips throughout the envelope. It would involve engine failure simulations or actual engine cutoffs in the whole flight envelope. It would also include some maneuvers not really dedicated to aircraft handling, but like checking the response of the engine toward the envelope for power transients and lack of stalling characteristics, and obvious by doing this for obvious safety reason, we would do it on one engine at a time, and to stay precisely at zero side slip during this kind of testing, it would require very precise inputs on the rudder, and this is done throughout the flight envelope.

Q The last one especially would be an example of the "closed loop" that he was talking about?

A Of course.

Q Were there any adverse comments concerning the rudder handling qualities during the testing?

A The rudder, as other flight controls, have been thoroughly tested, not only by Airbus test pilots, but also by test pilots from the French DGAC, test pilots from ABA, test pilots from FAA, and have also been evaluated by the flight standards people from these authorities. In addition, the airplane type has logged over 15 million flight hours, and this would involve thousands and thousands of pilots, and from any of this population of pilots, we have never got, to my knowledge, any adverse comment about the characteristics -- the design characteristics of the rudder control system.

Q And what proportion of the testing would be done at take off and landing speeds, and what proportions, say, at 250 knots or above?

A Obviously, minimum control speed would be at low speed. Concerning the side slip and engine failures, this would be done throughout the flight envelope, and of course at speeds at or close to 250 knots.

Q And Mr. Chatrenet was talking about the reasons for designing these -- for changing to the variable stop design, and indicated it was chosen because it maintains control harmony between the wheel and the rudder, as one of the considerations. What is control harmony? Could you explain that?

A Yes, control harmony is a notion which is related to a task. For a given task, it is the relative displacement on forces on two different axes of the flight control system, as related to a given task. These forces and displacements, especially forces, have -- it's recognized that there has to be certain relationship of certain proportionality between these two axes to have an acceptable or appropriate control harmony.

Q If I understand, Mr. Chatrenet was indicating that the forces between the wheel and the rudder were in harmony.

A Yes, the effect, as air speed increases, on any control surface, and this time I'm referring to the surface that actually move in the air stream, the effect of an increase of air speed on these surfaces is proportional to the square of the speed. And as -- with the TLU system, like the one which is fitted on the A300-600, this is a constant ratio. On the roll axis, you also have a concentration system, so the effect of going from one air speed to another affects these two axes in the similar way, thus maintaining the control harmony which was achieved at, say, low speed.

Q I guess my concern, if I understood Mr. Chatrenet was referring to force harmony, but the other aspect is displacement harmony, and my understanding is the wheel has a constant range of travel throughout the flight envelope, while in the variable stop design, the pedals changes its range of travel at different air speeds. Therefore, it seems that this design does not maintain a harmony in terms of distance, and that this would be very important to a pilot. Is that a fair concern?

A No. Actually it does maintain harmony. Just -- there is no limiter on the control wheel system, but as an effect of air speed, affects it the same way than on the rudder axis. Inputs made by pilots to achieve a desired motion would be smaller and smaller as speed increases.

Q But in terms of displacement, the speeds involved in the accident, 250 knots we're discussing, I understand the rudder pedal travels only about a third of its full travel range. Is there a danger that a line pilot might mistake the limited travel for a jammed rudder or for some other problem and not understand that this is the limit of the available control?

A As mentioned by Captain Rockliff, a pilot does not make arbitrary inputs to control his airplane. A pilot flies his airplane in a closed loop situation, which means that he is going to make the amount of input which is required to achieve the desired motion or objective he's looking for in his airplane.

Q I want to make sure -- what I'm thinking is that to the pilot, the wheel still has the full play, and yet the pedal does not, and this could be confusing. I guess I didn't understand the answer, I'm sorry.

A Okay, let me give an example. As Mr. Chatrenet mentioned, the curve of the limiter has been chosen to give enough authority to counter an engine failure throughout the domain, depending on the air speed. Thus, some room for yaw damper activity. And this is what is needed, and a pilot would, under those circumstances, either normal flight with an aircraft without failure, or an engine out situation, never goes to the stop. And therefore, of course, he would not fear the stop and not be concerned about it being there.

Q Thank you. And Mr. Chatrenet indicated, by my notes, that in designing the --

CHAIRMAN CARMODY: Dr. Brenner, please speak in your microphone, we're having trouble hearing you.

DR. BRENNER: Oh, I'm sorry.

CHAIRMAN CARMODY: Thank you.

BY DR. BRENNER:

Q Mr. Chatrenet indicated that in designing the

600 model, compared to earlier models, they lowered the roll force by 30 percent from the earlier models for more precise control of roll and lowered pedal forces commensurate, to be consistent. Is this correct?

A This is correct in terms of forces, yes, sir.

Q And I notice that the witness before paid a compliment to the airplane, the controls feel powerful -- I think that may be related to the design considerations.

A Yes, we actually got quite a few comments from pilots from all over saying that they liked the light and precise control of the aircraft.

Q But I think there could be a concern also. In one area of the rudder use, the combination of the very precise control with the variable stop design may result in extremely sensitive handling qualities, and this is particularly the air speeds involved in the accident, takes 32 pounds of force to command full rudder deflection, compared to 22 pounds of force simply to make the pedal move. And my question, are there test pilot guidelines on the ratio of maximum force to break out force?

A Excuse me, just the end of your sentence, I didn't get?

Q Are there test pilot guidelines -- here you have a one and a half to one ration between moving the pedal and getting maximum deflection in that area -- are there guidelines in terms of handling qualities as to what one ideal ratio should be?

A The adequacy of flight controls for any aircraft, when you go through testing and certification, is evaluated with the airplane and the pilot in the loop, which means that pilots are looking for a given task or a given aircraft response, and if this task is achievable without exceptional skill, and if it's possible to achieve it in a precise manner, the controls are satisfactory, adequate.

Q Is there a danger that a pilot might inadvertently command full rudder when he intended only to make a small rudder input, since he's not familiar with this area and the relation between the two forces is so close?

A This has been looked at, as I mentioned, by many pilots -- the ability to make precise inputs has been assessed and found satisfactory.

Q Have you experienced the pedal characteristics, full input in the 250 knot range, personally?

A Yes, I did by performing steady state side slips.

Q Do you think that a pilot, using the pedal for roll control, without training, would be able to make precise inputs?

A We do not recommend to use rudder for roll control.

Q It was a badly worded question, let me rephrase. Do you think that pilots need training to make precise entries in this air speed area, or is the use so intuitive that a pilot could use it appropriately without training?

A Again, it's basic airmanship to adjust inputs to the desired aircraft response, and based on the evaluation which has been conducted by test pilots from various agencies, and these test pilots, it's their basic -- it's part of their basic way of working, which is to make sure that not only they can make precise inputs, but the average airline pilot would be able to do so, and by doing this they have found the controls to be adequate and that an average pilot would be able to make the required, precise inputs, depending on the situation.

Q Then there might be a concern that as test pilots, you're familiar with the design, and you're working under precise situations, that a pilot who might experience this in a dynamic situation, or an emergency situation might have more difficulty. Is this factor considered?

A This is taken into account when certification authorities test pilots evaluate an airplane.

Q What are pilot-induced oscillations?

A Pilot-induced oscillation is a situation where, in the closed loop situation, the pilot and the aircraft response would get out of phase, resulting in large, sustained oscillation with eventually the pilot inputs and the aircraft response being in opposite phase. Pilot-induced oscillation is characterized by a very well measurable constant frequency of these oscillations.

Q How did Airbus examine potential PIO issues in the design certification of this system?

A Potential PIO issues -- all test pilots, when they fly an airplane, have potential PIO tendencies or issues in mind, so they are very -- any maneuver they might do, if they sense or see any tendency to PIO, they would notice it and they would be close -- a close examination of the circumstances to determine whether or not this was pilot-induced oscillation tendency. Now, the absence of PIO tendency has been checked by doing some demanding tasks throughout the flight envelope, like engine failure with a delay of pilot reaction up to three seconds, for example. And also the very demanding task of conducting engine power transients on one of the engines only.

Q Thank you. As part of its activities, the Human Performance Group attempted to simulate the motions of the airplane using the vertical motion simulator at the NASA Ames Research Center, it's the largest motion-based simulator in the world, and an attempt was made using both CVR data and the FDR data to try to recreate as close as we could, the accelerations that the pilots would have felt, along with the sounds in the cockpit. And you were a member -- and I appreciate your observations -- of the VMS trials.

In describing their observations, many human factors group members described the first notable event as typical of a crossing wake encounter. Was this your impression? Do you know what I'm referring to?

A Yes, I concur to this.

Q Could you discuss that, please?

A Yes. As the other pilots in the group, I have been faced with quite a few wake turbulence encounters, and in a large airplane like the A300-600, in all these encounters there was a essentially nil reaction on the lateral axis, but there was a marked, sharp kind of bump in the longitudinal -- in the vertical axis I mean, sometimes in the longitudinal one, and this was fairly consistent with what we experienced in the VMS for the first encounter.

Q And then there was a second notable event which then led directly into the accident situation. And human factors group members observed that they did not observe the visual or acceleration cue that would lead a pilot to apply the observed initial magnitude of wheel and pedal. Was this your impression?

A That was my impression too.

Q Can you describe, from a pilot background, your impression of that area?

A Going through that simulator run, after the first encounter, a couple of seconds later, there was a little bit of unloading felt in the cockpit, which means feeling a little bit lighter, but certainly not any visual or force cue in the lateral that would have led me, as a pilot, or any other pilot, that would explain this very large -- this large and abrupt inputs on the wheel and on the rudder pedals.

Q And based on the accelerations that you experienced in the VMS, do you think the pilot's call for max power was appropriate? Was it justified by the acceleration?

A It was certainly not justified by the energy situation in which the airplane was, because it was at a fairly reasonable speed, in the middle of the flight envelope, 250 knots. It was not close to the ground, so certainly from an energy point of view, there was no need for max power. In addition, the airplane was already at climb power in the engines.

Q In one of the VMS trials, the inputs were simulated -- the trial simulated the movement of a rudder pedal system as would have occurred with a ratio changer system, like that used on the earlier A300 models, and so we had the inputs displayed as they would have moved the pedals on that. What was your impression of this trial compared to the pilot's rudder pedal inputs as displayed on the variable stop system of the actual aircraft?

A May I just correct your sentence?

Q Please.

A You said that the inputs were made -- I mean what is correct is that the rate of travel of the rudder was kept as in the accident, and the pedals were back driven as if the system would have been a variable ratio system, which automatically makes these pedals move three times faster than with the other definition. And I do not think this is what would have happened with the variable ratio system because in what we are describing is just taking the problem backwards.

Q Yesterday, Mr. Chatrenet was talking about cable elasticity analysis by Airbus. If I understood, he indicated that during the accident sequence, these part of these motions, the pilot input -- the pilot was making inputs of 130 to 140 pounds, I believe was estimated, which went beyond -- that he was pushing on the rudder pedal beyond the force that would get to the stop. Did I understand correctly?

A Yes, that's correct.

Q Could this be evidence that the pilot was unaware of the design, and as he's straining to get more rudder response because he's unaware that one-third motion of the pedal is all that's available?

A Again, a pilot who's not flying his airplane by numbers, deciding that he's going to put this much rudder, is flying based on aircraft motion and desired motion. So if a pilot is pushing on the stop, that means at least that in his mind, he would like to get more rudder input. Or more rudder deflection.

Q Thank you. Yesterday we heard testimony that if the rudder inputs were made in a cyclic fashion at or near the natural frequency of oscillation, only small rudder inputs could produce very large amplitude aircraft responses. I think analogy was made to a child on a swing and being pushed lightly at the peak points. How does the frequency of rudder inputs in the flight 587 event compare to this natural oscillatory frequency? Does this indicate that there might have been an aircraft/pilot coupling, or pilot-induced oscillation generated during this event?

A I don't think so. The only inputs that look a little bit like constant frequency are the -- at the very beginning of the large aileron and rudder inputs going into the same direction, first right, then left, and right again. And the frequency at which these inputs are made is much higher than the natural Dutch roll frequency of the aircraft at that speed. Typically, the Dutch roll frequency, natural Dutch roll frequency, would be -- I mean the period -- we talk about the period -- the period would be, I would guess, about five seconds. And these inputs were much faster.

DR. BRENNER: Thank you, Captain Jacob. Captain Ivey will continue the questioning.

BY CAPTAIN IVEY:

Q Good afternoon, Captain Jacob.

A Good afternoon.

Q I'd like for you to describe the expected inputs on the aileron/rudder system from the first time a pilot enters the cockpit until he concludes his flight.

A Okay. First of all, when a pilot enters the cockpit, he's going to adjust his seat, adjust the rudder pedals, goes through various items of a check list, start engines, start to taxi, and some time between the start of the taxi and being ready to line up, there would be the flight control check, which would consist in going from stop to stop on one axis after the other -- pitch, roll and rudder, checking for free play -- for free displacement, no anomaly on the flight controls.

During the take off roll, the pilot would use the rudder pedals to steer the aircraft. At low speed, the efficiency of the rudder is obviously close to zero, and that's why there is a linkage between the rudder pedals and the nose wheel, this would allow the pilot to keep the airplane straight on the runway center line. Then at rotation -- then, of course, during the -- as speed increases, the rudder becomes more and more effective. This does not -- and the nose wheel link -- I mean the relationship between ... steering ... is decreasing, and therefore directional control to stay on the runway center line would primarily be insured by the rudder deflection.

Then -- I'm describing a flight without any failures, that's what you wanted?

Q Yes, sir.

A Okay. So after rotation, gear would be retracted, airplane would be flown and steered normally using pitch and roll control, rudder pedal deflection being essentially zero. The airplane would be cleaned up, accelerated to climb speed, normal climb speed, assuming the pilot would still hand fly it, of course he would have his feet on the pedals as mentioned by other pilots earlier, I concur to this, and prior to engage the autopilot, once reaching climb speed, the pilot would check the ball, the side slip indicator, and if it is not centered, he would make a light -- the required rudder input to center it and then trim the force out, and then engaging autopilot for the major part -- for the rest of the climb, the cruise and probably the start of the descent. And, as mentioned by other pilots, once autopilot is engaged, feet would probably be resting on the floor -- there's no requirement to keep feet on the pedal when not hand flying.

I would expect a pilot, when he takes control again from the autopilot prior to landing, to have his hands on the yoke, and the feet on the pedal. And then he would, after selecting flaps -- I forgot to mention that in the cruise from time to time, probably be required to make some small rudder trim adjustments due to either slight asymmetry in fuel or any asymmetry of the aircraft that would show up when changing speed. This is quite common on this type of aircraft, that when you go from one speed to another it requires a little bit of rudder trim adjustment.

So going back now to approach, pilot -- assuming that approach would be manually flown, the pilot would steer the aircraft down the proper trajectory, either INS or visual, using pitch and roll control. In the case where there would be cross wind, the pilot, described by Mr. Chatrenet would go into a crab to align the aircraft axis with the runway axis while maintaining trajectory, with the roll control.

And then upon landing, after touch down of the main wheel, the rudder would be used to steer the aircraft down the runway. And then taxi back to the apron and make the engine shut down checklist, and eventually leave the cockpit.

Q So at any time during the normal flight, a pilot would never expect to reach the limits of rudder travel. Would that be a fair statement?

A That is a fair statement.

Q And in non-normal operations, such as an engine failure at low air speeds, would a pilot normally still expect to not reach the limits of a rudder travel?

A Yes, he would normally expect not to reach the limit because any operational speed is, by regulation, above minimum control speed. He would expect to reach the stop of the rudder pedal in case of an engine failure at minimum control speed -- that's the definition of minimum control speed. Operational speeds having some margin in addition to this minimum control speed, this would mean that a pilot under this type of failure condition, i.e., an engine failure, even at low speed, would not reach stop. This is also true for higher air speeds.

Q Yes, sir. And I'd like to turn for a moment to your experience as a test pilot, when you indeed have to go beyond the normal operation limits that a typical line pilot would experience -- let's use rudder as an example. Do you reach the full stop limits in design and certification on the A300 airplane with full rudder displacement at some point during design and testing?

A Of course we reach the full stop limit when we do VMC minimum control speed testing, by definition, again.

Q And that's at several points? That is at different air speeds in the envelope?

A No, minimum control speed is -- there are basically three minimum control speeds. One on the ground, another one in takeoff configuration, and the third one in approach and go around configuration. All these minimum control speeds being defined by a sudden engine failure and max power on the remaining one. So we would definitely reach the stop in the case of engine failures at these minimum control speed in flight testing. We would also reach the stop in the whole flight envelope for other type of exercises, like, as I mentioned before, steady state side slips.

Q So you do at higher air speeds, and let's use 250 knots as an example, which would be an intermediate air speed, are there times in design and certification where you would indeed have full rudder pedal displacement?

A Full available --

Q No, sir, just your application of full rudder at say, 250 knots, is that part of your test program?

A Yes, in steady state side slips, for example, yes, we go to the stop.

Q And what margin of protection is afforded you, as a test pilot, before you start to engage in that sort of activity? How much protection is allowed you either through information or design, before you go up there to fly that airplane and to place full rudder travel in the airplane? Do you know how well you are protected by the manufacturer?

A The rudder travel limiter is designed so as to sustain -- so that the airplane can sustain full sudden travel of the rudder at any air speed up to VDMD. This is required by law. And we start first flying an airplane, we are -- there are obviously some -- a lot of temporal limitations before the whole flight envelope is clear. And clearance of the flight envelope implies many testing, like flutter testing, like load measurements, to make sure that the airplane is in accordance with the models that have been used to design it.

Q And part of your design and certification test plan is to test that rudder limiter system, is that correct?

A Not really the system. The test plan consists in making a whole set of exercises or maneuvers in the whole flight envelope, and these maneuvers are -- some of them are operational, some of them are completely academic maneuvers. And steady state side slip in the whole envelope are an example of this academic maneuvers. And it is true that we go to the stop in the whole flight envelope in this kind of testing.

Q In earlier testimony, it was stated that there was an envelope protection in the A300 -- no in advanced fly by wire aircraft -- and to -- the rudder system, that there is not that protection. Is that correct?

A That's correct.

Q Why is the rudder system not protected within its envelope?

A In a transport category airplane, there is no circumstance that -- no normal procedure that -- or actually, sorry, let me try it again.

Again, by definition, up to VDMD, whether on A300-600 or an advanced airplane, the full motion of the rudder up to the stop is possible without exceeding design limit loads of the airplane. So the airplane -- all airplanes, by law, are protected against this type of maneuvers -- one full stroke, all the way to the stop.

Q You've flown both rudder limiter system designs, is that correct?

A I have limited experience in the B2B4, but yes, I have flown it.

Q And is the B2B4 the only Airbus airplane that had the different rudder limiter design from the other Airbus aircraft?

A All the 320 type aircraft, and the 330/340 type aircraft are all equipped with the limiting system.

Q And I'd like to ask you, as a test pilot, and as a general pilot, which system do you like the best? Is there a difference that you've noted as a pilot?

A As a pilot, first of all, at low speed, when I mean low speed is typically in the A300-600, speeds below 165 knots, before the rudder limiting system starts to move -- at low speeds, or where the rudder is most likely to be used in engine failure case, or when you really need the rudder, both systems are strictly equivalent. So as speed increases, rudder, which has been sized for the particular case of engine failure take off at low speed, as speed increases rudder becomes more and more effective as a function of the square of the speed, and therefore less and less rudder is required. And essentially, I think it was Captain Delvin that mentioned it, in an airline very little rudder is used or necessary as long as the aircraft has no yaw or side slip asymmetry. So, as a pilot, I really have no preference. Both systems are equal.

Q Talking about the variable ratio versus the variable stop system, do you have a preference as opposed to the pedal travel? Do you prefer to have full pedal travel at all regimes of air speed, or would you prefer the current system that's on the A300 where you've got reduced pedal travel as the air speed increases?

A I have reduced pedal travel, but again, in any operational circumstances, I would not need to go to that stop, and as I mentioned earlier, efficiency -- as -- with speed increases the same way as the efficiency increases on the roll axis, so actually it keeps a good harmony and I quite like the system. I do not dislike the other one, but I have no preference.

Q Do you know why the new system was installed on the advanced airplanes that was different from the A300-B2B4?

A Say it again?

Q I'm sorry. Why was the system chosen for the A300-600R? The rudder limitations?

A I think Mr. Chatrenet explained this pretty well yesterday, and I concur to his explanation.

Q Alright. Is the variable limiter system a unique design to Airbus airplanes?

A No.

Q Regarding the regulations, what's required for rudder pedal forces and rudder limiting? Are there any FARs that say how much that force has to be?

A There are definitely numbers or maximum forces on all controls on all axes, and in the case of the rudder, there is an indication that the rudder forces should not exceed 150 pounds.

Q Is there any minimum requirement?

A There are no numbers for minimum requirements. However, by checking and testing the flight control system with all the certification exercises that are required, these exercises would not be satisfactory if the forces would be either too high or too low. So this takes practically in to care of the minimum forces required.

Q Do you think there ought to be a minimum requirement for certain forces?

A I don't think so. I think the guidelines and the way certification is conducted today takes care of this, and it has been a sense of history to go for lower and lower forces as technology improves.

Q Regarding the FCOM, is there written guidance regarding any cautions about control input at speeds less than DA?

A FCOM, no.
Q Is there any guidance at all that's been added since the accident regarding speeds?
A Yes, as Captain Rockliff mentioned, in response to the safety recommendations of NTSB, there has been some additions put into the FCOM.
Q In the case of -- Boeing has, of course, been the manufacturer for the KC-135, which was a variant of the 707, perhaps back in the 1950's and early 60's. A 2K-3, for example has a caution in there, and it's been part of the technical order Dash One, as it's called, to the United States Air Force flight crews -- if you'd like to put that up, 2K-3. I'll just read the caution that has been incorporated in their manual for some time, that "The sudden reversal of rudder direction at high rudder deflections due to improper rudder applications or abrupt release, can result in overstressing the vertical fin. This condition could be brought about during recovery attempts from a flight condition induced by a lateral control malfunction." Do you think that that's generic to the Boeing 707 or KC-135 airplane, or do you think that's a good caution for any large transport category airplane?
A I don't know which lateral control malfunction this recommendation is referenced to.

Again, in all the published procedures, whether normal or failure cases, there is no need for rudder reversals.

Q And I certainly agree with you. I think that that's what the caution is about, the fact that if they were to start to have abrupt or cyclic rudder applications that they're warning the crews about that very issue. Do you believe that any cautions such as that would have been useful in the FCOM, that might have advised crews as to how to limit the use of rudder, or an abnormal condition, or even in normal operation?

A I don't think so. As I said, normal and abnormal procedures do not require such inputs and if in any very extraordinary and very remote situations -- I cannot imagine, but I think one could imagine such a situation -- if you're really, for a reason I cannot imagine, this type of input would be necessary, I do not -- for preventing a drastic emergency situation, being close to hit the ground -- I do not think that this kind of limitations would have prevented the pilot to do so if it would have been in the manual. Again, I cannot imagine such a situation.

Q Has there been any time during your experience as a test pilot, or during normal line operations, you've ever had the need to use full aileron or full rudder as a flight control input?

A In normal flight, no. In test flights, yes, by definition of VMCA, there is not only a static conditions to be satisfied, there is also maneuvering conditions to be demonstrated, and again, at this very low speed outside of the normal flight envelope, the rudder is already on the stop because this is the definition of the VMCA, you are required to demonstrate maneuverability towards the live engine, and this, on some airplanes, requires up to full aileron. So this is a situations where you would apply full aileron and rudder -- not apply full rudder -- the rudder would already be on the stop before starting the maneuver.

Q I would like to ask you also what your definition of coordinated rudder means.

A I agree with the definition given by the other pilots. Coordinated rudder means ball or side slip indicators center.

Q Has Airbus ever provided you, either in the A300 airplane, or in any other airplane or simulator, upset maneuver training?

A No, upset maneuver is kind of -- maneuver recovery is kind of basic airmanship for test pilots.

Q And I'd like to ask you, have you performed any flight tests regarding the roll and yaw of the airplane as it pertains to the accident flight?

A The answer is no.

Q As a test pilot, what are your concerns about using simulators for training upset maneuvers, wake turbulence encounters?

A I concur with what has been said by Captain Rockliff yesterday, Airbus does not advocate use of simulators for such training because of the risk of negative training.

Q What changes have been incorporated or are being considered relative to the Airbus flight control system as a result of this accident?

A No changes considered.

Q And are there any changes anticipated in flight crew guidance, warnings, or cautions? Is there any other considerations as a result of this accident by Airbus?

A Nothing in addition to what has already been provided per NTSB recommendations.

CAPTAIN IVEY: Thank you, Captain Jacob, that concludes my questions.

CHAIRMAN CARMODY: Thank you, Captain Ivey. Are there other questions from the technical panel? Yes, Mr. Clark.

BY MR. CLARK:

Q I heard the discussion earlier about harmony, and the sense I got was that harmony is important for precision flying. Is that correct?

A That's correct.

Q How important is it in the event of some sort of upset recovery?

A Upset recovery does not require inputs on -- simultaneous inputs on roll and yaw, therefore control harmony would not be an issue.

Q Then, it's -- and correct me if I'm wrong. I'm going to give my impression here real quick and then ask your opinion. It seems we put a lot of work into building control loading -- those kind of issues in the pitch mode, but it seems that kind of detail is not put into the lateral mode, or the yaw mode. Is that correct?

A Lateral -- roll control, certainly there's --

Q I mean yaw mode.

A Yaw mode -- I have to go back to what the rudder is designed for on a transport category airplane. A rudder is there to steer the airplane during takeoff and landing roll, to de-crab in case of a crosswind landing, and to zero out any thrust or yaw asymmetry that might occur. And the amount of testing that is put in is in accordance with these design rules

Q In the pitch mode, we put in parameters to make the forces get greater at higher speeds to make it more difficult for the pilot to overcontrol the airplane. Why is that not also applied in the rudder mode?

A In the pitch mode there are, on this kind of large airplane, mechanical controls. These kinds of devices are necessary because the pitch axis is affected not only by air speed, but also by magnum (ph) effect, center of gravity effect, and angle of attack effect. So it's a much more complex situation, and this is why it requires this kind of devices to take care of that.

Q Okay, and I guess the inference is then, those kinds of issues don't exist in the directional mode?

A Directional mode and roll mode are affected only by air speed effect, which is pretty predictable and which pilots are used to in everyday flying. They know from day one, from their initial training and their theoretical background, that the effect of the controls is -- depends on the square of the speed.

MR. CLARK: Thank you.

CHAIRMAN CARMODY: Alright, I'd like to go ahead and start with the parties, and I think the order this time, we'll start with American, then Allied Pilots, then the FAA and finishing with Airbus with this witness. So Mr. Ahearn, do you have any questions for this witness?

MR. AHEARN: I do, ma'am, and I'll try to -- again, for the sake of time, as brief as I possibly can.

BY MR. AHEARN:

Q Good afternoon, Captain Jacob.

A Good afternoon.

Q Let me start off by talking about this issue of control harmony, because I want to make sure I understand what you had stated earlier. You stated that control harmony exists in all flight regimes, and I'm having a little bit of hard time understanding that. With the speed increasing from 165 knots to 250 knots, the traveller limiter reduces the pedal distance from four inches to 1.3 inches, and it changes the break out force -- I'm sorry -- the pedal force after break out from 45 pounds to 10 pounds, and there's no corresponding change in roll. I'm trying to understand how that can be control -- or how you can have control harmony with that type of system.

A Control harmony, as I mentioned earlier, has to be associated to a task. Typically, when you de-crab your aircraft for landing, this is a pilot task, and it's important to relate the control harmony to the task. The amount of rudder which is required, the amount of aileron which is required under these forces are in harmony. At high speed operationing, control harmony is assessed by performing steady state side slip up to the maximum available rudder deflection. And control harmony is maintained because, as I mentioned earlier, the effect of air speed on both axes is the same. When the rudder reaches the stop, the exercise is at the end, and control harmony makes no sense any more above the -- after deflection which does not exist.

Q So from a pilot's perspective, though, the reaction that he would be receiving, and again, not using the rudders at the speeds of 250 knots with a high degree of frequency, the average pilot wouldn't use it very often as testified earlier, would he not potentially be surprised by the deflection that you would get at 250 knots with only 1.3 inches of travel and ten pounds of force after break out?

A Pilot is not flying by numbers, as mentioned several times earlier. Pilot is flying by checking the response of the aircraft to his inputs and continuously adjusting his inputs. That is what is called closed loop to achieve the desired response.

Q Would the sensitivity of these rudder pedals -- how can a pilot use less than maximum rudder, especially when he's in a dynamic turbulent event?

A What do you mean by a dynamic turbulent event?

Q Well, there appears from what we've seen, quite a bit of movement of this aircraft and in doing so -- let me back up to a -- previous events. Earlier yesterday, there was quite a bit of commentary about the coordination amongst the flight department and the engineering team and we referenced two in service events. Are you familiar with the in service events of the A310 in 1991, as well as the event of American Airlines Flight 903?

A I wasn't directly involved, but I have the general information about this, yes.

Q In both of those cases, these pilots were in somewhat of an excited state, and it appears in both of these cases the pilots used maximum deflection, resulting in rudder doublets, resulting in some obvious exceedence of load limitations on the vertical stabilizer. That's what I mean by -- when I asked the question of dynamic event. How can, when a pilot is in a dynamic event as the pilot was in 1991, as well as the pilot in 1997, how can he possibly get to less than full stop with only ten pounds of force to get him to full stop?

A These two events you are referring to are characterized by a common factor. Both events were loss of controls -- temporary loss of controls -- and were not identified as such, and the inputs which were made that were kind of open loop inputs, which do not really correlate with observed -- or any motion that was observed during these events. To address these two events, we addressed the root cause of both of them, which is to reduce the probability to enter these events in the future.

Q Okay, let me move to another question. You said earlier that you had no preference between the VLA or the RTL system, because you had never used full throw. Wouldn't it be easier for a pilot to modulate controls to some point below maximum with four inches and 45 pounds of travel, compared to 1.3 inches and ten pounds of travel? And I know you addressed the issue that they're not -- pilots don't move the pedals to poundage, but visualize the fact that you have an opportunity to, after break out, in a VLA type system, you have, throughout the flight envelope, a full four inches of travel, where in the RTL system, you go from four inches to 1.3 at the 250 knots -- something less than that. Would it not be significantly easier for a pilot to modulate the pedal throws when you have the full four inches throughout the flight envelope?

A I don't think so. The rudder system behaves exactly like the roll systems, so pilots are used to adapt their entries as speed increases. Coming back to the 1.3 inches, actually this means two times 1.3 inches because as one pedal is moving forward, the other one is moving back. This is a quite significant motion for this control system.

Q And likewise, from that point then, if it's 1.3 equalling 2.6, then in the VLA, you would have eight inches in total, versus four.

A That is correct.

Q Okay. I just want to make sure that we have all the understanding associated with the transition from the VLA to the RTL system, from the B2B4 to the 300-600, and again, I just want to ask you to describe the -- how you evaluated the handling qualities as you transitioned from the VLA to the RTL.

A For any new aircraft certification, or any new aircraft type, you have to go through a whole set of certification exercises and tests. And the regulation is not specific to any type of design. So every aircraft design is evaluated on its own. Does that answer your question?

Q Well, let me get a little more specific. When you were testing the 300-600, what cautions, restrictions or limitations were the flight test pilots aware of concerning how and when to use the rudder, or how it should be applied? What types of cautions did you offer to the test pilot?

A There are the usual cautions that are associated with any test flight. When you are flying a development aircraft, there are pages of temporary limitations and some others related to the type of exercise you are going to perform. So could you precise which exercise or which type of flight you are referring to? In general, there are no specific limitations.

Q I'm referring specifically -- limitations to the use of rudder.

A Depending on what the flight was about, when you are doing a Dutch roll testing, obviously at Airbus, we -- there are different ways to excite a Dutch roll, and one of the ways to excite a Dutch roll, as taught in test pilot school for military type of aircraft, is rudder doublets. Are you referring to that?

Q Yes.

A So when we go for flight where we are going to perform Dutch rolls, it's part of the briefing to -- between the flight test engineer that has written the flight test order, and the rest of the crew, to cover this issue, and remind that the standard procedure at Airbus flight test to launch a Dutch roll is to arise from a steady side slip, not doublets.

Q So the restriction for the test pilot would have been that it would have been from a steady side slip, you would not allow the test pilot to do doublets.

A That's not a -- in -- doublets -- no, it's not a standard procedure at Airbus to generate Dutch roll while performing doublets.

Q Throughout any type of flight testing that you did on the 300-600, were there any restrictions on the flight test team about conducting what are doublets, whether it is associated with Dutch roll or any other maneuver?

A We use very small -- we use small and careful doublets from some of the analytic tests we perform for simulator that are -- but then -- rudder doublets, by themselves do not overstress an aircraft if they are not at the right frequency, corresponding to the natural Dutch roll. You can make Dutch roll test with rudder doublets, provided it is properly performed.

Q And do you do that with -- I presume you do that with the engineers monitoring it on the ground, so you're being advised by the engineers on the ground when to deflect the rudder in one way or another?

A No.

Q So that's done in flight. Okay. Is that done at all speeds throughout the flight envelope?

A Dutch roll tests?

Q Yes.

A At all speeds and preferably releasing from steady state side slips.

Q Okay, thank you. Just come back to one question, and then I have one final question after that. I believe you stated this earlier, and I want to make sure I understand it, that you conducted steady heading side slips throughout all portions of the flight envelope on the 300-600. Is that true?

A The flight test team at that time, and I was a part of it, yes, we conducted steady state side slips throughout the flight test envelope.

Q And in doing so, do you know if the test pilots were able to achieve stabilized interim rudder

pedal position at speeds of 250 knots or above?
A The answer is yes.
Q Do you know if that data has been shared with the human performance team yet? The data points --
A I don't know. This data is certainly available at the flight test -- at the certifications authorities. It has been shown to them.
Q Okay, thank you. Let me just move on to one final question. You said nothing in the VMS loads explain the pilot's reaction. Were the VMS accelerations accurate?
A In the dynamic phase of the VMS, yes, they were pretty accurate.
Q Do you believe that they possibly could have been reduced -- that the accelerations could have been reduced due to sampling rate?
A I don't think so because the sampling rate is quite -- quite adequate for the acceleration parameters. They might be missing some high frequency accelerations like vibrations, yes, but -- certainly. But the general overall accelerations are certainly very well represented in that VMS.
Q Okay, so then, just one final question on that issue, then. Do sampling rates and the conditions associated with the wake vortex -- couldn't the

pilots have seen much higher loads than what is being presented in the VMS?

A I don't think so.

MR. AHEARN: Okay, thank you, Madam Chairman.

CHAIRMAN CARMODY: Thank you, Mr. Ahearn. Moving on to Allied Pilots, Captain Pitts, please.

CAPTAIN PITTS: Thank you, ma'am.

BY CAPTAIN PITTS:

Q Good afternoon, sir.

A Good afternoon.

Q Regarding the VMS, was the equipment at the VMS fully capable of representing the flight parameters as recorded on the FDR, or did they have to be adjusted to protect the equipment at the VMS?

A What do you mean the flight parameters?

Q The recorded flight parameters on the FDR -- was the VMS able to accurately replay those without some adjustment, or was it forced into a reset mode when those were replayed?

A It was -- all the runs that I was on board were no reset mode, but I know that there has been some occasions has been a reset of the VMS.

Q Was there a discussion that you recall about the VMS not being able to accurately represent the recorded flight parameters?

A No, to my knowledge, the VMS was adequate to represent the flight parameters.

Q Yesterday, sir, Mr. Chatrenet testified that Airbus did not use the Cooper-Harper rating scale in its flight test program as an evaluation tool, and we've had many discussions on that. What is the quantifiable method that's used by the test pilot in lieu of that program?

A Cooper-Harper is a rating scale which, to my knowledge, is pretty well adapted to military type aircraft. It's not really used in the industry for transport category airplane. We rely mainly, at Airbus, and I guess it is the same at other manufacturers, on pilot appreciation of the quality of the result, and actually at each test flight, there is a debriefing with the design office that lasts for, sometimes several hours, that allows to provide them with feedback which is much richer than just the Cooper-Harper rating. We go to great details, when we discuss the results of any flight test.

Q Would you call that a quantifiable program or a qualifiable program, or subjective evaluations?

A It's an evaluation of the overall behavior of the aircraft, and as I mentioned before, this is how the certification test pilots work as well -- they check that if the aircraft meets the certification requirements that they have in mind at each stage of this work, the fact that the airplane will be flown by an average airline pilot, and they have this in mind when they check the adequacy of the aircraft to the pilot.

Q So then would that be subjective?

A It's an objective evaluation. Not a subjective one, it relies on the very well defined tests and checked against rules which are quite precise.

Q So when checking it against the rules that are precise, if I understood you correctly, then you're qualifying it to known uniform parameters in man/machine interface?

A We qualify it to -- we check it -- we -- and that means test pilots from manufacturers and from the certification authorities -- qualify the suitability of the aircraft. And it's described in the regulation and then there are -- there is a general statement in the regulation -- would you like me to read it for you? It says "It must be possible" -- and it's about airplane handling -- "The airplane must be safely controllable and maneuverable during takeoff, climb, level flight, descent and landing." And it states -- it's 25.143 (b) of the Part 25 rules, "It must be possible to make a smooth transition from one flight condition to any other flight condition without exceptional piloting skill, alertness or strength, and without danger of exceeding the airplane limit load factor under any probable operating conditions, including certain failure of the critical engine, configuration changes" and so on. So when the evaluation is conducted, it is in relationship to this kind of rules, and this is an example of the rules which are used by certification authorities pilots.

Q So the evaluation is measured against a regulatory compliance.

A Against a regulatory compliance which covers the capability or the adequacy of the airplane to be used by an average line pilot, and it's also covered -- it's also checked against a lot of maneuvers which are not operational, but which allow to get access to certain derivatives which will allow authorities to check the adequacy of the handling of the airplane.

Q Alright, sir. In your opinion as a test pilot, sir, can artificial trim and feel (ph) system which has small displacements and light force gradients lead to a severe over-control, especially in the dynamic environment of turbulence or an upset?

A I don't think so. Any flight control, any control system, if you make an arbitrary foot stroke open loop input, will certainly need to initial over-control.

Q I'm not sure I understood your answer there.

A Sorry, I will phrase it another way. Could you ask your question again?

Q Yes, sir, I'll be glad to. Can an artificial trim and feel (ph) system which has small displacement and light force gradients lead to severe over control, especially in a dynamic environment of turbulence or upset?

A If used as it has been designed for, the answer is no. Use has been checked in turbulent conditions and in high pilot abandoning task conditions.

Q So when you mentioned used as it was intended and checked for, would the human then be subjected to this kind of test of turbulence, to see if they could, in fact, perform precise maneuvers?

A The airplane has been flown in turbulence, in high turbulence, especially during icing (ph) trials, and the adequacy of the roll flight control system has been assessed in this kind of conditions.

Q You mentioned icing (ph) trials, was the aircraft flown in the presence of wake vortex for the same sort of testing?

A For testing, no. There's no deliberate research to fly into wake vortices throughout the flight testing.

Q Alright, sir, thank you. You mentioned basic airmanship earlier, a couple of references. What guidance does Airbus provide for you in terms of upset or unusual attitudes? Is there a company policy in how you would handle the aircraft?

A When you mean you -- you mean for the test pilots of the company?

Q Sure, yes.

A No, test pilots have extensive engineering background and they are very familiar with the aerodynamic principles that lead to an upset or to apply in an upset like full stalls or whatever, or even a spin, and this has been -- this knowledge has been acquired throughout their background, starting in, for most of the test pilots have flown fighters, and they have been through test pilot schools, and -- at Evers, for example, when we do flight tests which are likely, in the early stage of the program, there are many, many occasions where likely you would end up in an upset, and when this kind of tests are scheduled, it is always a senior test pilot in one of the seats, and we take advantage of this kind of test to have a less senior, junior test pilot in the other seat, to get him in situation, awareness and training. This is how this knowledge is acquired. It's gained by, based on a thorough theoretical knowledge of this kinds of situations.

Q So you're saying in lieu of a written guidance, you use experienced, more experienced test pilot to ensure that the prohibited maneuver or limitation was not exceeded.

A No, we use experienced test pilots when very demanding tasks where loss of control might be experienced, like early stalls at full aft CG in the program, and then we used the definitely experienced test pilots to do this kind of test. Just basically how it works.

Q In those tests, you referenced doublets. How is the difference between a doublet and an alternating side slip addressed in those flights you mentioned?

A Side slip is a stable situation. When I'm asked to put an aircraft into a side slip, I will put it into a side slip and limited to a side slip. This is just -- a side slip is a stable situation. A doublet is not. A doublet a dynamic entry on the flight controls.

Q Is an alternating side slip a dynamic or a steady situation?

A No, an alternating side slip is a succession of two steady situations.

Q So I'm confused. What's the difference between that and a doublet?

A A doublet would be -- a side slip is a precise maneuver, steady state side slip where you exercise, you put progressive input on the rudder and you -- accordingly, you make an input on the roll controls to keep your trajectory straight. This is a side slip. A doublet is just -- I'm going open loop now -- a doublet is typically an open loop input which consists in deflecting a given amount of rudder for a given time, and then the opposite amount of rudder for the same given time. It's a test maneuver which is taught in test pilot school, and which is used on military type aircraft.

Q Okay, back to that alternating side slip. You mentioned a limitation, I believe. There's a known limitation how far you would take that, is that correct?

A No. Side slips?

Q Yes, sir, alternating side slips.

A Alternating side slips is the side slip necessary to lower the gear or at these speeds you can go to side slips up to the rudder stop.

Q But back to your comparison --

A Yes, the rudder stop.

Q Back to your comparison of the alternating side slip versus a doublet, it sounded as if there was a limitation that you placed on the more precise maneuver. I think you referenced in the side slip -- alternating side slip.

A In the side slip there is no -- what kind of limitations?

Q Well, maybe I need to go back --

A Please.

Q -- and clarify for me. I think the confusion I had was what's the difference between an alternating side slip and a doublet?

A As I mentioned, the side slip is a steady situation. When I go into a side slip, I apply progressively, rudder, apply roll control to keep my airplane flying a given heading or trajectory, and I leave it there for steady condition. And once this steady condition is established, I am in a steady side slip. This is a steady situation.

Q So then in order for me to execute an

alternating side slip and avoid the hazard of a doublet, do I need to put that aileron control in?
A If you want to keep your trajectory straight, that's the reason why you would put your aileron control in. If you apply rudders to generate the side slip and you put no aileron control in, you are going to generate roll that way, as mentioned many times during the various testimonies. It is not the intent.
Q That would be an adverse condition to execute alternating side slip without aileron input?
A That would just not be a side slip, steady side slip. It would be something else.
Q But sir, I'm not asking you about steady side slip, I'm asking about an alternating side slip.
A Alternating side slip is a succession of two side slips. A side slip, by definition, is something which is steady, not dynamic.
Q Okay. Sir, do you know a gentleman by the name of -- and forgive me if I mispronounce his name -- Gerard Guiot? G-U-I-O-T?
A Yes, I do.
Q And do you know his position at Airbus?
A He is retired.
Q Formerly?
A Formerly he was the chief of the flight test

engineers.

Q The most experienced flight test engineer?

A He was an experienced flight test engineer, yes.

Q Are you aware of the work he performed in conjunction with the loss of control, joint safety analysis team, conducted by the Commercial Aviation Safety Team?

A I'm not aware.

Q Alright, sir. And I don't mean to spring that on you, but in their work in 2002, an opinion of simulator training and its appropriateness for use in advanced maneuvering training was achieved, and Mr. Guiot was a part of that. Would his evaluation of the simulator for use as an advanced maneuvering training device be in conflict with Airbus policy?

A Airbus policy is not to advocate use of simulator for large upset training. Some of the maneuvers in -- contained in AAMP might fit quite well in simulator, some don't.

CHAIRMAN CARMODY: Captain Pitts, may I ask you how much longer you expect to be with our questioning?

CAPTAIN PITTS: I have approximately six to eight more question, I'm not sure how long it'll take.

The answers are very long.

CHAIRMAN CARMODY: Okay, well, maybe the questions need to be reduced somewhat. I think we're going a little bit in circles, but I appreciate your cooperation. I hope to finish with this gentleman in time for us to take a lunch break soon.

CAPTAIN PITTS: Yes, ma'am, I'll endeavor not to go in circles.

CHAIRMAN CARMODY: Well, I think we have been. Thank you.

BY CAPTAIN PITTS:

Q Sir, are you familiar with the term aircraft/pilot coupling?

A Yes.

Q I'm going to reference Exhibit 14-C, page 3, if you will bring that up, please. While they're doing that, could you explain to me your understanding of the difference between pilot-induced oscillation and pilot-involved oscillation?

A Sorry, can you --

Q Yes, sir. Could you explain for me your understanding of the difference between pilot-induced oscillation and pilot-involved oscillation?

A I know pilot-induced oscillations, I am not familiar with pilot -- again?

Q Pilot-involved oscillation.
A -- involved oscillation. No.
Q Would pilot-induced oscillation imply that it is the pilot, singular, that might be causing the oscillation?
A In the pilot-induced oscillation, it's actually -- it's a closed loop situation where -- involving the pilot and the vehicle -- airplane in this case -- into a situation where the inputs of the pilot would eventually, coupled with the aircraft response, end up in a situation where the only way to stop -- practically to stop this cycle would be to release controls. That's pilot-induced oscillation.
Q I'm going to ask you to read the first two paragraphs for us, please, sir.
CHAIRMAN CARMODY: Is it necessary to read the first two paragraphs?
CAPTAIN PITTS: Madam Chairman --
CHAIRMAN CARMODY: If you look at that, is there a point you wish to make about it? I don't see sitting here reading exhibits at this hour. Is there one paragraph or the other, or one particular point you'd like to make on this?
CAPTAIN PITTS: It is a very complex subject, ma'am, but in honor of your request, I'll ask him to

just read the second paragraph.

MR. CLARK: It would be better, Captain Pitts, if you read the second paragraph, and then he can listen.

CHAIRMAN CARMODY: Yes.

CAPTAIN PITTS: Well, sir, I'm going to ask his expert opinion as an engineer and as a representative of pilots in the human and machine interface to speak to these, so I'd actually like to hear --

CHAIRMAN CARMODY: Well, I think it would be useful if you read it while he would think about his response.

CAPTAIN PITTS: Sure, very well.

"Although it is often difficult to pinpoint the cause of specific" -- and you have to forgive me, there's a bit of a glare on the right hand side of the screen, maybe we can bring it up right here -- "Although it is often difficult to pinpoint the cause of specific aircraft piloting events, coupling events, a majority of severe APC events result from deficiencies in the design of the aircraft, especially with regard to the flight control system, that reverse to adverse coupling of the pilot with the aircraft. In certain circumstances, this adverse coupling produces unintended oscillations or divergences when the pilot attempts to precisely maneuver the aircraft. If the pilot-vehicle system instability takes the form of an oscillation, the APC event is called a pilot-involved oscillation, also known as a PIO. PIOs differ from aircraft oscillations caused by deliberate pilot imposed periodic control motions, such as stick pumping. They are open loop in character, and open loop forced oscillation does not constitute a PIO. If the unstable motions of the closed loop pilot-vehicle system are divergent, rather than oscillatory in nature, they're referred to as either APC events or non-oscillatory APC events."

BY CAPTAIN PITTS:

Q My question, sir, is, does Airbus test their equipment to consider pilot-involved oscillations?

A I think the term pilot-involved oscillation in this text is used exactly in the same base or the same meaning that pilot-induced oscillation. And I already answered to the question about how we test and how the authorities' test pilots look at the susceptibility of pilot-induced oscillation throughout the testing they are doing. We have done a series of tasks that have not shown any tendency to pilot-induced oscillation. In addition of that, they have not been -

- ever been a report of the airplane, the rudder axis being -- having a tendency to go to pilot-induced oscillation, or pilot-involved oscillation. For me it has the same meaning as is written here.

Q Alright, sir. Do Airbus test pilots receive training concerning adverse aircraft-pilot coupling issues?

A They have most probably in their career been subjected to pilot-induced oscillation events. I have personally, and when I was in the military flight test center, I was in charge of prototype fly-by-wire aircraft that had characteristics due to the prototype flight control which were fitted in that airplane, mainly they were very, very slow, with a lot of time-lag, so this airplane was subject -- was PIO-prone. As a matter of fact, we even used it to demonstrate PIO to some other pilots. So most -- I would expect most test pilots to have encountered PIO at some time in their career.

Q I'm going to refer to Exhibit 14-C, page 5. Would you bring that up, please? The last bullet in the first paragraph.

A "The committee was disturbed by the lack of awareness of severe APC, even among pilots, engineers, regulatory authorities and accident investigators."

Q This was a National Research Committee effort. As a test pilot sir, and an important human-machine interface representative, what is your response to this statement?

A My response is that at Airbus, PIO issues are addressed on every program we develop.

Q Very well. One last Exhibit, ma'am. Please bring up Exhibit 2-X, page 11, please. If you could focus in on figure 13, it's on the right hand side of the page? And Captain Jacob, are you familiar with this report?

A I discovered this report when it was put on the Exhibit list at the pre-hearing.

Q Alright, sir. I understand it may not -- you may not have had an opportunity to thoroughly research it. Figure 13 highlights rudder movements of a transport category aircraft flying through multiple vortex rings known as pro-instability. As a test pilot, what is your interpretation of this work, if you had a chance to do so?

A I have looked at it. First of all, I do not know what pro-instability is. However, from what I have understood from this report is that it is a highly theoretical study. It's a theoretical study based on -- on unverified hypotheses. And in the conclusion it says that testing is needed -- actual testing to support this -- to make sure -- to know if this hypotheses are valid or not. So it's a theoretical study based on hypothetical data.

Q And you agree that maybe further testing is needed?

A I don't know. I have to look at the -- it seems very, very theoretical.

Q Alright, and one last question, sir. As it relates to special conditions in the turbulence criteria, as I asked in the questions yesterday of Mr. Chatrenet, the airplane flight manual and any appropriate special control instructions that may have needed to be included. Would you consider the modifications to the rudder usage that was introduced into the FCOM by Airbus in March of '02 as a special flight condition with a new limitation, or a new prohibited use of the rudder?

A I think it is in answer, certainly, to NTSB recommendation following the accident, and I think this kind of information is valid for all transport type aircraft, and as such, should, in the future, be included in training -- in general training for a transport pilot. It's not relative to any specific type.

CAPTAIN PITTS: Alright, sir, thank you very much. Thank you, ma'am.

CHAIRMAN CARMODY: Yes, turning to the FAA. Mr. Donner.

MR. DONNER: Thank you, ma'am, we have no questions.

CHAIRMAN CARMODY: And Dr. Lauber with Airbus.

BY DR. LAUBER:

Q Just two quick questions. Captain Jacob, you were asked about questions about forces observed on the pedals in 587, and specifically with reference to high control forces -- 120 pounds or so. Do you know whether or not such high forces were observed on the initial input to the rudder pedals that the pilot made?

A Say again? Sorry.

Q Based on Mr. Chatrenet's data that was shown yesterday, the first -- the initial pedal input -- was there any indication there of high control forces on that?

A No, not on the initial one.

Q Thank you. And my final question, based on that reconstructed time history of the rudder and rudder pedals that were shown yesterday by Mr. Chatrenet, do you believe that the initial control inputs made by the pilot in 587 were consistent with the training received in the AAMP program with regard to use of rudder?

A I do believe they are consistent.

DR. LAUBER: I have no further questions. Thank you.

CHAIRMAN CARMODY: Thank you, moving to the Board. Member Hammerschmidt, any questions?

BY MEMBER HAMMERSCHMIDT:

Q Just one very quick question. Concerning this whole issue of pilot-induced oscillations, as an experimental test pilot, would you say that the Airbus A300-600 aircraft is any more susceptible to lateral oscillations than would be any other transport category aircraft?

A The answer is no.

MEMBER HAMMERSCHMIDT: Thank you, sir, that's all I have.

CHAIRMAN CARMODY: Member Goglia?

MEMBER GOGLIA: No questions.

CHAIRMAN CARMODY: Member Black.

BY MEMBER BLACK:

Q Captain, good morning -- or I guess, good afternoon. Time flies.

A Good afternoon.

Q Are you familiar with the circumstances of flight 903, an incident in 1997 involving an Airbus 300-600?
A I was not directly involved in it, but I have reviewed the data, yes.
Q Were you aware of it at the time it occurred?
A No. I reviewed it later on.
Q Okay, that cuts off one avenue, but I'll ask the question anyway. Did it ever occur to you, or has it ever occurred to you since you've been at Airbus, or since you've been in the test flight business, that a pilot might make a doublet without knowing what it was, and what the consequences of that event might be?
A I don't see any -- any situation, either normal or in failure, that would require a doublet, and the -- this kind of inputs obviously would, in the situation of panic or something like that, any type of flight control might be possible, but then in this kind of situation whether you are aware or not aware that you should make it or not doesn't make any difference.
MEMBER BLACK: Okay, thank you.
CHAIRMAN CARMODY: Is that it, Mr. Black?
MEMBER BLACK: Yes, ma'am.
CHAIRMAN CARMODY: Okay. Thank you. Are there any additional questions from the technical

panel? Any of the parties? American, something new?

MR. AHEARN: Just one quick question, Madam Carmody. Captain Jacob, have you ever been to the AAMP training program?

THE WITNESS: No.

MR. AHEARN: Thank you.

CHAIRMAN CARMODY: Anyone else? Very good. Then I propose we come back at 2:30 and we'll resume with the next witness. Captain Jacob thank you very much for your testimony. Very helpful to us.

CAPTAIN JACOB: Thank you very much.

(Whereupon, at 1:45 p.m., the hearing was recessed, to reconvene at 2:40 p.m., this same day, Wednesday, October 30, 2002.)

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

2:40 p.m.

CHAIRMAN CARMODY: Can we take our seats and resume. We're running a little late, I'm sorry. Ms. Ward, would you call the next witness, please.

MS. WARD: Yes, I call Dr. Fred Proctor.

Whereupon,

DR. FRED HAYES PROCTOR

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

BY MS. WARD:

Q Dr. Proctor, would you please state your full name, your current employer, and your business address?

A My full name is Fred Hayes Proctor. I work for NASA Langley Research Center, Hampton, Virginia. Its address is Mail Stop 156-A, Hampton, Virginia 23692. I'm --

CHAIRMAN CARMODY: Dr. Proctor, if you could please speak a little closer to the microphone, it's sort of hard to hear you. Thank you.

BY MS. WARD:

Q And what is your current position, and how long have you been in that position?

A I am the research meteorologist, and I have been a civil servant with NASA for the past 12 years.

Q And what are your duties and responsibilities in your current position, and please list any education and training that you may have received that qualifies you for your position?

A I conduct and direct research in support of two national programs, the Wake Vortex Element of the Airport Capacity Program, and the Aviation Safety Program. In the latter, I provide tools and data sets for potential certification of -- for potential FAA certification of look ahead wind shear -- or, excuse me -- turbulence radars.

My education is -- I have a Bachelor's in Meteorology from Florida State University. I have a Ph.D. in Meteorology from Texas A&M University. My specializations are computational meteorology and fluid dynamics, with special emphasis on aviation hazards such as modeling of wake vortices, flight turbulence and wind shear.

MS. WARD: Madam Chairman, I find this witness qualified and now pass it to Mr. John O'Callaghan for questioning.

CHAIRMAN CARMODY: Yes, Mr. O'Callaghan, please begin.

MR. O'CALLAGHAN: Thank you, Madam Chairman.

BY MR. O'CALLAGHAN:

Q Good afternoon, Dr. Proctor. Dr. Proctor, you performed an analysis of the wake shed by the Boeing 747 that preceded American flight 587 out of JFK. Does your work support an encounter of the 747 wake by the American flight 587?

A Yes, it does.

Q And what were the characteristics of the wake at the time or times of these encounters?

A Characteristics were that it was 60 to 80 percent of its initial strength, and that there were meanders in the wake, but there was no linking instabilities going on at that time, in other words, Crow instability had not set in yet.

Q Thank you. At the time of this encounter, can the wake be analyzed or modeled analytically or, given that it hadn't decayed into vortex rings?

A Yes, it can be modeled analytically.

Q And you actually developed a model for the NTSB?

A That's correct.

Q How would you characterize the 747 wake at the time of the encounters? Is it a typical wake, or anything unusual or remarkable about it?

A Nothing extraordinary about it, other than it occurred in an environment which was favorable for long lasting wakes, but this is nothing out of the ordinary.

Q Thank you. And referring to Exhibit 2-X, there's a paper -- it's a paper entitled "An Engineering Study of the Unsteady Response of a Jet Transport During a Wake Encounter and the Transitional State of Potential Crow Instability". Have you had an opportunity to review that paper?

A Yes, I have.

Q And does the paper in question explicitly purport to describe events that actually did occur or could have occurred during the accident flight?

A The paper is flawed because of the assumptions that it made. It assumed that Crow instability had occurred, which our analysis showed that it had not, and two, that the Crow instability had somehow rotated 90 degrees into a vertical plane, which is -- which is never observed and unjustified.

Q But does the paper, does it pretend to say that that had actually occurred on this specific accident flight, or is it just postulating this in a general way?

A It postulates that it might have occurred.

Q And again, you started answering a question I had about whether the assumptions and conditions described in that paper are applicable to the wake encounter. You mentioned a couple assumptions that were flawed. Were there any other assumptions that don't apply to this case?

A Another assumption is that the analysis ... no decay had occurred in the vortex, that it was at full strength.

Q Whereas your work shows otherwise, is that right?

A That's correct.

Q So I guess to the point, then, is the phenomena described in the paper relevant to the circumstances of this accident?

A No, it is not.

MR. O'CALLAGHAN: Thank you, Dr. Proctor, and Madam Chairman, I have no further questions.

CHAIRMAN CARMODY: Thank you are there any questions on the tech panel? Any additional questions? Seeing none, alright. Let me proceed then to the parties, and I would suggest an order this time of Allied Pilots to begin, and Airbus, and American, and FAA, if that's agreeable. Captain Pitts, would you like to start the questioning?

CAPTAIN PITTS: Yes, thank you.

CHAIRMAN CARMODY: Uh-huh. Thank you.

BY CAPTAIN PITTS:

Q Sir, your discussion mentioned the data used in the development of the model was semi-empirical. Could you identify for us what was empirical and what was inferred?

A This is referring to the APA model?

Q No, sir, to your model.

A My model.

Q Yes, sir.

A There is no empiricism in the model that I used which developed the data sets -- very low empiricism. It is a Avery-Stokes Code which is developed in a meteorological framework and it does a large ... simulation of the wake vortex phenomena in three dimensions and time.

Q And does it then give you sufficient surety to estimate the strength and the possible potential of the Crow instability with that large a degree of generalism?

CHAIRMAN CARMODY: Excuse me, we've had some requests Dr. Proctor, for you to get a little closer to the microphone so we can hear your testimony. Thank you.

THE WITNESS: Excuse me.

BY CAPTAIN PITTS:

Q Would you like me to repeat the question?

A Yes.

Q You said that it was general in nature, and not empirical?

A The terminal area simulation system, yes. My model.

Q That you used.

A We used several models in this study. One model to generate the data sets and another model to do the prediction of the wake vortex --

Q And based upon the non-empirical basis of that, what degree of surety do you have in your estimates in evaluation of the vortex, then?

A I think the greatest uncertainties will come in as far as the input of initial conditions, for example, the initial cross wind profiles and turbulence profiles that were used to initialize the model.

Q But it gives you sufficient information to give a determination that Crow instability could not have possibly been developing?

A Not if the input is true, and the input came from the flight data recorders of the JAL47 and the 587.

Q Alright, sir. Your slide presentation

material provided in your study does not indicate the derivative model of the Boeing 747 used in the analysis. Which model was that, sir?

A I'm sorry.

Q Which model of the 747 did you use for your analysis of the derivative data?

A We used -- as far as the input data?

Q Yes, sir.

A We used -- it was the data provided by the NTSB from the analysis of the --

Q So it was specific to that 747-400 that preceded the -- it was --

A Yes.

Q -- exactly --

A The JAL, yes.

Q Alright. What gross weights -- were the gross weights recorded by the aircraft as reported by the --

A The weights were given to us by NTSB.

Q If we could bring up Exhibit 13-A, pages 156, and I think it carries over to 157. Slide titled "Three Dimensional TASS Model".

A Correct.

Q Would you like for us to wait until it shows up on the monitor?

CHAIRMAN CARMODY: Yes, I would, and if you -- I don't see it of course, but if you could indicate when it does, what paragraph, what part of the page, our technician could probably find it more quickly, but right now it's not on the screen. I'm sorry -- are you saying there's no -- oh, here it comes.

MEMBER BLACK: Is this Exhibit the performance study?

CHAIRMAN CARMODY: What was the Exhibit number again, Captain Pitts?

CAPTAIN PITTS: 13-A.

MEMBER BLACK: Is it the performance study?

CAPTAIN PITTS: Yes, sir.

MR. CLARK: Okay.

CHAIRMAN CARMODY: Well, we're half way there. Need to turn it -- does that look like the right Exhibit?

CAPTAIN PITTS: Yes, ma'am.

CHAIRMAN CARMODY: Okay.

BY CAPTAIN PITTS:

Q How was the concluding circulation value derived, Dr. Proctor? Previous page?

A I'm sorry, what page are you on?

Q Let's use the previous page to that, it would be -- I'm sorry, the subsequent page, page 157.

A 157?

Q Yes.

A Okay, the initial circulation was based on the weight and air speed of -- and the aircraft wing spans of the JAL-47.

Q Yes, sir, that was the initial. And the concluding circulation value, how was that derived?

A Concluding circulation -- the numerical simulation was initialized with that value, and all the other initial conditions, and the simulation progressed in time and the vortex decayed with time, and then after, say, I think it was about 100 seconds, the value had decayed to the value that's quoted there, which is -- in the text, which is about 80 percent of the initial value.

Q And so that was derived from known characteristics of a standard decline or standard degradation of a vortex?

A (inaudible)

Q I'm sorry, I didn't understand that.

A Avery-Stokes determined it. In other words, it was calculated using equations of motions and physics.

Q What is the tangential velocity of the vortex that we see in circulation here?

A In numerical simulation, the peak was about -- a little less than ten meters per second at the time of encounter.

Q Alright.

A And that was over a core radius of three or four meters.

Q Alright, sir. What is your estimate of potential forces, direction and magnitude generated by the vortex?

A I cannot answer that question at this time.

Q Is there something that's missing from the information that you need to make that determination?

A These data sets were provided or being provided so that more detailed dynamic model analysis can be made, and also they can be used in flight simulator studies as well.

Q So those more dynamic models that might be made, do you think they would show different final conclusions based upon this degradation that you outlined for us, and the fact that there could possibly -- was no Crow instability present? In other words --

A No, the flow ... would not change, but what -- a person that has an aerodynamics background can do, is then run simulations of what an aircraft would encounter using different trajectories through the vortex.

Q I see. In terms of the vortex and what forces it can generate, can you speak to the assumption that the vortex can or cannot create an equal and opposing force in a given area? For instance, on a flight control surface or a surface of a aeroelastic (ph) vehicle?

A My background is not in aerodynamics, so I really can't speak to that.

Q But in terms to what the vortex is capable of?

A I have no -- a very -- circulations there of -- of -- they range from ten meters per second over four meters, or ten meters per second to tangential velocities over four meter decreasing with smaller radii.

Q Alright, sir. What conditions do favor Crow instability?

A Crow instability is a strong function of the ambient turbulence in the atmosphere. The stronger the turbulence, the sooner Crow instability will occur.

Q And that turbulence, then, could that be generated by an aircraft that flew through the area as well, versus an atmospheric condition of turbulence that may be from moving air masses?

A Highly unlikely. It's mostly or almost

entirely due to the ambient level of turbulence.
Q And you're saying that those conditions were not present in the atmosphere on the day of the accident?
A From our analysis of the flight data recorder of the 747 which preceded it, we showed very light levels of turbulence, above the atmospheric boundary layer which had an altitude of about 1500 feet.
Q Is it possible that we could not see Crow instability and it in fact be present in the atmospheric conditions that existed on the day of the accident?
A You would not be able to see, probably, this vortex, regardless of what it was doing at that time.
Q I'm sorry, I may have misspoke. I don't mean see with our eyes, I'm talking about see in the review of the data that's available. You spoke earlier to the general nature of some of the information that you had. Is it possible that Crow instability actually exists out there and we can't see it with some of the tools that we have to measure it?
A I still don't quite understand the intent of your question.
Q In terms of a hazard to aviation, is it possible that we had Crow instability present in these

atmospheric conditions which are not conducive to it?
A I can't answer that other than our modeling studies and the observations, the years and years of observations that we have, would indicate it was a strong function of the ambient turbulence.
Q Last questions. Are you familiar with the FAA wake turbulence separation criteria?
A Vaguely, yes.
Q Does your understanding of the FAA wake turbulence separation criteria allow you to comment on our current separation criteria?
A I know what they are, but I can't really comment on it, no.
Q In knowing what they are, do you feel as if we have sufficient separation criteria between aircraft?
A Most people believe in the field that the criteria are quite conservative, and this is borne out by the very few accidents that occur.
Q So the absence of an accident would suggest that it's safe?
A Again, I think this would be probably better addressed to the FAA or people who are responsible for making these.
Q In your opinion, sir, does the contemporary

science support the application of the same wake separation criteria to an aircraft in trail of a 255,000 pound aircraft as that for a aircraft weighing nearly 900,000 pounds?

A Would you repeat that, please?

Q Yes, sir, I'll be happy to. In your opinion, sir, does the contemporary science support the application of the same wake separation criteria to an aircraft in trail of a 255,000 pound aircraft as that for a aircraft weighing nearly 900,000 pounds?

A Again, I would rather not comment on that. I'm not an aerodynamicist so -- nor a policy maker as far as that.

Q In your studies of wake vortex, have you seen an effect of aircraft gross weight on the intensity and the strength of a wake vortex?

A Yes, the heavier the aircraft, the stronger the wake vortex.

Q Alright, sir, and the current science now speaks to heavy aircraft at a weight of 255,000 pounds or greater, correct?

A That's correct.

Q And are there any gradients to reflect aircraft twice that weight?

A I cannot really comment on that question.

Q But you would agree that as the aircraft gross weight increases, that it would increase the strength of the vortex?

A Yes, it would.

Q Alright, sir. And I apologize, I have one more series of questions. How does the pressure vary cross sectionally in a vortex core?

A The pressure field will try to balance the tangential velocities, so you can have a very low pressure in the core of the vortex. These vortices are like, I guess, weak mini-tornadoes.

Q And does that pressure gradient increase linearly towards the core? In other words, it's stronger --

A Probably exponentially drops into the core. The pressure decreases exponentially into the core.

Q How would such an area of low pressure affect an aerodynamic surface, if it were encountered? Are you qualified to speak to that?

A I am not qualified.

Q Alright, sir, I understand. Have you ever had an experience where a core of a vortex coming into contact with an aircraft has made a sound like a thump? In your studies have you seen this?

A I'm not aware of such.

Q Alright. I'll skip the next question that speaks to aerodynamics. Would it be possible -- and I won't ask you to comment on the aerodynamic properties of the aircraft -- but if there were a low pressure area existing on one side of the aircraft versus another as created by the wake vortex core in a tangential encounter, would it be possible for it to effect enough of an oscillation as you've seen in the presentation of the aircraft performance capabilities?
A I would be unfamiliar of how an aircraft would respond to it.
Q I understand. One last Exhibit, 13-A, page 152. In the depiction of the aircraft's movement relative to the vortex, how much lateral air or system tolerance do you think exists in the placement of the aircraft relative to the vortex?
A Probably at least 50 meters.
Q Plus or minus 15 meters?
A At least.
Q I'm -- was that 5-0 or 1-5?
A 5-0.
Q 5-0, I'm sorry. Is it possible that there is a more tangential motion of the aircraft, then, if we were to move that 50 meters one direction or the other?
A Again, I can't really comment to the

aerodynamics.

Q You didn't place the aircraft in the depiction?

A No, I did not.

CAPTAIN PITTS: Alright, sir, fine. No further questions.

CHAIRMAN CARMODY: Alright, moving -- I believe I said American would be next, Mr. Ahearn, questions?

MR. AHEARN: Thank you, Madam Chairman, just a couple topics that I'd like to review with Dr. Proctor.

BY MR. AHEARN:

Q Good afternoon. Thanks for your time. You talked about the characteristics of what would drive the wake and generate the wake off this aircraft. Other than weight and lift, are there other primary factors that you use to determine the strength of this vortex?

A The initial or the calculated at the time of the supposed encounter?

Q Well, let's just talk about the initial.

A Okay, the initial would be just the function of the weight of the aircraft, its wing span and its air speed.

Q Thank you. If the powerful wake vortices generated from this very heavy JAL aircraft in a clean configurationing climb out, actually struck the vertical stabilizer -- could it generate a yawing moment?

A I really can't comment on the aerodynamics of how the flow would affect the aircraft.

Q Okay. Is it possible, with your study, and what you've looked at from the wake off the JAL airplane, is it possible that the JAL vortices could have interacted with flight 587 more than once during the second event?

A Yes, it is possible.

Q Okay, and then it's part of the size of its wake -- based upon your experience, and obviously your analysis of this event, is the 747-400 wake with an airplane at maximum gross weight, as strong as a wake that we'll ever see in this industry with the aircraft that are flying today?

A It is one of the strongest, yes.

Q Okay, and then one final topic with you, sir, just on the -- this is an issue associated with the DFDR -- the digital flight data recorder. Are you familiar with the sampling rates on the airplane?

A Vaguely.

Q Okay, the lateral sampling of rate on the DFDR is four times a second, and with that type of sampling rate, is a wake vortices capable of generating movements with a higher frequency than could be captured at the DFDR sampling rate, that being four times a second?

A You could certainly capture the outer circulation of the wake vortex. You may not be able to capture the core or the strong tangential velocities at that small a scale.

MR. AHEARN: Dr. Proctor, thank you for your time. Madam Chairman, those are the questions I have.

CHAIRMAN CARMODY: Thank you. Moving to Airbus, Dr. Lauber.

BY DR. LAUBER:

Q Just a couple of questions, Dr. Proctor. Good afternoon. Captain Pitts asked you about the possibility of a low pressure, drop in pressure in the core of the vortex. Would that pressure drop be such that it should be detectable by means of the barometric altimeter on the airplane?

A No, it would not because it would be over a very small distance.

Q With regard to your modeling, have engine effects been considered at all in the development of the vortex?

A No, they have not.

Q They have not. Do engines have an effect on vortex development? Engine thrust plume?

A Very little.

Q You indicated that the -- your data show something between 60 and 80 percent of the original vortex strength with the time of the encounter, is that correct?

A That's correct.

Q That seems like a large spread -- we've got a 20 percent spread here. I'm just trying to get some feel for whether this is a situation where -- what causes the uncertainty in the data?

A I ran three different models on this case. Some were semi-empirical. The semi-empirical model, the APA model, is primarily used to predict where the vortex track will go and the circulation of the vortex. It predicted about a 63 percent decrease, I think, at the time of the second encounter. And the large LES code that I used that I was referring to before, the TAAS model predicted about an 80 percent decrease.

Q 80 percent decrease --

A Excuse me, it was 80 percent of the value.

Q Of the original -- a 20 percent decrease.

A Yes, and the APA model was 63 percent of the initial.

Q Are these so-called two-dimensional field models, either of the techniques that you used?

A The APA, I guess you would consider more one dimensional than two dimensional. It's one dimensional and in time.

Q Would you say that their utility is probably greatest in determining the theoretical maximum strength of the vortex in any given situation, rather than being applied to an evaluation of the specific situation?

A No, I think it would probably give a good estimate. It has been used in some of our NASA field programs and done reasonably well, and the parameters themselves were fine tuned with actual observations.

Q Were you here yesterday, Dr. Proctor?

A Yes, I was.

Q You heard the testimony of Mr. Chatrenet. Do you remember the chart that he put up showing the results of two different approaches to calculating side slip? One was the NY integration method, the other was the aircraft model, the simulation model, and that there was about a one degree difference during a certain period of time in calculated side slip, due to the -- produced from the different models. And he indicated that that could be accounted for by about five knots of lateral wind component. Is that consistent with your 60 to 80 percent strength estimate?

A I'm not sure. I don't see the connection between the two.

CHAIRMAN CARMODY: Would it be helpful to have the chart you're referring to?

DR. LAUBER: Do you recall the chart?

THE WITNESS: Vaguely.

DR. LAUBER: Vaguely.

CHAIRMAN CARMODY: Was it an exhibit?

DR. LAUBER: It was a presentation.

CHAIRMAN CARMODY: Then if he doesn't recall it --

BY DR. LAUBER:

Q In effect, if I can just characterize it, and if this doesn't make sense, we'll go on to something else. But at the -- during the encounter that was the subject of analysis by the two methods, the results -- the differing results of the two models could be accounted for by assuming a lateral wind component of five knots at the time of this encounter, and this would be during the vortex encounter. For a two second period this lasted. Is that five knot lateral wind component consistent with your estimate of 60 to 80 percent of the original strength of the vortex?

A I'm still not seeing your point, other than five knots is a very small number and you can probably get that much variation in the ambient atmosphere.

Q Okay, well, alright, I think I'll go on to one final question. With regard to the effects on following aircraft, the effect of a wake encounter on a following aircraft is dependent upon, among other things, wing span and mass of the follower, is that correct?

A That's correct.

Q Do you think it's even possible for an aircraft the size of an A300-600 with about a 150 foot wing span and 340,000 pound airplane, is it possible for a vortex that's 100 seconds old to roll such an aircraft to extreme attitudes, beyond 90 degrees, say?

A I have not seen any studies that would support that.

Q It would be less, in all probability?

A Again, the data sets that we generated could certainly be used to test all these hypotheses.

DR. LAUBER: Thank you, Dr. Proctor. No further questions.

CHAIRMAN CARMODY: Thank you, FAA, Mr. Donner. Any questions?

BY MR. DONNER:

Q Thank you, ma'am. Dr. Proctor, just for my own clarification, I may have missed it, did your research indicate one or two wake encounters?

A Up to two wake encounters, yes.

Q And did you find two wake encounters using both the winds from JAL and from American 587? When they were looked at separately?

A The wind from the profile from the 47 was -- the JAL 47 -- was quite different from the wind profile from the Airbus, and especially at lower levels where the first encounter occurred, so if you use the wind profile from JAL-47, you only got one encounter. When you use the wind profile from the 57, then you got the encounter at the lower altitudes.

Q Did you calculate the duration of each of those encounters? How long did they last?

A I did not calculate that, no.

MR. DONNER: Okay, thank you very much. Thank you, ma'am.

CHAIRMAN CARMODY: Member Goglia, any questions? Member Hammerschmidt does not have any.

MR. CLARK: Chairman Carmody?

CHAIRMAN CARMODY: Yes.

MR. CLARK: I think there was a question raised -- can I follow real quick?

CHAIRMAN CARMODY: Yes, we'll come back to us, go ahead.

BY MR. CLARK:

Q There was a reference earlier about how strong a wake can be from a fully loaded 747. This airplane was at 240 knots. What would happen if that airplane slowed down? What would happen to the wake at a slower speed, such as take off speed or approach speed?

A The circulation is inversely related to the air speed, so as the air speed moved down, the circulation would go up.

Q And that --

A Vortex strength speeds would be more intense with a slower aircraft.

Q So if separation standards were set, but the worst condition, the lower speed should be considered, is that what --

A Yes, that's correct.

Q And the faster we go, I get a lesser wake.

A Less intense wake, yes.

Q And then just to follow up on what Dr. Lauber was following up on. You stated that the vortex flow field at core was about ten meters, which I think is about 20 knots, roughly, how far out -- and the core had a -- what, a 12 meter -- or a three or four meter radius. How far out would I have to go before that degraded down to a five knot flow field?

A About a radius of six or eight meters. Five meters per second, or ten knots, and then half that again and it would be -- double that, excuse me, about 20 meters, I guess, something like that.

Q 60 feet out from the core, I'm in a five knot flow field.

A If that vortex is active that way.

MR. CLARK: Okay, thank you.

CHAIRMAN CARMODY: Any questions, member Goglia?

MEMBER GOGLIA: Yes, I do, Madam Chairman.

BY MEMBER GOGLIA:

Q In your modeling, did you use any of the data that the NTSB had collected for wake vortex studies that we did several years ago after the US Air 427 accident?

A No, I did not.

Q A more general question. In warming atmospheres, such as we have in the morning, there is definitely a difference in the density of the air, or the behavior of the atmosphere between land and water. In this particular accident, we have both of those forces in play, Jamaica Bay being a very large body of water. Does that factor into your modeling at all?

A Our team looked at the observations in and around the airport from several different sources, and we didn't see anything that would suggest a real strong variation above the atmospheric boundary layer.

Q And I take it from just the conversation that's occurred thus far, that we didn't have any doppler radar available to us to see what the atmosphere was doing in this area?

A The -- I know that the doppler radar data would input into the ... system which was providing some data as well. Now, I don't know what the status of the radar was at that time.

Q And you said that the effects of engines have very little effect on the vortices? Is that correct?

A That's correct.

MEMBER GOGLIA: Thank you, no further questions.

CHAIRMAN CARMODY: Member Black.

BY MEMBER BLACK:

Q Thank you, ma'am. Just a couple, Doctor. Do winglets have any effect on vortices production? Same airplane, same gross, same speed, one with winglets, one without?

A I really can't answer that question. I really don't know.

Q Has anyone ever looked at that?

A I'm not familiar with any study on that.

Q What do you think might have caused this difference in wind from the -- the derived wind from the data recorders on the two airplanes with only a few minutes in between them, and a few hundred feet vertical altitude? What could account for that difference in winds between two derived profiles?

A I'm very suspicious that one might be incorrect.

Q Why?

A It's very hard to justify that -- a meteorological scenario that would justify that much difference in the wind profiles for -- for being that close in time and space.

Q How does -- what effect does weight have on the intensity of vortices produced? Is it a linear relationship or is it an exponential relationship? Is it easy to quantify that?

A The initial circulation is a linear function

of weight, proportional to weight.
Q Directly proportional in a linear fashion?
A That's correct.
Q I guess that sort of goes to a second question that might lead to the future. Boeing is just in the process of certifying an increased gross weight 747, I guess they're going to call it a 400, and the people at the table here are about to produce one that might go over a million pounds, I think on gross weight at Airbus. Do we need to be reexamining this issue with these much larger airplanes that'll be flying in a couple years?
A Most certainly.
Q You believe we do?
A Yes, most certainly.
Q One more I think. This paper that's in the docket that I looked at the other night, it seems to be totally based around this incident, is that correct?
A You're referring to 13-A?
Q I'm referring to Mr. or Dr. or Mr. Brown's paper.
A Oh, okay. Yes, he is.
Q It basically took this incident and then generated a scenario, I don't know -- but it generated a scenario about rotation of the vortices during the

decay process. I know he mentioned what he's observed in contrails at altitude and that sort of thing. Is this a juried paper? In other words, was this thing peer reviewed before it was published?

A No, it was not reviewed.

MEMBER BLACK: Thank you sir, I appreciate it.

CHAIRMAN CARMODY: Thank you. Are there any additional questions from the technical panel? How about any of the parties? FAA, Airbus, Allied Pilots.

CAPTAIN PITTS: Just one more question, ma'am. Mr. Clark reminded me of another variable.

BY CAPTAIN PITTS:

Q He asked about the speed effect on the intensity of the vortex. What are the other variables that affect the vortex intensity?

A The weight of the aircraft, and the wing span.

Q If the aircraft were to initiate a climb and increase the wing loading on the wing due to acceleration, due to gravity, would that increase the intensity or the strength of the vortex?

A It's primarily -- I mean there can be other very small fluxuations due to flap settings and so forth, but primarily the intensity of the circulation is a function of the weight of the aircraft and the air speed, and the wing span.

Q So just to make sure I understand, you don't think the wing loading that would change as a result of the pilot initiating a climb, and the accelerations due to gravity would have an effect on the vortex strength?

A No, I do not.

CAPTAIN PITTS: Thank you.

CHAIRMAN CARMODY: And American, any additional questions?

MR. AHEARN: No, Madam Chairman, thank you. Alright, thank you. Let me thank the witness, then. Dr. Proctor, we appreciate your testimony and your moving up at our request. Thank you very much.

DR. PROCTOR: Thank you.

(The witness was excused.)

CHAIRMAN CARMODY: And Ms. Ward, I believe we have a panel coming up.

MS. WARD: Yes, I'll go ahead and call the next four witnesses. We have Mr. Robert Jones, Mr. Don Stimson, Mr. Loran Haworth, and Mr. Guy Thiel.

Whereupon,

ROBERT JONES, DON STIMSON, LORAN HAWORTH, and GUY THIEL were called as witnesses, and first having been duly sworn, were examined and testified as follows:

MS. WARD: I'll start with Mr. Jones. Would you please state your full name, your current employer and your business address?

WITNESS JONES: My name is Robert Charles Jones. I work for the Federal Aviation Administration, 1601 Linda Avenue, Southwest, Renton, Washington.

MS. WARD: And what is your present position and how long have you been there?

WITNESS JONES: I'm an aerospace engineer for the transport standards staff of the FAA. In the position I'm in, I've been there for three years now.

MS. WARD: Could you briefly describe your duties and responsibilities and any education and training that you may have received for this position?

WITNESS JONES: My duties include helping to develop standards and rules with respect to mechanical systems, including some flight controls. Part of my duties have included being a member of the flight controls harmonization working group, supporting the system design analysis harmonization working group. I've also support various i-seen (ph) venues that have been over the past several years in that position.

I have a Bachelor of Science degree from Arizona State University. My working background, I have 11 years of experience from the Boeing Company, working in the area of flight controls. There I developed system requirements, performed hazard assessments and developed failure modes and effects analysis and fault tree analysis. I was a designated engineering representative for the Federal Aviation Administration while I was there as well. After that I moved over to the FAA and worked in the Seattle Aircraft Certification office for two years.

MS. WARD: Do you happen to possess any FAA aviation certificates and do you have any flight time and what kind of aircraft have you flown?

WITNESS JONES: I have a private pilot's license, but I haven't flown as pilot in command in many years.

MS. WARD: Thank you, Mr. Jones.

Mr. Stimson, can you please state your full name, your present employer, and your current business address?

WITNESS STIMSON: My name is Donald Curtis Stimson. I'm employed by the Federal Aviation Administration, and the business address is 1601 Linda Avenue, Southwest, Renton Washington.

MS. WARD: And what is your present position and how long have you been in that position?

WITNESS STIMSON: I'm currently the acting manager for the Airplane and Flight Crew Interface Branch. I've been in that position since October first of this year.

MS. WARD: And could you also please describe your current duties and responsibilities and any education and training that you have for your current position?

WITNESS STIMSON: Certainly, In that position I manage and have overall supervisory responsibilities for the Branch, which is responsible, primarily, for developing and maintaining the standards, policies and guidance relative to issue areas such as airplane performance and handling qualities, human factors, electrical avionics, autoflight, communication and navigation systems, as well as software.

I received a Bachelor of Science degree in aerospace engineering at the University of Virginia. I received a Master's Degree in aerospace and astronautics in 1983 from the University of Washington. I was employed by the Boeing Company for 11 years as an aerodynamics performance specialist, including flight testing responsibilities, also served as an FAA designated engineering representative during that time.

For the last 11 years I've been employed by the Federal Aviation Administration as an aerospace engineer, with responsibilities for performance requirements and handling quality requirements for the development of standards, policies and guidance pertaining to those.

MS. WARD: Do you happen to have any aviation certificates, flight time and what kind of aircraft?

WITNESS STIMSON: No, I do not.

MS. WARD: Thank you, Mr. Stimson.

Mr. Haworth, can you please state your full name, your present employer, and your current business address?

WITNESS HAWORTH: My name is Loran Alan Haworth, and I work for the FAA. My business address is 1601 Linda Avenue, Southwest, Renton, Washington.

MS. WARD: And what is your present position and how long have you been in that position?

WITNESS HAWORTH: My present position is human factors specialist, and essentially that means working on policy.

MS. WARD: And what are your current duties and responsibilities and also would you please tell us of any education and training that you received to qualifies you for your current position?

WITNESS HAWORTH: I came to the FAA approximately two years ago, and since that period of time I've been working both, as I mentioned, on policy and certification programs. Prior to that time I was at NASA Ames, working with DOD at NASA Ames. I was an engineering research psychologist. Also spent about ten years as an engineering test pilot, and I have a background -- a B.A. and also an M.A., both from the Departments of Psychology, one from the University of Northern Colorado, one from Western Washington State University. And I have several hours of flight time in addition.

MS. WARD: Could you tell us what type of aircraft you've been certified in and any certificates that you have?

WITNESS HAWORTH: The best way to start, probably, is just talking about my certifications. I have several aircraft qualifications. Essentially from a certification standpoint, or qualification standpoint, I have a commercial in both airplane and in helicopter. I have an instrument in both airplane and helicopter, glider, and also instructor pilot.

MS. WARD: Thank you, Mr. Haworth.

Mr. Thiel, could you please state your full name, your present employer, and your business address?

WITNESS THIEL: I'm Guy Thiel. I work for the FAA at the Los Angeles Aircraft Certification Office. The address is 3960 Paramount Boulevard, Lakewood, California.

MS. WARD: And what is your present position and how long have you been in that position?

WITNESS THIEL: I'm a certification test pilot. I've been in the position with the FAA for 14 years.

MS. WARD: And what are your current duties and responsibilities and any education and training that you may have received that qualifies you for your current position?

WITNESS THIEL: I basically do flight tests, make evaluations of airplanes to make sure that they comply with the FARs. I have a -- specialize basically in performance, collecting data for performance of the airplane, for the flying qualities of the airplane, and what takes most of my time is working the man/machine interface.

MS. WARD: Since you're a test pilot, go ahead and list the aviation certificates that you have, any flight time and aircraft that you've flown?

WITNESS THIEL: To continue -- I have an M.S. and a Master of Science and a Bachelor of Science in aerospace engineering. I have about 1000 hours of commercial time, then I went in the Air Force for 20 years. I flew T-38s as an instructor, C-130s in the Tactile Airlift Command. I then went to test pilot school, graduated from test pilot school and was a test pilot school instructor for two years, and then finished a number of programs in the Air Force.

I have an airtransport pilot rating. I have MD-80, MD-11, Boeing 737, Boeing 777, and Airbus A320 type ratings, and I'm also a glider pilot.

MS. WARD: Thank you, Mr. Thiel.

Madam Chairman, these witnesses are now qualified, I'd like to pass over to Dr. Malcolm Brenner for questioning.

DR. BRENNER: We appreciate your being here. The topic of this session, of this portion was to talk about the certification issues, human performance issues in terms of flight controls. I think there was a sense among the parties in preparing, that it would be helpful to have your wealth of backgrounds represented. So what I'd like to do is address most of my questions to the panel, and among yourselves, perhaps, one person can lead, and then if there's other thoughts, we'd appreciate it.

QUESTIONING OF MR. STIMSON

BY DR. BRENNER:

Q A general question. What are the requirements -- can someone lay out the requirements for certification of handling quality of rudder systems, specifically, on transport category airplanes?

A I can talk to the handling qualities requirements that end up driving flight control systems design. The requirements I'm talking about are in 14 Code of Federal Regulations Part 25, which is the transport category airplane certification airworthiness requirements. And I can give you a brief overview here, but of course they are quite detailed and complex, so I recommend that you also refer to the 14 CFR Part 25.

Basically, the handling quality requirements are divided into control requirements, controllability and maneuverability; trim requirements; and stability requirements. For the rudder axis, for example, directional control, I'll go into those first. There's first the overall general controllability requirement. There are four controllability requirements that pertain to the rudder axis, and the first one is a general controllability requirement that Mr. Jacob touched on earlier, which pertains to all three axes, and that is that the airplane must be safe, controllable and maneuverable throughout the operating envelope under any probable operation condition, which includes conditions such as engine failure, without requiring exceptional piloting skill, alertness or strength, and without danger of exceeding the limit load factor of the airplane.

There are specified allowable maximum pilot force limits specified in the rule that are used to comply with the requirement that it not take exceptional pilot strength. That portion has quantifiable allowable force limits in each axis.

Then, to go on with the other three controllability requirements, one is an engine out controllability requirement that says that the airplane should have sufficient yaw control with an engine inoperative, to make reasonably sudden heading changes of up to 15 degrees in either direction, into or out of the inoperative engine.

Further, the airplane must show that it has sufficient control capability to make crosswind takeoffs and landings. And there is a minimum crosswind specified that for this airplane, it would have to demonstrate at least a 20 knot crosswind capability. That's the minimum. Basically, for -- to operate the airplane at higher crosswinds, the manufacturer typically will demonstrate higher crosswind values than that.

And the last controllability requirement is one that was also discussed a bit earlier, and that is that the minimum control speeds must be demonstrated in various phases of flight to be the minimum speed that the airplane could be recovered after a sudden engine failure and maintain straight flight.

The trim requirement, basically it generally says that trim must be able to be maintained throughout the flight envelope in normal operating conditions.

And then there are four stability requirements having to do with the directional stability of the airplane. One, again, is the general requirement that applies to all three axes, that there must be positive stability. Then there's specific requirements for each axis.

For the rudder, the first one is with the rudder free in a yaw condition, it must recover -- return to straight flight with the rudder free. The second one is -- and it's a combined lateral directional stability requirement, and the reason for that is that lateral directional stability is really a coupled mode. It's very difficult to have roll without yaw and yaw without roll. So the lateral directional is covered together. With that requirement, that is the requirement that steady heading side slips must be flown throughout the envelope, from very low speeds out beyond the maximum operating speed of the airplane. And it must be shown that the rudder and aileron forces and displacements are proportional to the angle of side slip that's generated. And that must be demonstrated throughout the range of side slip values that are appropriate to the operation of that airplane. And again, in that range of side slip values, the factor of proportionality between the angles -- the displacements and forces in side slip angle must be within safe limits. At greater side slip angles, beyond that which would be normal to the operation of the airplane, all the way out -- we test all the way to full rudder application, regardless of whether the airplane can actually maintain a steady heading side slip in that condition, and demonstrate that the rudder forces don't reverse and we don't have any bad characteristics.

Control harmony has been discussed previously and that gets in -- that's where it gets assessed, principally, in this requirement of conducting steady heading side slips.

And then the final stability requirement for the rudder is that the airplane, in a dynamic mode, the dynamic stability of the airplane has to be positive. For any mode except for the Dutch roll, it must be heavily damped, and the Dutch roll has to be positively damped with the controls free and easily returned to -- or reduce the oscillation with the pilot using normal techniques if the controls are not free.

So those are basically -- in the rudder axis -- those are basically the requirements.

Q Thank you very much. You mentioned there is some quantification standards for rudder certification. Could you review those?

A In the rudder axis, the primary quantifiable requirement has to do with the maximum forces that can be allowed to be taken credit for in certifying the airplane for various maneuvers. For instance, for minimum control speed, you either go out to the rudder limit, the stop, if you will, or there's a maximum force that you're not allowed to go beyond and take credit for, and that force is 150 pounds. So in any of these tests that demand full rudder, in terms of controllability, from the control side, you're limited to a maximum of 150 pounds of force.

Now, on the stability side, when we examine the stability of the airplane, we -- in the steady heading side slips for example and out the full rudder, you have to either go out to the stop, or in case the pilot is capable of exerting more effort, you have to go out to 180 pounds of force in that axis.

Q And where there are no quantification standards, would you do the evaluations by pilot judgement, or how would you do that?

A They're qualitative judgements made by the flight test pilot.

Q What are the quantification standards for rudder certification compared with quantifications standards for wheel and column?

A From the longitudinal axis, again we have controllability, trim and stability requirements. For controllability, again, there is a maximum force that's allowed to be taken credit for in showing the controllability. And controllability requirements for the longitudinal axis have to do with -- for instance, if you are at a reduced speed, close to the stall speed, you have to be able to put the nose down and recover back to your trim speed, from any speed down to the stall speed so that you have adequate longitudinal control to do that.

Then, under configuration changes, speed changes, changes in thrust, you have to be able to show that you can maintain steady flight in those conditions without exerting more than 50 pounds force on the control column. And that 50 pounds is in the requirement, 25.143, the controllability requirement as the maximum force that can be taken credit for exerted by one hand on the control column. So that's a case where you might be using the other hand to make adjustments either to the configuration of the airplane or for other reasons.

Q In general, are the quantification standards for rudder as prescribed or as broad as they are for the other controls, or less so?

A Oh, they're really very similar. There's probably only one area where the -- in the longitudinal axis - where there is probably one more quantifiable parameter than there is in the other axes, and that has to do with speed stability.

In the longitudinal axis, there's a speed stability requirement, basically from a trim speed, you have to reach and -- to maintain and obtain lower speeds you have to exert a pull on the column. To reach and maintain higher speeds, it has to be a push throughout the stable trim range. Now, as you get to lower and lower speeds, it has to still be a pull and at higher speeds, it has to still be a push. That gives you a gradient, basically, of stick force versus speed change.

There are a couple of requirements that pertain to the gradient of that curve. One is, first of all, there has to be basically positive at all points, so it's a local slope type of issue. The second is, is that in the stable speed range, there has to be an average slope to that curve of at least one pound for every six knots of speed change. So that's a quantifiable -- I guess that's a numerical parameter that's not present in the other axes.

Q Are there examples of rudder design issues that have become certification concerns in transport category?

A Yes, certainly, there are some issues that have come up over the years. I think probably the most recent one that I recall had to do with control harmony on a particular airplane that, in doing the steady heading side slips, which is a primary way of evaluating control harmony, this particular airplane reached a condition where full lateral control was used before you got very much rudder -- before you used very much rudder, and it was to an extent that there was quite a bit of rudder left, and it raised the issue of whether or not the amount of lateral controls, was consistent with the amount of directional control that was available to the airplane.

QUESTIONING OF MR. THIEL

BY DR. BRENNER:

Q Thank you. I guess I wanted to ask on the more human performance side, I guess the more experimental test pilot side, what kind of human performance issues are involved in evaluating forces in rudder systems?

A When we do specific, like steady heading side slips, we would basically want to make sure that we have increased forces symmetrically throughout the whole side slip and back -- that would be the most important thing, in other words, that you wouldn't have a gradient change in the middle of that, or that you wouldn't have some bad characteristic at the end -- as you get towards the end of the -- looking at the side slip.

Q What would you look for in break-out force?

A Break-out forces, it's really been discussed the last couple days a lot. I think the Airbus philosophy of having enough break-out force that you wouldn't inadvertently hit the pedal and disturb the airplane is a good one. I certainly couldn't put a number on that. I wouldn't have a feel for that. So that would be the break-out force, and at that point, you have to understand when we do these tests, we do them at a very slow, methodical way, so we would start, you know, with our feet on the rudders, decide which way we're going to go to do the side slip, and very carefully and slowly start to ease -- put force on the rudder pedal until a point where we get some motion from the rudder. Then we'd all aileron to keep the heading steady. Stop at that point, take some data, add a little bit more, stop, take that data, until we get to the very end.

Q Now earlier in the hearing we were talking about the ratio of break-out force to maximum force. I think we were looking particularly at a range in the variable stop design we were discussing on the airplane, where you had a one and a half ratio to one. Specifically, I think we were talking that a maximum deflection of this air speed be produced by 32 pounds pressure, break-out was 22 pounds pressure. Are there guidelines as to what a ratio should be between the two?

A There are not.

Q With this type of design, would there be a danger that a pilot might inadvertently command full rudder when he intended only to make a small rudder input?

A I think Captain Jacob really talked about this very well. In fact, pilots don't fly airplanes like that. Pilots fly airplanes -- they basically want to do something, they put an input in, and if it's not enough, they put more in, if it's too much, they take it out. So they respond to the motion of the airplane. So if I was going to add rudder, I'd have to have a reason to add rudder, and I would add rudder sufficient to do what I want to do, and that would probably be coordinate the airplane.

Q Do you think a pilot, with this type of design, with this ratio, would need training to make precise entries, or do you think that it would be intuitive enough that a pilot could use it appropriately without training?

A I think a pilot, by the time he gets to this stage of the game and is an air transport pilot, should have a lot of background in how to use rudder and how to apply it. I don't think the average person would stomp on the rudder. I think he would slowly add pedal as he needed it. So I wouldn't think at this stage that you wouldn't need any training.

Q And we also heard testimony that line pilots may not receive any ground or simulator training in the design factors of the rudder system. So in a variable stop situation, you might have a case of a line pilot who's making input at this speed for the first time, in turbulent conditions without this type of background. Under these conditions do you think the pilot would have any difficulty making precise inputs?

A Again, you'd have to have a reason to make an input at a speed that he's never used before, in other words, an engine failure or something along those lines, and again, I think he would respond to what he needed. If you have an engine failure, you would, first of all, level the wings, and the second thing you do then is coordinate your steady state with as much rudder as is required to center the ball. So I would think not.

Q And we were talking this morning also about the control harmony. Does control harmony apply to both force and displacement?

A Yes.

Q And as described, we were talking about the variable stop design, how does that maintain control harmony, based on the discussion you've heard?

A Well, again, it was discussed earlier -- I think the discussion was right on. As you're doing these steady heading side slips all the way from minimum speeds to maximum speeds, you're again doing it in a very slow, methodical way, and you're adding enough rudder just to get some movement and then balance it with the aileron to maintain a steady heading side slip, and you'd do it all the way to the very end. As long as the harmony is there between the two axes as you do that test, it is an acceptable test and complies with the rules.

Q And I guess we discussed that at the air speed we were looking at, this design used one third of the full travel range, and I guess there was a question, is there a danger the line pilot might mistake this limited travel range for a jammed rudder or some other problem. Does that seem like it might be a problem?

A Again, I think by the time he's where he is, in flying the airplane and with the experience he gains as he continues to fly, he should have an idea of how the airplane design and that he has a limiter of some kind. I would hope that -- and how that kind of works. So, again, I think, at that air speed, even though it's an air speed he wouldn't use very often, would have to use it. I think he would use what was required as opposed to making a large input without thinking about what he's doing.

Q Thank you, and I understand then, that this would not raise certification issues -- these type of --

A No, I don't have any experience on the A300 airplane at all, but I have experience in other airplanes that are all different types, and none of the ones in the transport category have had a problem that I would say would be unacceptable. I've only seen bad characteristics on fighter type airplanes.

Q What are pilot-induced oscillations?

A What I'm going to do is since that's already been defined by at least one person, maybe two, what I thought I would do is read to you what -- we have a manual that we use. It's called -- it's a manual on flight test techniques on how to gather data. It's called Aircraft -- it's AC25-7A, and this is the document where the criteria for doing PIO testing has been put. So in this document -- and again, this is a very complex subject, and there's a lot of definitions out there, but I wanted to do is for the record, is to read to you what it says, and that's just the first sentence. It says, "The classic PIO, commonly referred to as pilot-induced oscillation" -- and by the way, there's a number of PIOs out there. There's pilot-induced, there's pilot in the loop, there's all these different names that have been used, but PIO is the only thing anybody really understands -- "is considered to occur when some airplane's response metric" -- that would be pitch or roll -- "is approximately 180 degrees out of phase with the pilot's control input."

So basically what you have is the pilot is making an effort to do something with -- let's say, pitch -- and then instead of getting what he expects to get, he gets a motion that he doesn't expect. So when that happens, he could then reverse what he's done and that gets him out of phase 180 degrees. Once he gets out of phase 180 degrees, if he continues in that vein, you then have an oscillatory PIO.

Q And how does the FAA evaluate PIO certification?

A We put most responsibility on the manufacturer, so when his certification program begins, we sit down with the manufacturer, we discuss all the different requirements that he's got to do, and of course one of them is he has to make sure that the airplane is PIO-free. He doesn't want a PIO any more than we do. As a matter of fact, if you had a PIO, there'd never be a discussion. It's always the stuff in the middle that's difficult, when you're around the ragged edge.

So he would explain to us what his program would be to make sure the airplanes are PIO-free, and of course, the more fly-by-wire you get, the more difficult it is and the more tasks he's got to do because those airplanes that have that characteristic tend to be more PIO-prone than a mechanical airplane. So he would tell us what he's going to do, and then we would basically meet occasionally. He would hopefully tell us that -- we almost would be sure that he would tell us if he's found some problems, tell us what he's doing. We have discussions with the test pilots all the time.

So at the end of that development program, they would then tell us that they have seen nothing or whatever, so then we would start our certification testing, which wouldn't start off with PIO. It would be all the normal tests would be done. Of course, we would be looking for anything that would be susceptible to PIO as far as flying qualities, or anything else in the flight envelope.

At the end of that, if we've seen nothing, and they've reported nothing, we would do two tests. We would do one test at cruise speed, which would be a pitch and roll tracking task, and then we would do offset landings. Those are the two tests that we would do if everything goes well. If they have a problem, then we would explore, and we would negotiate and we would figure out how to solve the problem.

Q Could you describe the two tests briefly, please?

A The airplane would be up around a cruise mach number, and that's a good place to do one, everybody agrees, because that's where problems have been seen in the past. And we would -- there's a number of ways of doing something like this. You could do it purely in the pitch axis at first, and then introduce roll. The best way to do it is to have a display put in front of the pilot and this display is programmed to go through maneuvers, and you basically just follow the display through the maneuvers, and you'd be going through a pitch and a roll, probably all the way up to, I would say, plus or minus ten degrees of pitch and roll angles maybe up to 30 or 40 degrees. And you would be tracking this -- you would be tracking a -- it looks like a little airplane symbol or whatever, and you would track that as tightly as you possibly could. In other words, you would very aggressively track this target so you're trying to close the loop. That's where the idea of pilot in the loop comes, so you have a task to perform. You're tracking this as tightly as you can, and that's the way you flush out PIOs. And if you've ever seen one, you'd know it when you found one.

QUESTIONING OF MR. HAWORTH

BY DR. BRENNER:

Q I think the next few questions will be to Mr. Haworth, the member of the human performance group. We talked earlier about the vertical motion simulator -- the NASA vertical motion simulator recreations of the accident information -- the FDR and the CVR information -- and as someone who has this background and was involved in this trial, I want to ask your impressions as well. We talked about the second notable event, the one that led to the accident and the observation that the group agreed to that they did not observe a visual or acceleration cue that would lead a pilot to apply the observed initial magnitude of wheel and pedal. Was this your impression as well?

A Yes, that's my impression of the second event. In fact, I think the human performance group went further to say that it was barely perceivable. In fact, during the simulation runs, on occasion I actually held onto the controls very tightly to see whether it was cab motion was generated first or control motion, and it was very difficult to tell, because if it did occur, it occurred more simultaneously with the control inputs.

Q So basically, then, there were no dramatic accelerations of the sort that you might think would have been correlated with the magnitude of the --

A We could not determine a triggering event.

Q And another one of the trials that we talked about, the VMS trials simulated the movement of the rudder pedals as they would have been displayed on a ratio changer system. What was your impression of this compared to the same movement of the rudder pedals under the variable stop system?

A Much like Armand Jacob mentioned this morning, when you went from an approximately three or four inch displacement -- I'm talking about stop to stop -- on the rudder pedals to approximately eight inches stop to stop, the velocity is quite higher, and in this particular case we have to remember the controls are being back-driven, so we were trying to basically place our hands and feet on the controls and just follow through those control actions. And when the velocity increased because most of these motions were fairly rapid anyway, I think something like 30 degrees per second, it literally just threw my feet right off the pedals

QUESTIONING OF ENTIRE PANEL

DR. BRENNER: You've been here since the beginning of the hearing, we've been discussing a lot of design issues. Is there anything that you've heard that raises certification concerns, concerns about controllability without unusual alertness, strength or skill, or any of the other as we discussed? Perhaps each one of you could say something about any observations from the hearings so far.

WITNESS JONES: >From the things I've heard, generally the information that's been presented seems accurate for the types of rudder control systems that I've had experience with, and similar types of rudder control systems have all met the requirements of the FAR Parts, both from the handling qualities point of view, and from the design analysis, reliability point of view. So I haven't heard anything that really gives rise to me of any issues with the compliance or the design of any of these systems.

WITNESS STIMSON: I guess I'd have to say that I don't really have anything to add to that.

WITNESS THIEL: >From what I've heard throughout the hearing and Captain Jacob's discussion today, I would agree that I don't have anything to add to that either.

WITNESS HAWORTH: I don't think at this point

I would have anything to add. However, I must say that the human performance group is going through a process of eliminating different possibilities, just like you would in physical evidence, to find out if there is -- certain considerations are warranted that might be built upon later on, based on facts and findings.

DR. BRENNER: Thank you very much. Madam Chairman, I believe John O'Callaghan has some additional questions.

CHAIRMAN CARMODY: Fine, please proceed.

MR. O'CALLAGHAN: Thank you, Madam Chairman, and good afternoon, gentlemen. Just as Mr. Stimson suggested, I'm going to be referring to some of the Part 25 rules, so I'll ask Mr. Goldberg to bring up the PowerPoint on those, please, Exhibit 7E. Thank you. So probably Mr. Stimson would be the appropriate one for this, but whoever wants to take it, feel free.

QUESTIONING OF MR. STIMSON

BY MR. O'CALLAGHAN:

Q What I show up there are two FARs that govern the -- parts of the FARs that deal with part of the longitudinal and directional stability requirements and I'm just wondering if you could just briefly explain the reasons for those requirements, and in particular, why the longitudinal speed stability requirement has a quantitative value or limit for the factor of proportionality as you mentioned earlier, whereas the directional axis does not.

A Sure, the reasons for the requirements I think I alluded to a little bit earlier, in that they're both stability requirements. In the longitudinal axis it's a speed stability, basically speed stability requirement that the pilot should be aware of speed changes and he's made aware through the forces on the stick.

The 25.177 is a directional and lateral controllability -- stability requirement, and as I alluded to earlier, those axes are typically coupled. It's very difficult to separate directional stability from lateral stability, and so it, in the same sense, is a stability requirement for the other axis in that we don't want to see bad qualities that result in, for instance, reversals in rudder forces that may be caused by things such as fin stall or rudder hard-overs type of situations.

Now, how they evolved the way that they are -- the predecessor regulations to Part 25 were contained in civil air regulations 4B -- CAR 4B, and those date back to the early 1950's. There was a -- and in that time period, of course, was the origin to these requirements, and these requirements were very similar to what they are today. Probably the most notable difference is that the longitudinal stability requirement was that any significant speed change be perceptible to the pilot through stick force change. And that -- consistent with how the static directional and lateral stability requirement specifies that basically your rudder control forces and displacements should be proportional to the side slip angle. The CAR 4B original requirement for static longitudinal stability was that the stick force versus speed curve should be positive and should be proportional.

Now, in 1962, there was an amendment made to CAR 4B, the 12th amendment to CAR 4B is where the first time that the gradient was actually specified in terms of a quantitative value. And the reason that was given at the time is that it was very difficult to administer the requirement from a compliance point of view of what was perceptible. And so at that time it was proposed to use, I think at that time it was actually a half a knot for three pounds, which is the same gradient as a pound for six knots -- excuse me, a half pound for three knots which is now a pound per six knots. That was the time period in which it was changed.

The reason it was changed was basically an administrative compliance difficulty in negotiating over what was perceptible. And those same issues haven't given rise to any concern about the static lateral direction stability requirement.

Q Okay, thank you. And looking more closely then at 177, where it says that the factor of proportionality has to be within limits necessary for safe operation throughout the range of the side slip angles. I think Mr. Thiel talked about it a little bit earlier, but could you explain, perhaps again, how exactly that factor of proportionality is determined to be within the limits, safe limits, essentially?

A Sure, it's a qualitative flight test evaluation and that has to do with the control harmony issue as well.

Q And what are the maneuvers used to demonstrate that, and are any of the maneuvers involve rolling the airplane with the rudder?

A It's a steady heading side slip maneuver that is used to determine what the factor of proportionality is in that area, and that's where the requirement -- the requirement applies to side slip angles that are appropriate to the operation of the airplane, which generally, actually we go out to -- we conduct these steady heading side slips out to greater side slip angles than we really expect to see in operation of that airplane. Typically, for a transport category airplane, we go out to side slip angles of about 15 degrees or so.

Now, beyond that range of values that are appropriate to the operation of the airplane, we will go all the way out to full rudder. If, for that particular design, the airplane has more lateral control -- excuse me, more directional control power available to do it than lateral control power, you will end up in a roll situation at the end of that test.

Q Okay, but there are no specific dynamic type maneuvers induced with the rudder that are used in the evaluation of that factor of proportionality. Is that correct?

A Could you restate the question?

Q I say in the demonstration that the factor of proportionality is safe, the only maneuver I heard you mention was the steady heading side slips. And those are the only ones? There are no dynamic maneuvers that are used in the evaluation of that factor of proportionality?

A For that particular requirement, it even states specifically that it's done in steady heading side slips.

Q Alright. Thanks. If we could have the second page of that PowerPoint that has 25.147 on it please -- on the screen? Question about that. I'll wait for that to come up. You have a problem with the PowerPoint -- the second page of the one that was just up there? Well, while we're waiting for that to come up, I'm sure Mr. Stimson you're familiar with the FAR, so I'll just go ahead and ask the question. Basically, the FAR 25.147(e) deals with -- it's also on page 23 of Exhibit 7-E if you need to refer to it -- that has to do with roll control, and I'm just wondering how are the requirements of that section demonstrated and can rudder be used during the demonstration?

A That particular demonstration says that you should have enough -- this is with all engines operating is the normal operating condition -- that you need to have enough roll power to be able to conduct crosswind take offs and landings and yet be able to adjust for gusts and other operating conditions such as that. And then beyond that, it says that all the way out to the maximum speed, that we demonstrate the stability characteristics at, which is higher than the maximum operating speed of the airplane, that you have to be able to generate a peak roll rate that's considered necessary for safety.

Q Okay, but is rudder used at all during the demonstrations of that?

A Rudder would be used in the case of a crosswind takeoff and landing to maintain the side slip necessary, but only enough to maintain the side slip and make sure that you can correct for any gust upsets in the roll axis with the ailerons. We don't -- we don't have any requirements for use of rudder as a primary roll control.

Q Okay, thank you. And then, so then would rudder be used for roll control at any point during certification testing? I guess from your last answer the answer is no, but --

A Right, as I said, the only time it comes in is actually as a consequence of going out to full rudder on airplanes that have more control power available to the rudder than they do the ailerons to counter it. And that's just to make sure that if the pilot were to either inadvertently or otherwise, go all the way out to full rudder, that we don't have bad characteristics, such as rudder force reversals and such.

Q Okay, thank you, and the final question, also dealing with rudder --

WITNESS THIEL: Mr. O'Callaghan, just to add

-- just to make sure we cover -- covers enough base. We do do a test that involves using rudders to excite the Dutch roll. I know Airbus doesn't do that, they do the Dutch roll demonstration with steady heading side slips. I typically would always do them with a rudder doublet. With a rudder doublet, you're using the rudder pedals to -- you're trying to cycle the airplane to get its natural frequency so it starts to respond, and when you've got the motion basically the same plus and minus, you would then release the controls, or fix the controls, depending on what you're doing, and then count the number of overshoots. So that would be a case where you actually do use the rudder pedals to induce roll. If that's what you --

MR. O'CALLAGHAN: Thank you for that piece of information. So I guess to induce roll -- but how about for a roll control itself, to achieve a desired bank angles and such -- okay, thanks.

BY MR. O'CALLAGHAN:

Q Again, the final question would deal with 25.147, and I'll just refer you to the Exhibit because it's not on the PowerPoint, that part of it, but 147 is page 23 of Exhibit 7-E, and the question is -- deals with demonstrating sudden changes of heading up to 15 degrees between certain speeds, and if you could just explain what the speeds are and how the demonstration is accomplished, please.

A Generally -- the controllability requirements are generally conducted at a fairly low air speed, because that's where the control power would be the lowest. You don't get -- if you're at very low Q or dynamic pressure, you don't have as much control power. So most of these controllability requirements are conducted at a speed of 40 percent above stall speed, and that's the speed referred to in this specific requirement. So you'd show it at 1.4 VS, and you simply, with an engine inoperative, in a critical configuration, critical weight, have to show that while holding the wings approximately level with the ailerons, that you can make sudden heading changes of up to 15 degrees.

MR. O'CALLAGHAN: Okay, thank you. Thank you all, and that concludes my questioning. Thank you, Madam Chairman.

CHAIRMAN CARMODY: Thank you, I believe Mr. Magladry was going to question.

MR. MAGLADRY: I have no questions.

CHAIRMAN CARMODY: No questions. Anything else from the technical panel. Mr. Clark.

QUESTIONING OF MR. STIMSON

BY MR. CLARK:

Q I heard a comment earlier, when this started that part of the stability and control evaluation is to protect the airplane from going over limit load. I think in this case we can see that rudder reversals can certainly get us past limit load. Why isn't that considered in part of this certification requirement?

A Basically, the Part 25 and particularly the flying qualities part of it, civilian control, reflects the normal operational use of the airplane, plus some margin. So for instance, for the rudder control, although the rudder control -- we usually look at steady heading side slips out to the normal use of the rudder, and we also demonstrate usage of the rudder in VMC demonstrations for engine controllability, we also show that the airplane is safe from a flying quality standpoint to a full application of the rudder. That's different than the other axes, for instance, pitch axis, we don't show that you can do a full pull back on the stick and not damage the airplane. But in that axis, for example, feel (or FIO) might be added to it to give the pilot some indication that he's not -- that he's approaching the area where he should tread lightly.

Q That's in the pitch mode?

A That's in the pitch mode. As I said, basically it reflects the standard operation of the airplane. For example, we don't have requirements to cover spinning. We don't have any aerobatic requirements in there, and the cyclic motion on the rudder is not considered a normal piloting maneuver.

QUESTIONING OF MR. THIEL

BY MR. CLARK:

Q There was a comment that -- or we were talking about PIO -- what is the -- is there a primary cause of PIO -- was stability and control problems or instability and control?

A Well, there's some of the most classic are typically flying quality problems, or they're flight control problems, especially in the digital systems. We've actually had them in the systems that weren't digital, but because a digital system is so complex, and there's so many different routes that can couple into motion, that's where we start really having problem trying to 1) predict them, and 2) find them.

Q What's the -- given that it's a digital system, what is it about a digital system that gets you into a PIO mode?

A Well, again, it's the -- remember what gets you into a PIO is a pilot putting an input into a control system and getting unexpected motion. So he does one thing and what happens is something else, and he responds to that in a motion to the other direction, and, depending upon the air speed, that can be catastrophic, which we sometimes call a flying qualities cliff, and the airplane will actually -- well, you can destroy the airplane. That happened at Gripen twice.

Q What about the time delays in responses to flight control inputs?

A The digital time delays are -- turn out to be a factor that actually we stumbled into again, we didn't really realize at first that if the time delays were such, there would be a big problem. But with some research and some problems, we decided -- we did a lot of research to find out that those digital time delays have got to down around a tenth of a second. If they're bigger than that, what happens is you get a lag. If your time delay is very big, you get a lag in the control -- from the control input to the motion of the airplane, so the bigger that is, the pilot doesn't know what the airplane's doing. He's giving it input but it's not responding the way he likes it.

Q And then what happens? He gives it more? Holds?

A Basically maybe the worst case of course is he pulls this much, expects the nose to go this much, and it goes that much. Which thinks he's going to lose the thing. So when he sees that -- initially he would be very quick to react to that, probably would make the next motion down to try to stop it. That would probably be three times as big as it should be, and now you've got the same problem going the other way. So the only way he can get out of that is to let go of the controls.

Q But do we have a positive or a fast response with rudder pedal inputs?

A We have never seen PIOs in rudder.

Q Well, not directly in the rudder, but if I put the pedal in -- I think somebody said earlier, I have to develop a side slip and then I get roll on top of that, can I get a cross coupling thing that's called PIO out of that?

A We've never seen that. That's because the rudder design is very linear, typically, because that's the proportionality part of it. We've not seen a PIO in the rudder axis or a coupling into roll, as far as I know. All the work that we do on PIO, trying to find

PIOs, are basically pitch & roll in other words, we have pitch problems, which I described, and we have lateral roll saturation. We've seen those. As far as I know, we haven't seen a lateral problem. Doesn't mean that -- I don't know about them -- I don't know of any.

MR. CLARK: Does anybody else have any comments on that whole line? Everybody comfortable. Okay, thanks.

CHAIRMAN CARMODY: Alright, thank you, Mr. Clark. We'll move down to the parties, and --

MEMBER GOGLIA: Can I ask a question.

CHAIRMAN CARMODY: Sure, out of order, but I'll let you do it.

MEMBER GOGLIA: Just one question, Guy, you used the term, describing the rudder inputs back and forth, and that was not familiar to me. And I didn't hear it either, something that ended in cliff, I think?

WITNESS THIEL: Oh, I wasn't talking about rudder. What happens with a PIO is that the airplane diverges quickly -- with a very bad one -- that actually exceeds the structural failure of the airplane, actually break up in flight in about five cycles. I don't know if you remember the Gripen in accidents -- those are two very classic cliffs -- we call them flying quality cliffs.

MEMBER GOGLIA: Okay, I've got you now. Thank you.

CHAIRMAN CARMODY: Alright, the parties. We'll start with Airbus, Dr. Lauber, please. Any questions?

DR. LAUBER: Thank you, Madam Chairman, yes I do have a couple of questions that I think are primarily to Mr. Thiel, although the others can jump in if they wish to add to it.

QUESTIONING OF MR. THIEL

BY DR. LAUBER:

Q Were you present for this morning's presentation or testimony by Captain Young and Mr. Ghoshal?

A Yes.

Q So you heard the description of the roll inhibit button in the simulator and how it was used?

A Yes.

Q Do you have any opinions as a test pilot as to what effect that would likely have on pilot behavior?

A I have done upsets in a couple of different simulators with a couple different airlines -- American was not one of them, unfortunately. So I've seen it done more than one way. I've seen the typical way that

I'm used to from my military training is close your eyes and, you know, he puts the airplane and something, and let go and away you go. When I did it in the other simulator, I don't know whether they had the same kind of set up or not, but what the instructor said is don't do anything. In other words, it wasn't a multiple scenario that I was going to do a -- teach one thing and add this to the end, it was just basically, you know, close your eyes almost and don't do anything, and then the airplane was set in upset and they said now recover.

Q It was used strictly as a device to enter into the upset condition and then the pilot was supposed to --

A Yes, yes.

Q According to Captain Young's testimony this morning, the way American used it was -- at least often the scenario was to take off scenario. They were told they were following a 747 and they made a normal takeoff and at some point in the climb out, and apparently this could happen at various places, the instructor would activate this roll inhibit function and then the scenario would proceed from there. What kind of closed loop pilot performance would the introduction of this roll and inhibition function have and what would the pilots take away in terms of control strategy from this kind of situation?

A I can't comment on what they'd take away exactly. I have no idea what they would take away, but what I think -- if the pilot is hands flying the airplane and he takes off and does his thing, cleans the airplane up and now all of a sudden he gets uncommanded motion, he's going to try to stop that motion. And if it's a roll, he's going to use roll to stop it. He's going to use roll to do something with it, and he's going to probably continue, maybe all the way to the limit, maybe, if it's that bad. I don't know how -- I have no idea how dynamic this was.

Q It was apparently about a 30 degree per second roll rate, and it was in effect until the roll attitude reached about 50 degrees or ten seconds elapsed, it depended on where the roll started from, so it's fairly dynamic -- 30 degrees per second. If you were a pilot in that situation where suddenly you had an uncommanded roll, you said that you would counteract that with available roll control. Suppose you ran to the stops on the aileron, what would be the next likely --

A You only have one thing left. You might unload a little bit, to do that, but then you have no choice but to try to use the rudder.

Q And if the roll was continuing as you were -- would it be likely that you could go all the way to the stops on the rudder as well in the situation, if this took you to extreme attitudes?

A Very possible. I would -- you know, when you run out of ideas, you run out of ideas.

DR. LAUBER: Okay, thank you. Any other comments from the parties? Thank you, Madam Chairman.

CHAIRMAN CARMODY: Thank you. Moving to American, Mr. Ahearn, do you have any questions for the panel?

MR. AHEARN: Just a few topics, Madam Chairman, thank you. I'd like to address this question to Mr. Jones, if I might.

QUESTIONING OF MR. JONES

BY MR. AHEARN:

Q Mr. Jones, I believe with your background, you'd be familiar with a hinged moment limited rudder system, is that correct?

A Yes. That's the blow-down type of system that's referred to, I believe, yesterday.

Q We spent quite a bit of time talking about that yesterday, and let me ask you a question regarding that. Isn't it correct that when a -- when you're in a side slip in a hinged moment limited aircraft, you cannot achieve full rudder deflection in the opposite to side slip, is that true?

A You mean to the -- well, you'll always go to the blow-down limit. You'll always be able to achieve that pressure limit, but the -- probably the amount of rudder that you'll be able to achieve in direct degrees would be slightly less than if you were flying straight ahead, because you'll have your rudder turning into the wind at that point.

Q And then because of this, wouldn't this reduce the instantaneous loads and development of higher side slip loads due to the multiple doublet inputs? Would that not in fact reduce the loads?

A Well, the loads would -- you'd get some high loads because you have your rudder turning into the relative wind, and it would build up the loads under that condition.

Q It indeed would, but would the effects of blow-down, it would also reduce the loads on the vertical stabilizer, would it not?

A I perhaps don't understand your question. If you have a -- it sounds to me like what you're asking is that if you have a full pedal input in one direction and the airplane builds up side slip at that point in time, then your reverse the rudder into the -- essentially do what we've been calling a rudder doublet, that will induce a new hinge moment, which will be reflected through the fin and the rudder in that case, and reverse the load on it.

Q Okay. Let me move on to a different set of questions, please. This will be to Mr. Thiel.

QUESTIONING OF MR. THIEL

BY MR. AHEARN:

Q Mr. Thiel, does the FAA agree with the NTSB safety recommendations concerning the lack of industry awareness of structural limitations and rudder control characteristics of transport category aircraft, basically the recommendation that came out this year?

A I can't speak for the FAA, because there's a lot of them. I can speak for myself.

Q Okay.

A I think it's always important to put out information that pilots might not be aware of.

Q Okay, and I'll ask you another question in response to that. Would you agree, then, that it's the manufacturer's duty to identify and warn of any flight control system maneuvers that, if performed, could jeopardize the structural integrity of that aircraft?

A I can't comment on duty, but I would hope that they would.

Q Okay. Let me ask you one more question in that regard, then.

WITNESS STIMSON: Can I add something in that regard, please?

MR. AHEARN: Sure.

WITNESS STIMSON: Actually both of those, the first question regarding the NTSB safety recommendations. I think 01 and 02, yes, the FAA does agree with the intent of those safety recommendations and that's why we put out a notice and have also been working with the manufacturers to make sure that that information gets put into the proper operating manuals.

As far as the second question goes, could you repeat that one again, please. I think you asked if it was the duty of the manufacturer --

MR. AHEARN: Let me rephrase the question. Would you agree that it's the manufacturer's responsibility to identify and warn of any flight control system maneuvers that if performed could jeopardize the structural integrity of an aircraft?

WITNESS STIMSON: Well, see there are a myriad of potential flight control maneuvers, or maneuvers that are possible with flight control system that could jeopardize the structural capability of the airplane. The pilot could may cyclical maneuvers in the longitudinal axis as well. Any kind of open loop maneuver of the airplane that was not in -- in essence, within the operational capabilities of the airplane would have that potential. I think there are a myriad number of ways that you could get yourself into trouble.

MR. AHEARN: We specifically talked to the V_A chart yesterday as it relates to maneuvers and full utilization of the flight control systems at speeds below V_A. Do you have a comment in that regard, Mr. Stimson?

WITNESS STIMSON: That particular requirement says that full application of the rudder and aileron should be confined to speeds below that value. That's all it says. And so that if you're going to make one full application, which is what it says -- a full application -- that's where you should confine those applications to.

MR. AHEARN: Below maneuvering speed?

WITNESS STIMSON: Right.

MR. AHEARN: Thank you.

QUESTIONING OF MR. HAWORTH

BY MR. AHEARN:

Q Mr. Haworth, let me move on to some of the issues associated with the vertical motion simulator that I know you're familiar with. I'll give you a moment to turn on your mike.

A Thank you.

Q I know you're familiar with the limitations of the VMS with respect to DFDR data. Are you also aware of the modifications to the DFDR data that was made to make it compatible to the VMS in the testing that was done?

A I am just a little bit aware of that. Most of that was taken care of by John O'Callaghan while he was at the VMS, so I just heard that in the background, I guess you might say.

Q Okay. With your commentary earlier regarding lack of VMS cues during the second vortex, I believe was your statement, isn't it possible that due to the DFDR sampling rates and the fact that the VMS had to be -- what I'll say is desensitized to reduce the feedback, could that not have reduced feedback to the VMS pilots?

A Could you specifically restate your question, please?

Q Sure. There were two things that were, to my understanding when we went into the VMS to test it. One, was the issues associated with sampling rates, and they're not everything, I mean because the DFDR is like taking a snapshot with a camera versus doing it with a motion camera, there are limitations of the DFDR. And then the other is that they had to do some desensitizing of the VMS. Could that not have reduced the feedback that you would have receive as one of the VMS pilots, addressing your lack of VMS cues commentary?

A I really don't think so. I mean there is probably some high frequency information that was -- as introduced earlier -- that we did not have, that I'm not really certain from what I could tell that if a reintroduction of the high frequency information would have made much of a difference. But you know, you don't know that until you actually put that in an experimenter, into a trial to really find that out, and that's the way it should be. I do also know that of course, the sampling rate on the flight data recorder has different sample rates on different channels, and certainly that could filter some of that high frequency information.

Q Okay, well perhaps we'll get that in the phase three of our testing.

FURTHER QUESTIONING OF MR. THIEL

BY MR. AHEARN:

Q When you did the simulator training for upset recovery, did you find it more valuable than just the pure classroom environment?

A Abso -- oh, obviously. The best thing to do is go up and do it in an airplane, there's no doubt about that, but I'm not sure there's enough money in the world for everybody to do that.

Q I agree, sir.

A But as far as doing it in the simulator, it has to be done extremely carefully. It should be in the center of the envelope because you know, we do know the limitations of simulators, and you have to be very careful of what you're doing. So -- you have to orchestrate what you're doing very carefully.

Q Agreed.

A So that's why I think the idea of doing it the old fashioned way is put it in the heart of the envelope, let the pilot close his eyes, don't give him something ridiculous, just give him something -- you don't need to make the airplane violent to get the training across that hey, guy, you're upside down, you've got to roll towards the horizon, and I think you will get some additional training that you wouldn't get otherwise.

Q Okay, thank you.

A Let me tell you, that's my opinion only. Because the people in charge of simulator are the flight standards people. That's their --

Q Thank you, appreciate it. And to your comment about American, maybe one day we'll get you into the AAMP program.

A Any time.

MR. AHEARN: Madam Chairman, that ends my questioning, thank you.

CHAIRMAN CARMODY: Thank you. On to Allied Pilots, Captain Pitts.

CAPTAIN PITTS: Thank you, Ma'am.

QUESTIONING OF MR. JONES

BY CAPTAIN PITTS:

Q Mr. Jones, could you help us sort out the questions of the certification history of the aircraft. Were you here to hear the previous day's testimony on that/

A Yes, I've been here for the hearing.

Q Can you tell us what the certification basis of this aircraft, the 605-RS?

A The 605-R, for the most part, the 605-R is a derivative aircraft from the original A300 and the genealogy is that you had the A300, B2/B4 was the original, then the A310-200, the A310-300, and then the A300-600. And my understanding is that Airbus had stepped up to the latest certification requirements at the time, for most of the requirements -- there were several that weren't stepped up to, but for quite a few of the latest certification requirements, they were stepped up to as far as a certification basis for the A300-600.

Q So 605-R had areas that were not stepped up to, is that correct?

A There were two or three that were not stepped up to.

Q Can you share which ones those were with us?

A I don't recall which ones they were. I know with regard to -- I could speak to the general flight control system requirements, that that one was stepped up to, and in fact, the original A300 had a special condition that was essentially the same thing, and I believe that for the handling requirements, they had requirements that were stepped up to -- to the latest, but Don Stimson could talk to that.

WITNESS STIMSON: Sure, I can --

CAPTAIN PITTS: Yes, please do.

WITNESS STIMSON: For the handling qualities requirements, they did step up to -- and then the 44 was the certification basis for most of the airplane -- Part 25, amendment 44, and amendment 42 was the last one that added some handling qualities requirements.

BY CAPTAIN PITTS:

Q So the special handling, special conditions that you mentioned, was that inherited with the previous rudder design?

A The original special condition was applied to the A300 B2/B4, which had the original rudder control system with rudder ratio change. And incidently, I'll just mention here that that same special condition had been historically been applied to the various transport airplanes that had been certified, probably since, I think, 1968, 1970 time frame.

Q Okay. Considering the requirement to demonstrate by test or test analysis, the handling qualities, what is -- what is your opinion of the lack of the test using doublets -- that technique by Airbus, versus -- as it was previously discussed and testified to by Captain Jacob?

A That's really a handling quality issue, and I think that probably Mr. Thiel would be the best person for answering that.

WITNESS THIEL: The -- I think you're speaking about Dutch roll -- you're speaking about how you excite the airplane to look at Dutch roll.

CAPTAIN PITTS: Yes, sir.

WITNESS THIEL: Okay, when you're doing a maneuver to gather flight test data, as we've been talking about, you're trying to excite a Dutch roll frequency -- that's the only thing you're trying to do. So whether you do it with a steady heading side slip and release, which, for me, always winds being unsymmetric, that's why I don't like doing it. The other technique, which is used, I think, by most of the people that I know, and certainly taught in the test pilot school, is you start moving the rudders, just very little at a time. The frequency starts very slow until you say, ah, there's the natural frequency of a Dutch roll, at typically -- you know, five cycles per second is pretty typical. And once you get it excited enough that you can gather the data, and that's -- and you're probably moving -- you're probably three or four degrees of side slip, maybe, and maybe ten degrees of bank, you want to release your feet off the rudders and you count the overshoots. So you're not trying to go beyond anything other than to excite the Dutch roll.

CAPTAIN PITTS: Alright, sir. Mr. Haworth.

WITNESS HAWORTH: Yes.

MR. CLARK: One quick question. You commented the Dutch roll is about five cycles per second, is that -- or five seconds per cycle?

WITNESS STIMSON: Point two hertz.

WITNESS THIEL: Yes, thanks, sorry.

QUESTIONING OF MR. HAWORTH

BY CAPTAIN PITTS:

Q That's it? Mr. Haworth, in Part 25.143, there's a discussion of airplane/pilot coupling. Are you familiar with that?

A I'm familiar with the 143, but Don Stimson probably would be the most familiar with it since he's a specialist in that area.

Q Okay, I'm not going to ask a question about the regulation itself, but I'll give him a chance, certainly to comment. I'm most interested in where it speaks to -- it states that "artificial trim and feel systems, which produce controllers with too small a displacement and light force gradients may also lead to severe over control". As a human performance expert, in your opinion, does the A300-605-R rudder system have a too small displacement and light force gradient which may be falling prey to this very warning?

A I have to tell you, it's situational, and I have not flown the aircraft before, and I'd have to defer that to the test pilots.

Q Do you know of an aircraft that has a lower break-out force on the rudders?

A I have to tell you I'm not familiar with all the aircraft in terms of break-out forces to make that conclusion for you.

Q Alright, sir, and then in terms of human performance studies, you're not aware of any studies which speak to maybe a minimum value that might want to be considered in terms of human/machine interface?

A I can't think of any that I could cite at this particular time, no.

CAPTAIN PITTS: Alright, sir. Mr. Stimson, did you have something you wanted to add to that?

WITNESS STIMSON: No, I guess maybe to clarify that actually in the requirement 25.143 does not refer to APC directly. It's a general controllability, maneuverability requirement and I think you're quoting from the guidance material that we use as a means of compliance, but you are correct in citing that requirement as being the one that drives the evaluation of APC tendencies.

CAPTAIN PITTS: Thank you for clarifying that. Mr. Stimson, what is the definition, or what does the term fail-safe concept mean? In terms of the regulations?

WITNESS STIMSON: I think you're getting more into the systems safety aspects and structural aspects that we don't deal with the fail safe concept, typically, in handling qualities.

WITNESS JONES: Yes, I'd just mention that fail safe is, at least from my point of view, although I always am looking for other definitions, but it basically is the notion you can have a failure and the system is still safely flyable. And the requirement of 25.671 requires that no single failure in a control system should result in catastrophe, and that combinations of failures that could must be extremely improbable, which tends to drive towards redundant systems, that if one channel fails, that continued safe flight and landing is possible after that failure.

CAPTAIN PITTS: Were you here to hear the testimony on the rudder system design from yesterday?

WITNESS JONES: Yes.

CAPTAIN PITTS: Would you consider the RTLU system to have an adequate redundancy and meet design to a fail safe concept?

WITNESS JONES: It is designed to a fail safe concept, in my opinion.

CAPTAIN PITTS: And what would the system use as a level of redundancy in the event of the jammed or stalled electrical motor discussion that we had previous during that system's discussion?

WITNESS JONES: I'm thinking that you're referring to the fact -- are you referring to where the pilot application of pedal force would stall out the RTL?

CAPTAIN PITTS: That's correct.

WITNESS JONES: Actuator? I don't know that I would call that particularly a failure. I do know that if they hold and maintain the actuator in a stalled condition like that by pilot application of force, that there will be an alert. The system will provide an alert in the form of an oral warning, which would then provide a direction to the pilot of something that he should do. For that to be a real problem, I think you would have to stall that actuator at a low speed and then speed up to a very high speed and just stall the actuator at that point, and maintain pedal.

CAPTAIN PITTS: Then other systems that use -- or other aircraft that have used this system with other features, such as blow down, you think that's a triple redundancy then -- another redundancy layer that may not be necessary?

WITNESS JONES: In blow down systems? in systems that use --

CAPTAIN PITTS: Yes, sir. Other systems

using this methodology of limiting the rudder travel limit.

WITNESS JONES: I'm just -- a system -- now some of the systems that I heard discussed yesterday had also mentioned about -- I think they called it flow limiting, which I think was probably the same thing as using pressure reducers, which -- you could have the effect of a pressure reducer failure which could then allow you to have more authority under those types of conditions, and -- but for just a direct blow down system that doesn't use pressure reductions part of it, I don't see how you're going to get more authority than the blow down limit with that type of system. I don't see a parallel failure.

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

CHAIRMAN CARMODY: Thank you. And finally to the FAA, Mr. Donner.

MR. DONNER: Thank you, ma'am. Only one question, and I believe it was Mr. Jones who was talking about the cert basis for the aircraft, and mentioned that Airbus had stepped up to a particular amendment. Could you say a few more words about what you meant by stepped up to?

WITNESS JONES: It's my understanding that the original cert basis of the -- I don't recall, I think it was the original cert basis for the A300 -- was to -- was the FARs as amended through amendment number 19. At the time of the certification of the A300-600, I believe that Airbus voluntarily stepped up, or chose to show certification to a higher level of requirements up through, as Mr. Stimson had mentioned, up through amendment level 44. And the particular requirement that I mentioned, 25.671 -- they voluntarily stepped up to that one, and that was through amendment level 23. It hadn't been changed since amendment level 23.

MR. DONNER: Thank you. I just wanted to make sure that was clear. Thank you very much.

CHAIRMAN CARMODY: Was that all, Mr. Donner?

MR. DONNER: Yes, ma'am. That's all, thank you.

CHAIRMAN CARMODY: Very good. Thank you. Up to the Board. I see nothing from Mr. Hammerschmidt. Member Goglia?

MEMBER GOGLIA: No questions.

CHAIRMAN CARMODY: Member Black.

MEMBER BLACK: Yes, ma'am. Just one to was it Captain or Colonel Thiel -- or whatever you go by now. A question, I think you mentioned you had gone through some sort of an unusual attitudes training at one airline -- you don't need to mention which one --

WITNESS THIEL: Actually two.

MEMBER BLACK: Two?

WITNESS THIEL: Yes.

MEMBER BLACK: Have you been here to hear a description of the AAMP of American?

WITNESS THIEL: I've been here listening to the discussions the last two days.

MEMBER BLACK: Would you describe the others as being similar, equal to, more than in aggressiveness or could you characterize?

WITNESS THIEL: That would be difficult -- it would be hard for me to compare when I've never seen what they do. I can only describe what they did to me, or what I was involved in.

MEMBER BLACK: Did it hurt?

WITNESS THIEL: Sometimes it does. As I mentioned to you, one of them was heart of the envelope, put your hands in your lap and close your eyes, and basically they gave me a nose high and a nose low. And that was all there was to that type of maneuver.

In the other airline, they actually -- this was kind of aggressive, too, I have to admit. We're at about 2500 feet and they induced a roll to about 120 degrees of bank and said recover -- with no warning. I thought that was a little aggressive, and I made that comment to them.

MEMBER BLACK: Thank you sir. I yield my time to Mr. Clark. Oh, you're finished now. He had sent me an e-mail that he had wanted to ask a question.

CHAIRMAN CARMODY: And nothing Mr. Clark? Nothing further --

MEMBER GOGLIA: Mr. Thiel, did you recover?

WITNESS THIEL: Yes, I did, and the airplane -- the simulator didn't crash.

CHAIRMAN CARMODY: Is there anything from any of the parties? Any additional questions from FAA, Airbus, Allied Pilots, American? Alright. I propose then that we thank the witnesses and recess for about 15 minutes. I'd like to start on the next panel. We may not finish with them, but I would like to start and perhaps we can do the technical panel portion of the next two witnesses.

Thank you very much, gentlemen, for your testimony and your time.

(The witnesses were excused.)

(Whereupon, a 25 minute recess off the record was taken.)

CHAIRMAN CARMODY: Ms. Ward, would you call the next witnesses, please.

MS. WARD: Yes, I'd like to go ahead and call Mr. John Howford and Mr. Henry Offerman II.

Whereupon,

JOHN HOWFORD and HENRY OFFERMAN II

were called as witnesses, and first having been duly sworn, were examined and testified as follows:

MS. WARD: Mr. Howford, could you please state your full name, your current employer and your present business address?

WITNESS HOWFORD: My name is John Howford. I am presently employed by the FAA as Chief Scientific and Technical Advisor for loads and aeroelasticity. The business address is 3960 Paramount Boulevard, Lakewood, California 90712.

MS. WARD: And how long have you been in that position?

WITNESS HOWFORD: Almost four weeks.

MS. WARD: Very briefly, then, what are your duties and responsibilities and any kind of education and training that you received to qualify you for your new position?

WITNESS HOWFORD: I'm employed primarily because of my experience and knowledge working in industry as a loads analyst -- that's been my entire career. And my role is to advise and consult with the aircraft certification department, primarily, and to assist the FAA in maintaining knowledge of the latest standards, disseminating those latest standards to people in the FAA and in the industry at large, training functions, and to promote any research that would benefit aircraft loads analysis.

My education -- I have a BSc from South Hampton University in England, aeronautical engineering. I did some post graduate studies at the Canfield College of Aeronautics, also in England. I took an MSc in aerodynamics. After that I worked for a period of about seven years at the British Aerospace Military Aircraft Division on combat jet aircraft, doing loads analysis work, and that was mostly mil spec type criteria for military airplanes.

In 1979 I moved to Douglas Aircraft Company in Long Beach, California, and I was with them for 13 or 14 years. I worked on the whole range of different aircraft, but mainly I guess, DC-9 and its derivatives, DC-10 and its derivatives. I did quite a lot of work on loads methods development. I left Douglas in '93 and then I worked for two other smaller companies since that time. I worked for a period of five years in

Indonesia, the Indonesian Aircraft Company on a 50-C twinprop aircraft, and most recently I have been in San Antonio, Texas working on a Part 23 airplane, six passenger biz jet.

MS. WARD: Thank you, Mr. Howford.

Mr. Offerman, can you please state your full name, your present employer, and your business address?

WITNESS OFFERMAN: I am Henry Offerman II --

CHAIRMAN CARMODY: Mr. Offerman, would you pull that -- Yes, good, thank you.

WITNESS OFFERMAN: Henry Offerman II, generally Hank I'm more comfortable with. I presently work for the FAA in the Transport Aircraft Directorate, 1601 Linda Avenue, Southwest, Renton, Washington.

CHAIRMAN CARMODY: I'm sorry, we can't hear you. Could you pull that a little closer to you, please?

WITNESS OFFERMAN: Certainly.

CHAIRMAN CARMODY: Thank you. Is it on? Is the button --

WITNESS OFFERMAN: Yes, the button is up. The name is Henry Offerman, Hank. I work for the FAA in the Transport Aircraft Directorate, Standards staff, 1601 Linda Avenue, Renton, Washington. And I'm an airframe engineer -- aerospace engineer, airframe specialist.

MS. WARD: And how long have you been an aerospace engineer for the FAA?

WITNESS OFFERMAN: A little over five years now. MS. WARD: And what are your current responsibilities and duties and what is the education and training that you received for your present job?

WITNESS OFFERMAN: My current responsibilities and duties is responsibility for an area of Part 25 in loads and dynamics, the rules associated with it, and working in the ARAC groups that handle those load sections, regulatory sections. I also provide standardization and provide for -- yes, standardization throughout the ACOs in the United States, and with foreign regulatory agencies. I assist in the certification of foreign aircraft and provide advisory material and guidance to the various ACOs, through either ACs or correspondence.

My background that put me in this -- 1962, a degree in mechanical engineering from the Newark College of Engineering, Newark, New Jersey, which is now part of the New Jersey Institute of Technology. Master's program at Georgia Tech in the mid 70's, I got a Master's in aeronautical engineering and aerodynamics from Wichita State University in the 1970's.

I started my career at vertol Aircraft, now Boeing Helicopters, working in cockpit and flight station design. Transferred to Lockheed Georgia Company, working in cockpit design initially, then in structural analysis in structural test, flight test support. Beech Aircraft Corporation where I worked as a group engineer in the structural analysis area, eventually transitioning in to found the aerodynamics loads group at Beech Aircraft Corporation. Moving on to Martin Marietta where I was the manager of the mechanical engineering department for their commercial aircraft division in Baltimore, Maryland. Was a subcontract designer in manufacture for Boeing, Airbus, McDonnell Douglas, and a variety of other companies. Left that to go to work for Hiller where I was vice president of engineering, a helicopter company, and after that had my own company which was engaged in aircraft modification and certification. Sold my part of that company, came to the FAA. During the period of time from the 1980s on up I was a consulting BER for the FAA for Part 23, 25, 27, and 29 aircraft in the structural field.

MS. WARD: Do you currently have any FAA aviation certificates, flight time, or -- and what type of aircraft have you flown?

WITNESS OFFERMAN: Private pilot, single engine land, inactive.

MS. WARD: Thank you, Mr. Offerman.

Madam Chairman, I find these witnesses qualified, and now pass over to Mr. Brian Murphy for questioning.

CHAIRMAN CARMODY: Please go ahead.

MR. MURPHY: Good evening, gentlemen. I'd like to discuss just the following topics with you today. The lateral load requirements in place at the time of the certification of the Dash 600-R. The FAA's actions since the accident from a load perspective only, and the FAA's role in foreign certification programs from a load and structures perspective. Mr. Goldberg, if you'd go to Exhibit 7-F, page two, please. Also the text of this regulation is contained in the actual document, Exhibit 7-E, page 31. This Airbus Exhibit is much, is easier to -- oh, I'm sorry -- the text is contained in that, this illustration helps to explain that.

QUESTIONING OF MR. HOWFORD

BY MR. MURPHY:

Q Gentlemen, would you please describe the yawing maneuver requirements.

A Do you think we could start with the next slide, please, page number three?

Q That would be fine.

A FAR 25.351 subparagraph (a) is the maneuver part of the yawing design conditions. This is a maneuver that is particularly called the rudder kick maneuver. It's a rational maneuver, in total, the regulation defines a single maneuver from which -- within which there are embedded a few points which are of special interest to loads. The regulation details what those conditions are. But this is just in total a rational commission. It's one that you can go and fly in airplane. It's a wings level condition. It's not coupled with any roll, although when you do the maneuver, there will be some lateral motion of the airplane.

So if you take a look at the picture, what you see is that from straight and level flight, the pilot is basically assumed to rapidly, suddenly, input full rudder control up to a maximum of 300 pounds at any speed between VMC, minimum control speed, and VA, the design maneuver speed, and hold that. In response, the airplane suddenly slips and rolls somewhat sideways. The rolling motion is controlled by the ailerons, so as the rudder is held, the side slip is going to build dynamically to a peak value, before eventually settling down to a final steady state side slip value. That peak value -- unfortunately this picture is schematic only, it's not particularly well done to scale -- the peak side slip value would typically be something like 1.5 or 1.6 times the steady state value, and so we have a number of points to consider.

The first one is the point where the rudder first reaches its initial maximum deflection. At that time the airplane is still basically flying straight ahead and hasn't had time to yaw yet, but we have a large initial rudder displacement. Subsequently, as the side slip develops in response to that rudder input, the side slip hits a peak value, which we often call the dynamic overswing side slip value. That is the second point we will look at.

Subsequently the airplane settles into a steady wings-level yaw, that becomes the third point. Then from that point we rapidly, suddenly return the rudder to neutral position, and that becomes the fourth point. So that's the description of the maneuver.

Q Thank you. A couple questions with regard to that. Now, I won't go into the requirement for doing a doublet because I think we've beat that to death today. One thing I would like, though, is could you illustrate on there where Beta-max would be. You described it -- is that point B, then? Maximum side slip?

A It's here.

Q Okay, so that would be max side slip, and then -- Where are you? I believe it's point B, the peak on the graph, yes. Now the only question I have regarding that was that the regulations currently do not require the return of the rudder at max Beta, max side slip. Could you address that?

A That's correct.

Q Could you address possibly why that consideration is not taken, and what would be the effect if it were on the loads on the vertical stabilizer?

A If the rudder were to be reversed from steady side slip or from maximum side slip?

Q From maximum side slip.

A Okay, if we were to return the rudder to neutral position from maximum side slip, we would see, probably an increase in one of the components of fin load, probably that would be the bending load on the fin. We may or may not see some changes in some of the other load components. The rudder kick is of interest for bending on the fin and for torsion. It may well be that there would be no increase in torsion, but there would almost certainly be an increase in the bending on the vertical ...

QUESTIONING OF MR. OFFERMAN

BY MR. MURPHY:

Q Now, I understand that you're not a pilot, the reason for not requiring this, you're speaking from a loads point of view -- would the reason for not requiring this be as stated with the doublet, it's not considered rational?

A I think in addressing that one should recognize that Part 25 in the main, defines an envelope of design conditions that define the strength of the airplane under various conditions. While the loads development is rational, the rational is a great sense due to historic evidence and historic -- the history of the uses of the airplane. Part 25 is a transport category airplanes -- Part 25 airplanes are meant to be an airplane for the transportation of passengers, large numbers of people and are heavy airplanes. And historically, in developing the loads envelope, these maneuver conditions for the maneuvering portion of the design of the vertical fin was described in this form with the implementation of CAR 4B about 1953. Since 1953 there has not been any historical evidence that would lead us to believe that this, as an envelope and design requirement was inadequate.

Q I said I was going to stay away from it, but Mr. Offerman, what would be the effect then of -- when we were at Beta steady state, if we did do the doublet that we've been discussing today?

A That is an extreme maneuver. One of the things to recognize is the result in returning the rudder to -- or reversing the rudder at point C, is that the position you're talking about?

Q Once we've established a stead side slip, instead of just going to neutral, pass through neutral to the opposite.

A If you were to reverse the rudder at point C, you would first have a load build up, that is in excess of the point C load requirement right now. It'd be a bit higher, but more importantly, if you actually performed a reversal and then allowed the airplane to go out to the other side and then reversed it again, you would start a series of dynamic maneuvers which could be either benign or could lead the airplane into a severe dynamic situation where, at the proper frequency, this continued application of this surface would allow the motion of the airplane to build up to the point where the side slip would become excessive and overload the airplane.

Q Thank you. Mr. Goldberg, if we could go to Exhibit 7-M. I think we're going to start on page four. It should be a graph. I believe for everyone else, it's page five in the Exhibit packages, but that's the proper page. Now the text of this regulation as well is contained in 7-E, page 32 in the top left hand corner.

FURTHER QUESTIONING OF MR. HOWFORD

BY MR. MURPHY:

Q Gentlemen, would you please describe for me the gust criteria that was in place at the time of the certification of the Dash 600-R?

A Yes, that's subparagraph (b) in the same regulation, 25.351 at that time. That defines a discrete gust event. Again, it's a rational event. It's not a instantaneous condition, it takes a certain time. It involves the airplane traversing a gust which is a bump of the shape that you see on that picture -- a harmonic one minus cosine shape -- and the gust velocity builds from zero initially to a maximum in the time it takes an airplane to travel a distance equal to 12 and a half cord lengths of the wing. Thereafter it decreases back to zero again in a further 12 and a half. So we call this -- we actually call this a 25 cord length gust.

The design intensity, the peak gust value, is also specified in criteria at one of three different speeds that we have to look at. We have to look at VC, the design cruise speed, which is the nominal case. We also look at VB which is design gust speed, which is a lower speed but we assume a higher gust velocity. And we also look at the case of operating a V-dive which is outside the normal operating envelope with a reduced gust velocity.

Q If you can move two pages forward in that please? Could you just, Mr. Howford, possibly describe or discuss the means of compliance that's described here, the possible models that would be used to comply with this regulation?

A Yes. The applicant has a variety of options, ways to show compliance with the discrete gust requirement. The two that are listed here are discrete gust quasi flexible, which is on an Airbus sheet here, is what I would call static air elastic effects. The second one is discrete gust full flexible, which is including dynamic elastic effects. There is a third way, not mentioned here, which is to use a simple formula called the Pratt formula, and I think that's discussed earlier in this sheet.

Both of the methods that are shown here include flexibility of the structure, so that the loads that the airplane encounters during the gust include the deformation of the structure. But in the first case, in the quasi flexible case, the deflection that they mean there is the quasi-static deflection, no vibration of the structure, just the steady deformation of the structure as it loads up, and then relaxation of the structural deflection as the load comes off again. That deformation of the surface has the effect of changing the aerodynamic profile, and therefore changing the aerodynamic loads. In general, those effects are relieving, so they will relieve the load.

The second one, the discrete gust fully flexible is something different again. It's a very much more complicated analysis where we involve not only the flight dynamics of the airplane as it flies through the gust, but also the structural dynamics of the vibration of the structure. And the structure, being an elastic structure, composed of mass and stiffness elements, will vibrate and it's relatively easy to determine a set of modes, shapes, which are the characteristic deformation profiles, which the airplane will vibrate and if it's excited at sufficiently fast a frequency. And when we do the fully flexible analysis, we would be exposing the airplane to exiting those structural modes -- the gust itself is a very quick event. It's -- the distance taken to travel 25 cord lengths is very short -- so there is an opportunity there, a very quick loading, almost an impulsive loading, and that will excite structural vibration. That brings with it incremental aerodynamic loads on steady effects, and of course inertia loads as the structure vibrates backwards and forwards, the mass accelerations have incremental inertial loads too.

Now, the discrete gust fully flexible, at the time of certification of the A600 was not an FAR requirement. Only the discrete gust, either rigid or quasi flexible was a requirement.

FURTHER QUESTIONING OF MR. OFFERMAN

BY MR. MURPHY:

Q Now that we have the baseline definitions out and understood, could we move on to the Exhibit 7-I, pages four and five, the actual certification documentation contained in Exhibit 7-E, page 46. Before I begin the discussion on these, could you tell us what the complementary condition is? Why they would be required or why they would be put in place?

A Certainly, the regulations were formulated based on airplanes that were, as they were understood and envisioned at the time the regulations came into place. From the time the regulations originated until the time of the A300-600 came along, airplanes changed significantly and in the area of controls and control systems, the airplanes went from manual controls -- the old DC-3, DC-6, DC-7 wrestling matches -- to power controls systems.

A little bit of a history. The requirement for the deflection of the control surfaces, that VA, was built around the airplanes with mechanical control systems where the pilot put his input in, could detect directly the force build up as the surface was deflected, and had a direct control over the surface, either through the surface itself or through aerodynamic servos that did this tasked for him. And the requirement that existed at the time was to simply -- not simply, but to design the surface for deflections to the maximum limits of the stops, or the maximum pilot effort, which for the rudder pedals is 300 pounds, from VMC to VA. There was no explicit requirement to design above VA and it was understood that the pilot recognized that as speed built up, he would apply the controls a bit more gingerly.

When you went to powered systems, the hydraulic actuator doesn't know this any more. The hydraulic actuator will put out the force that it's designed to put out and typically speaking, the feedback systems are positional as limited by the maximum hinge moment of the actuator such as in a blow down system. So there had to be something to be done above VA for these powered systems. And the complementary condition was a requirement imposed by the European communities as a means of explaining an appropriate way of complying with those regulations for airplanes for which a literal direct compliance would not be appropriate.

And in a position of CC5-1, we had the recognition that you had a powered control system in there, so they were required that the airplane be designed up to VD, from VMC to VD for the maximum deflection as limited by the stops, for the maximum power of the servo controls -- if it was servo control limited, or by the application of the 300 pound pilot effort force, which for a servo system and an artificial field system kind of becomes a little bit superfluous. But that was the reason for CC5-1, it was to expand the regulations and interpret them in a manner that would be consistent with the intent of the regulations but specifically for that type of an airplane.

Q Okay, having given that definition then, would you say that the addition of CC5-1 met or exceeded the requirements in place at the time of the certification?

A In a literal sense, they exceeded the requirements of certification at that time. At that time, because it required the use of the maximum pilot effort of 300 pounds up to V-dive, or the maximum travel compatible with the stops up to V-dive, which was beyond what the present regulation required. It was not inconsistent with the intent of the regulations, which was to assure a certain strength level in the controls and control systems.

WITNESS HOWFORD: I'd also add it exceeds the current requirements also.

FURTHER QUESTIONING OF MR. HOWFORD

BY MR. MURPHY:

Q If we could, if we could go to Exhibit 7-I, page six. This is another complementary condition. This one's with regard to the gust. I believe these are probably -- this complementary condition, I believe, is summed up fairly well on -- I'm sorry, Mr. Goldberg, if you would go to Exhibit 7-M, page four, I believe these -- there are four bullets there on the bottom of that page which summarize that complementary condition. And gentlemen, if you could take us through the -- what's the effect of adding those four bullets at the bottom of page four in Exhibit 7-M?

A These are the two gusts that we were talking about just a moment ago, the fully dynamic gust. CC6 is telling us that Airbus is electing not only do a rigid body gust, but also do a fully flexible tune gust --

Q Just one second. I'm sorry, Mr. Howford. Mr. Goldberg, it would be 7-M as in Mary, page four. Yes, and then those four bullets at the bottom. I believe they're what is contained -- the summary of what's contained in complementary condition number six. Again, Mr. Howford, if you would tell us the effect of those.

A Yes, they've elected to do a tuned discrete gust, which means that they're not only using fully flexible aircraft structural response in gust load calculation, but they're also varying the gust wavelength to see if they can tune the structure response to a specific maximum load within a given range. And what they've done is about the mean of 12.5, they've tuned the gust with different gust wavelengths in the range of seven cord lengths to 18 cord lengths.

In addition to that, they had done something somewhat -- this regulation or something very similar to this regulation is now part of the current criteria both here and in Europe. But at the time, it wasn't, so there had been talk about this at the time, and Airbus elected to go ahead and do that. On an earlier model, they had done that on the A300 -- A310-300, I believe -- they had done this same method, but they elected to use 90 percent of the design gust velocity. When they came to the A300-600, they reverted back to full design gust velocity, tune gust dynamic response.

In addition, the last bullet -- the last of those four bullets says that they are also going to study an additional gust load criteria, which is the loads in flight through continuous turbulence.

Q And then again, this would be in exceedence of what was in place at the time, and more closely resembles what is required of today.

A Indeed.

WITNESS OFFERMAN: I think I would like to mention that for US certification, the aircraft requirement to evaluate the gust loads continuous turbulence was a requirement, not a study.

BY MR. MURPHY:

Q Okay. We don't need to go to the next

Exhibit, but have you had a chance to review the material in 7-K on pages three and four? It's the loads methods that were applied -- that are used at Airbus for calculating their loads? It's two slides there, basically summarizing loads programs, loads methods?

A Yes, Mr. Murphy.

Q Very simply, are the methods that are described here for determining loads due to maneuvers in gusts typical in the industry? Would this be carried out in the same way at other major manufacturers? Same approach, same thought process?

A Well, this is very much a top level job and yes, it conforms very much to standard practice. This is the kind of processes that would go on in defining the aircraft response condition, the design conditions, as we call them. Having developed those, using processes like this, you would then go on to a separate process where you obtain the distributed loads on the components you're interested in, e.g., vertical tail. But yes, this is very -- this is pretty standard methodology.

What it's showing is that -- I guess on the top line they're showing methods -- static methods, dynamic methods and statistical methods. On the bottom, rigid model, quasi flexible, and fully dynamic. The top line, the methods, is the kind of conditions, the kind of flight conditions they're looking at. The static case, for instance might be a steady bank turn, which doesn't vary with time. I mean, yes, you're going in a bank turn but everything is staying the same. Some of the other conditions can also be considered static. The timed demanded (ph) dynamic conditions where the flight dynamics become important and you have to predict the response of the airplane so that you, in the computer, develop the response much as the pilot would see out the window, like a rudder kick maneuver. And the statistical processes are the ones like the continuous turbulence, where we have a randomized statistical procedures to determine the average loads during continuous flight through turbulence.

On the bottom, the bottom line is airplane methods, and this is a reflection of whether or not they're including the structural dynamics in that or not. And there's a full range here. They're including rigid body dynamics, that is to say when the airplane moves around the sky doing maneuvers but the structure doesn't vibrate. This quasi flexible, which is when you include the static effects of structural deformation on the aerodynamic load distributions. And there's the full dynamic where you consider the structural vibration as well.

Q As well, so that full dynamic would imply then the quasi flex is in there as well. It's the best we're going to get.

A It's the best you can do.

WITNESS OFFERMAN: I'd like to add a little to that, if I may. The regulations require that the applicant compute his loads in either a rational or conservative manner. And so the applicant has his own -- has his choice of how he wants to conduct his business, how he wants to do his engineering, as long as we understand it to be rational or conservative. And so any of these methods are appropriate. They all have their advantages and disadvantages, depending on what areas you're looking in. But in the end, when an applicant selects a method to do an analysis, he then has to do the whole analysis consistent with the various assumptions, conditions and requirements for data contained in that.

FURTHER QUESTIONING OF MR. OFFERMAN

BY MR. MURPHY:

Q Thank you. Mr. Goldberg, if you could go to Exhibit 7-F, page four. The text of this chart is contained on, again, Exhibit 7-E page 28 on the lower left hand side. Mr. Offerman, if you would, could you please just take us through this graph and explain to us, for the days to come, the discussions to come, the definition of limit load, ultimate load, operating loads?

A Certainly. In the regulations, all loads in the regulations are defined as limit load. Limit load is defined in the regulations simply as being the largest load expected in service. And with regard to certification to FAR 25, that is the largest load that is consistent with any of the design conditions that come out of FAR 25. In many areas, as I indicated, this becomes an extreme condition or extreme maneuver for the airplane, which sets up a load envelope such that we are reasonably sure that all of the loads that the airplane will experience in service will fall inside that envelope. That's limit load.

Operating loads are significantly lower than that for many parts of the airplane. I dare say that for maneuver load factor, a transport airplane is typically two and a half Gs. You can get into turbulence, to hit two Gs is kind of an extreme event. The lateral load conditions -- these design conditions might give you a lateral load factor of about --

correct me if I'm wrong -- three to four Gs. It is unusual to hit a side load -- 0.3. It's unusual to hit a side load factor of 0.2 Gs -- 0.3, yes, thank you -- of 0.2 Gs, and for a vertical tail, in particular, the operational load is basically -- are the maneuverable loads during take off and landing, descent and occasional maneuvering which are generally rather mild. For continuous operation, it's yaw damper operation or whatever turbulence you encounter. We have the operating loads for certain aspects are relatively low compared to the limit loads.

Ultimate loads are the limit loads multiplied by a safety factor, and that safety factor is a minimum of one and a half, and one and a half is the number that's consistent with the aircraft industry.

Q Two quick questions with regards to this. How often is an aircraft expected to experience limit load?

A As I said, the definition is the limit load is the maximum load expected in service. For the maneuver conditions that define the design envelope of the airplane, it is fairly safe to say that the data that was used to develop that envelope would yield a once in a lifetime event, one in every 60,000 to 100,000 hours for the most part, and that, as I said, this number wasn't picked in a vacuum. There's been approximately 75 years of study that has gone into this through NACA, NASA, the FAA, the military, the CAA and other agencies that provide the data upon which this envelope is based.

Q Then one last question, it's probably already obvious, but is an aircraft ever expected to experience ultimate load?

A An aircraft is not expected to experience ultimate load in service.

FURTHER QUESTIONING OF MR. HOWFORD

BY MR. MURPHY:

Q Okay, thank you. And move on to the FAA actions since the accident. If we could refer to Exhibit 7-F, pages five and six. This describes an operational loads monitoring program that was put in place by the FAA. If you would, could you describe this study, why it was performed and then summarize the results for us?

A Yes, this was started almost ten years ago. This is an ongoing research program that the FAA instituted to try to collect data from the operational fleet, to try to build up the database of what happens day in, day out on the everyday fleet. So we've had -- we've been able to instrument certain fleets of airplanes, A320s, DC-9 fleets, some others, and we're basically collecting the data recorder data for an analysis on the ground.

As a result of this, we're accumulating a large bulk of data on operational statistics of airplanes -- what do they see? What do they don't? In particular, lateral acceleration, I think is one thing that might interest you. That's an event that we're able to now predict statistically, based upon thousands of hours in many hundreds of airplanes, that you would typically see nothing more than 0.2 G. And if you extrapolate the data out to the once in a lifetime event that might represent limit load, you're still going to be less than 0.3 G. In other words, the average airplane, during its entire lifetime should not see more than about 0.3 G.

WITNESS OFFERMAN: I'd like to make one correction to this chart also. The 727 and the Fokker F27/F28 were not -- are not part of this operational monitoring program. The data we have for those airplanes comes from a previous program. They were included in the chart by error.

FURTHER QUESTIONING OF MR. OFFERMAN

BY MR. MURPHY:

Q Okay. Now there was an AD put out after the accident happened, it was the one that was prescribing inspections based on certain levels of lateral Gs that would be -- could have occurred in flight, so called high load events, anomalous events. Were the results of this study used to help develop that AD? That AD, by the way, is contained -- I believe it's Exhibit 7-G, three and four. It's long and wordy though.

A No, the results of the study did not go into that AD. That AD was based upon data that was generated by Airbus from information that they had, that relates back to the specific characteristic of their airplane. If I could expand just a little bit. The load on a vertical tail, because it has a large control surface on it, the rudder, is very much a function of both rudder deflection and side slip angle. The lateral load of 0.3 G is not an absolute number in this case. It's an indication that you may have experienced a high load event and it is worth your while to look at the airplane, or at least look at the data to decide what to do with the airplane.

Q There are -- in Exhibit 7-Q on page five and six, there are several events described -- high load events, several of them systems related, a thrust reverser deployment and the two that are really at the top of the list that don't have anything particular written against them. Were these events identified as a product of the AD, or were they identified during the development of the AD?

A These events were investigated as we got into the A300-600 airplane after the accident. It was the identification of these events that led to the issuance of that AD. When you look at it, on the surface it would appear that there is a large number of events, however, we do have about four events that were in the range of limit load, a little bit above, and then two events that we achieved loads that approached ultimate loads. But the fact that these existed raised the concern and because of the requirement to insure the continued safety of the A300-600 fleet, or at least assure ourselves and the flying public that the airplane was indeed a safe airplane to continue flying, we thought it prudent to issue the AD so that we would have a handle on these types of events as they came up and try and decide whether this was something that might be a characteristic of the airplane or whether these were explainable, identifiable situations that could have applied to any airplane under the same conditions.

Q Since you said that, did you think that these events were explainable or identifiable to other aircraft as well?

A Well, they certainly are all A300-600s. As we went into these events and started looking at them, there were four events that appeared to be -- and this might be a question for a systems expert -- but as part of the decision process -- there were four events that appeared to be events that were generated by system failures where the airplane behaved, I suppose, as expected. The loads were high, but they weren't exorbitant. The airplane recovered and the pilots recovered from that, made the appropriate configuration changes, whatever, pressed on and finished the flight.

The other two events were rather high loads. Both of those events were associated with departures and high a high pilot activity or pilot component to them. And indeed, if you look through the events, they were rather long in duration, probably one minute for both of these. By the way, one was the Miami incident that's been discussed before. I think the total time of that event was about one minute of flight, and the Interflug (ph) incident, the other one that was looked at, was more than that. But the reality is that we had a situation where the airplane had departed from flight and the pilots were actively trying to gain control of that airplane. And as has been previously discussed, once you get into that situation, you're in an area where the regulations are not intended to insure a complete success, necessarily. You can encounter loads that could exceed the capability of the airplane.

Q To the best of my knowledge, there's been no finding since the issuance of that AD, is that correct?

A That's correct.

Q Let's move on to foreign certification. Mr. Offerman, I understand you've been involved in several programs. I know you were not involved in the Dash 600-R in its time, but would you please describe to us the FAA's role in foreign certification projects as it would apply to loads and structures?

A I could certainly describe my participation in it. As you know, the concept of certification in the United States of a foreign airplane involves a bilateral air worthiness agreement with the foreign authorities, which is achieved after the foreign authority establishes a demonstrated level of competency and the ability to interpret our regulations and find compliance with our regulations.

I have personally been involved in the technical sense in evaluating these agencies, and we do go in and look at the systems that the agency has put in place for certification. We look at how they interpret our regulations and insure that they interpret our regulations as we would interpret our regulations, and we take a look at the competence of the people that they have in evaluating the product that they other person turns out as far as being compliant with our regulations.

That's at the upper level where these agreements are established. Once these agreements are in place, when a foreign, non-US agency or authority -- or company, excuse me, company wants to certify an airplane in the United States, they submit to us their application and information on the airplane. At that point in time, we go and evaluate the airplane, and look at the airplane from the point of view of any unique features, any unusual characteristics, anything on that airplane that we believe that is out of the ordinary. At that point we decide how much participation in that foreign certification we wish to retain for ourselves.

If you have an airplane that is a model change for an airplane that we have already been over and has had a satisfactory service history, and we believe that the foreign certification authority is perfectly capable of evaluating that airplane in the light of our regulations, we accept their findings of compliance. In other areas, where we believe that we are in a new area or a unique area, or an unusual area, and we want to retain those findings of compliance for ourself, we will not allow the non-US agency to find compliance. We will have our own people do that.

Q Are you aware of any areas on the Dash 605-R where that was the case, where we actually did take an active roll?

A Well, on the 605-R directly, I'm not aware of any areas where we took an active role, per se.

Q You may have to go back to --

A I'm going to elaborate on that. It is a derivative airplane. There were several areas on the predecessor airplane, for example, the carbon fiber tail, composite tail on that airplane was initially put on the A310, I believe it was, and during the A310 certification, we kept the findings of compliance on the design and strength of the carbon fiber tail and the requirements for the evaluation of the graphite tail to ourselves in a certain sense, and we were very active, as an organization, in working very closely with both the manufacturers and the European agencies to set up the design certification and test program for that tail. That's one example.

Q Thank you. Have you had a chance to review the FDR data from 587?

A Just in a cursory sense, but I'm not part of the accident investigation team.

FURTHER QUESTIONING OF MR. HOWFORD

BY MR. MURPHY:

Q Okay, then. Would you consider the loading on the 587 vertical tail to be a static or impulse type loading?

A I would consider it to be a static type loading. It's rapid but relative to speed of structural vibrations, it's not -- I mean it's basically five swings of the rudder in about six to seven seconds, which yes, is quick, but relative to structural vibrations, it is not. So I would consider it basically a static event.

Q A static event then. Would you consider the structure to be fully loaded at each rudder input then? The load to be fully developed throughout the vertical tail structure?

A If I understand your question -- could you give me that question a different way, please?

Q Because it's a static loading then, you would consider the load -- the air load distribution -- then to be fully developed on the surface, and then therefore the internal loads in the structure to be fully developed?

A At any particular time for a given rudder or a given side slip angle, yes, I would expect the loads to be per that particular rudder and side slip on the essentially static deformation conditions.

Q Thank you. This may be a question that we've -- I'm not even going to address it, the effect of rudder reversal, we've answered that enough today. Based on the information you've seen through the -- during the past two days, do you think the response of the aircraft is similar to that response of an aircraft experiencing a Dutch roll? There's been a great deal of conversation with regard to Dutch rolls so far today.

WITNESS OFFERMAN: In responding to that, I'm going to, I believe, box in my answer a little bit. I'm going to talk about an airplane of that size and type and that configuration that has a control system that's controlled by the pilot and doesn't have any other modulating influences -- no yaw damper, no autopilot, nothing of that sort.

In some of the studies that have been done, the response of the airplane is similar to the studies that have been done on similar airplanes, and that is as you start to cycle the rudder and put in repetitive cyclic inputs, as you approach the Dutch roll frequency, the plane diverges in side slip very rapidly. In about two cycles at the Dutch roll frequency, you can build the load up to above limit load and at about four cycles you can be up as high as ultimate load.

That's not an absolute number because under these conditions, there's an awful lot of what has been referred to as roll-yaw coupling, that is what you do with the rudder affects the roll of the airplane; what you do with the wing affects the rudder. This number, a load that you reach, can be modulated by how the pilot works the control. There is a lot of control activity in this kind of thing also. If you just fix the control wheel, the loads get very high. If the pilot responds in one manner, the loads will go down somewhat. If he responds in another manner, they'll go up a little bit, but nonetheless, as you get to these large side slip angles, the airplane becomes very dynamic.

MR. MURPHY: I'm just going to finish this out with two questions, then. Was the maneuver condition experienced by 587 covered in certification?

WITNESS OFFERMAN: No.

WITNESS HOWFORD: No.

MR. MURPHY: Okay. Based on your review of the Airbus certification documentation and your discussion since the event with Airbus and the DGAC, do you feel that Airbus has complied with the intent of the previously described regulations with regard to lateral load requirements?

WITNESS OFFERMAN: Yes.

MR. MURPHY: Madam Chairman, I have no more questions for the witnesses.

CHAIRMAN CARMODY: Thank you, Mr. Murphy. Are there other questions from the technical panel. Mr. Clark.

QUESTIONING OF MR. HOWFORD

BY MR. CLARK:

Q Thank you. You commented about the maneuvering in the 587 that you would consider those static loads in the sense that the loads would be fully developed. Can you give me an example of a dynamic load where it takes a period of time for a load to develop? Or what is that period of time that it would take for a load to fully develop?

A For the structural dynamics to become important you really have to have loads that change quite rapidly. The kind of conditions that we get that happening in, is flight through discrete turbulence, where there's lots of random fluctuations happening at very high frequency. You would get it in a dynamic landing event where you essentially impact the ground and spin up the wheels and everything is extremely rapid so that excites modes. You can get it in certain blast situations, but that would only be for military type applications.

So for aircraft applications, the only time -- for a conventional design of conventional size and conventional vibration characteristics, the only time that it would be warranted to go to the full flexible aircraft model would be for gust analysis or for landing analysis, or one more, taxi -- sometimes taxi can also be a dynamic condition.

Q What kind of frequency are we talking about?

A It depends -- the structure has many, many modes and many different frequencies. So it depends what you're loading up what kind of frequency you're interested in.

Q Back in the tail area. We heard earlier that the natural frequency of the airplane is 0.2 cycles per second, they're five seconds per cycle. And that's going to your static load. How much would we have to detune to -- in the tail area to --

A We're getting towards the area of where --

obviously there's a borderline. You would not -- you can't say this is static, this is dynamic. And so you have to make a call on that. You're getting into the area where there could be some dynamics taking place, but at a level which I think would not be warranted to include in the analysis.

Q So this area --

A -- give you anything.

Q This 0.2 cycles per second is getting down to an area that you'd have to start watching carefully for dynamic loads?

A That's why I mentioned aircraft size, because if you have bigger aircraft where the structural frequency is a lot lower --

Q Specifically the A300 --

A Exactly, yes.

Q The 380?

A Oh, sorry, I beg your pardon.

Q Well, I'm talking specifically about the A300-600 type model.

A I don't believe that the structural vibrations are -- sufficiently slow on the A300-600 airplane to have had a significant dynamic component during the events -- the crash event.

Q But then, to follow -- how far down can I --

how far -- how much of an increase in the frequency do I have to give before you would start getting worried about something going on in the tail? In a dynamic manner.

A Well, you're not far away. You're getting there.

Q Okay.

WITNESS OFFERMAN: I'd like to maybe clarify that a little bit. We seem to be confusing a couple of things. One of them --

MR. CLARK: No doubt on my part!

WITNESS OFFERMAN: Yes, one of them is the five second cycle, which is a rigid body response of the whole airplane, and the airplane is just kind of wallowing through the air from side to side. That's relatively slow, that's absolutely a static loading. But the fact of the matter is, if you excite the airplane at that frequency, that motion will continue to build until the airplane diverges from its flight path. The other types of dynamics you're talking about is the actual vibration of the structure under load, and if those frequencies are excited, you can have inertial effects. I don't know what the natural frequency of the vertical tail is in its fundamental modes -- would you have an idea?

PARTICIPANT: Maybe five hertz.

WITNESS OFFERMAN: Okay, five hertz, bending (ph) mode, which is five cycles a second, one cycle is 0.2 seconds. The rate of application of the rudder is maximum 60 degrees a second, and 60 degrees a second is considered to be a -- a static type of a load application as far as load buildup goes.

MR. CLARK: Okay, alright, let me follow up just quickly then, on the issue of wake turbulence and an encounter there, how should we handle that in this structural consideration -- if there's a potential of some sort of a flow field still acting on the airplane?

WITNESS OFFERMAN: In a load sense, at this point in time, we don't consider wake turbulence as a structural loading condition. There's been discussion about what wake turbulence can do to an airplane. The rules and the flight parameters that have been set up around wake turbulence have more to do with loss of control or upset of the airplane than the structural response. It would appear, and the evidence seems to support that at this point in time that the loading that you get from wake turbulence in a structural sense, falls well within the parameters established by the gust load criteria and the maneuverable criteria, for example. I realize there have been papers published that -- and the one presented today is not the only one that discusses the structural loading on wake turbulence. Things like fighters and these types of airplanes generate high loads, but once again, these are based on rather specific scenarios, rather exact conditions that are designed to maximize the effect of wake turbulence and they're done as design studies, not as something that has developed to the point where they would demonstrate a need to change the rules, and certainly the accident evidence to date says that wake turbulence isn't a structural problem.

MR. CLARK: Okay, I understand that, but my point is -- let me get myself in a lot of trouble here. I assume that the wake vortex issue in and of by itself isn't a big structural consideration for the most part, for what we're dealing with here.

WITNESS OFFERMAN: I think that's what I tried to say.

MR. CLARK: Yes, that's -- okay. And then the -- but the -- if I am in a large side slip and I have a large rudder deflection and then I lay on any residual wake vortex or portions of flow field, how should I handle that?

WITNESS OFFERMAN: You're talking as a pilot or as a loads analyst?

MR. CLARK: Loads.

WITNESS OFFERMAN: I just said we don't. And as point of fact, we hadn't much thought about it. While we have evaluated the data that has come out of these incidents to date, the evidence of aircraft in operation indicates it's not a structural problem. I'm not too sure when you talk about wake vortex velocity, that would describe today being in order of ten meters a second, which I think you characterized as what -- eight knots, something of that.

MR. CLARK: Well, ten meters per second is 20 knots ... curves that Airbus developed says that we're down to five knots I think.

WITNESS OFFERMAN: But these are numbers that are either on a range where their impact is not very significant or they fall within the range of the existing design requirements for high turbulence gust velocities. Superimposing all of these things one on top of another, for that to happen, there has to be a demonstrated probability that this is a reasonable design condition expected in the operation of the airplane.

MR. CLARK: I understand from a design standpoint, but to find out what's going on with this airplane is the issue at hand, sir. Thank you.

WITNESS HOWFORD: If I may say, I think it would be an interesting thing -- I mean it's one thing that would be nice to get some firm information about -- I think Hank is right at the moment, we don't have any evidence to suggest that it is a problem, but that's not to say that there may be something in there that we might want to look at. At the moment, I don't think that there's any evidence that it is a problem, though.

MR. CLARK: Okay, thank you.

CHAIRMAN CARMODY: Anything else from the tech panel? Yes, Dr. Kushner.

DR. KUSHNER: Yes, I just wanted to follow up a couple things.

QUESTIONING OF MR. HOWFORD

BY DR. KUSHNER:

Q If we have a five or six hertz system, and it sees loading ramps that go up in the neighborhood of about a second, as in the accident loading, would you qualify that then as completely a static, quasi static load, or would you expect to see some small transient effects?

A I would expect to see some transients.

Q And in doing the full dynamic analysis, in addition to the relationship between the loading ramp -- you know, time history of the loads and vibration frequencies, are there any other characteristics of the loading field that need to be taken into account in deciding how much of a dynamic effect there is in exciting the vibration modes?

A I'm not sure I understand what you mean. If you have something particular in mind?

Q Okay, if the vibration mode has a different shape, let's say, than the normal quasi static deformation pattern, then does the loading associated with the static deformation excite the vibration mode? At its full strength, so to speak, in comparison to the static?

A I'm sorry I'm afraid I don't quite understand the question. Any loading will excite the structural modes, any kind of loading. Most different amounts to different degree. If you want to be more specific, maybe I can give you an answer.

Q Well, in calculating the dynamic response, one needs to take a convolution integral and time of the load with the vibration modes, but in addition you need to integrate the load distribution over the shape of the vibration mode. And so if the shape of the vibration mode is somewhat different than what we would associate with the static deformation, then would you expect to see another difference between the effect of static deformation and the transient?

A That's --

Q I didn't mean --

A Maybe we could talk about that. I'm afraid your mathematics is probably a level higher than mine. It sounds interesting.

Q Let's try and avoid that. Thank you.

CHAIRMAN CARMODY: Okay, I'll move then to the parties. I would propose starting with American, and then going to Airbus, Allied and FAA. So Mr. Ahearn would you like to begin?

MR. AHEARN: Thank you, Madam Chairman, and thank you, gentlemen, good evening. Just a couple topics that I want to discuss with you. It seems to me that through the description and the questions that were raised, that there's varying methodologies to meet the standards, and what I would ask you is do all these varying methodologies to meet the standards result in varying requirements for limit load on a given structure?

WITNESS OFFERMAN: As I explained in point of fact, the applicant has a choice of how he chooses to compute his loads and his requirement is to compute those loads in either a rational or conservative analysis. And you can make some very simple approximations, and you can calculate a very good set of loads that will provide a design penalty in the fact that the loads are higher than what the airplane will really see, and the benefit to doing that and accepting the penalty of the increased weight in cost of manufacturer's product is that you do not have a very difficult task of validating that your loads are good loads.

Conversely, you can sharpen your pencil, as it were, and use very fine analytical techniques that represent the airplane and compute the loads that are acting on the airplane. In those cases, we require that the applicant go to a great deal of trouble to insure that the data that's used to calculate those loads or these loads that are calculated actually do reflect what the airplane is going to see.

And I think the answer to your question is yes, you get different numbers.

WITNESS HOWFORD: I've got a slightly different slant on that, Mr. Ahearn.

MR. AHEARN: Okay.

WITNESS HOWFORD: I guess from my viewpoint, where everybody meets the regulations, we have a certification standard which everybody meets. If people use some simplified criteria, that may be conservative, it may not be. All we know is that we meet our criteria.

MR. AHEARN: Okay, but the point of it is that that criteria may be a very large door that one would walk through to meet that criteria. In other words, limited does not necessarily mean limited, depending upon the criteria that is utilized. Is that a correct statement or a fair statement? I know it meets the certification requirements.

Let me give you a different example, see if I can help explain it. Given what you just describe to me, would you expect that the A300 and the Boeing 767 which are competitive aircrafts of comparable size, would have the same limit loads for their vertical stabilizer?

WITNESS HOWFORD: I would expect they would.

QUESTIONING OF MR. OFFERMAN

BY MR. AHEARN:

Q Okay, thank you. Let me move on to another Exhibit. If you need to refer to it, it's something that's been referred to earlier, it's Exhibit 7-F as in Frank, page five and six. This is the operational loads monitoring program that I believe Mr. Offerman, you discussed earlier. In this program where the FAA is monitoring multiple aircraft types from multiple manufacturers, during the time period that you've operated this program, has the FAA ever seen any commanded rudder doublets, other than the ones described on the A310 or the A300?

A I'm going to answer that question and then qualify it, if you don't mind. The answer is no, we have not. Now --

Q That's fine with me. Go ahead.

A But the qualification is that this is a voluntary program that provides data for us for operational loads monitoring for the use in helping us determine appropriate methods for the application of our damage tolerance and fatigue rules. And what we're interested in the standard operational data. The airline is permitted to, and we accept this as part of the data collection, to clip unusual events from the data set that's given to us as they sanitize it, as you were. So if they have a situation where a pilot has exceeded a requirement or something has happened to the airplane that is an unusual event, that is not part of the daily operational characteristics of their airplanes, the airline can take that data out. Sometimes they don't, then we do get these peaks that raise hell with our statistical analysis, but nonetheless, we don't know what has been removed from that database when it was given to us.

Q Okay, thank you. Let me just as a question. in the same database, have you seen any vertical stabilizers reaching limit and ultimate loads, other than on the aircraft types -- the A310 or the A300?

A The load distribution charts are -- flow level distribution charts that I have seen have not exhibited that.

Q And in your time period, are you aware of any other transport category aircraft that has suffered a vertical fin separation?

A Again, that's a difficult question to answer because historically, in modern times -- and I consider modern times to be post-World War II -- as you will recall over the years there have been a number of inflight breakups of aircraft, and some of those were separation of vertical fins. Some of those were, in fact, fuselage separating, some were wings coming off, and they have been as recent as the Turkish Airlines 737 that, for apparent reason -- no apparent reason came apart in flight. And these have been attributed to flights into extremely turbulent weather and that the loss of the airplane was a result of either divergence in control flight, overload trying to recover flight, or just plain overload and turbulence.

And so to say -- the question, do you know of any where the fin has come off? Yes, I do. Do I know of any where the fin has come off under the circumstances that existed to this airplane, which is a rather benign meteorological environment on a rather nice day, no, I don't. I have gone through three databases -- European and US databases back to World War II is what I've concentrated on, I could find no record of that.

Q Okay, thank you. You must be thinking at this late hour, because that was my next question. Let me go to just a different subject here, and Mr. Offerman, I want to direct this question to you. It's my understanding that you worked on the transition from the B2/B4 to the 310 composite?

A No. No, I didn't.

Q You did not. Then I must have misunderstood what you said earlier. Can you clarify your knowledge of the transition from the B2/B4, the metal fin, to the composite fin.

A The transition was a historical search at the time. After the accident, as we were reviewing the aircraft certification and qualification data, however, our national resource specialist, Joe Soderquist (now retired), actively participated in the composite design and certification program, and also our fatigue and damage tolerance national resource specialist, Tom Swift, was involved in that. On the predecessor airplanes, Terry Barnes, Mr. Howford's predecessor was actively involved in that airplane also, in reviewing -- this is the A300 series and later on.

Q Do you have any knowledge of the robustness of the vertical stabilizer and the difference between the metal fin and the composite fin?

A Superficial.

Q Anything you want to comment about? Whether one was stronger than the other?

A I don't know the strength of the metal fin.

Q Okay.

A That's a simple statement. I -- the areas that we looked into on the certification with reference to the metal fin was the flexibility characteristics of the fin, the structural stiffness of the fin to be sure that the data carried from one airplane model to the other was applicable.

Q And just one final question or topic that would help, especially if you gentlemen would, do you have any sense as to why the AD or safety recommendation that was issued as a result -- or post the 587 accident you highlighted two events, one in 1991 the Interflug (ph), I believe you referred to it as, and the event in 1997 with our airplane, flight 903, why the AD was not issued subsequent to either one of those events?

A I can't answer that with any degree of certainty. I wasn't a participant. I do know that the airplanes went through those events. The events were reported as being extreme events. One of them was investigated as an accident. The airplanes went through the appropriate inspection procedures that existed at the time and there was no apparent damage to either of the airplanes that I'm aware of, and the airplanes returned to service. This is the standard procedure that existed at the time. It's only retrospectively that we became aware of the significance of these events with regard to structural loading.

MR. AHEARN: Okay, gentlemen, thank you for your time, and Madam Chairman, that ends my questions for this evening. Thank you.

CHAIRMAN CARMODY: Thank you. Airbus, Dr. Lauber.

DR. LAUBER: I have one very quick question.

QUESTIONING OF MR. HOWFORD

BY DR. LAUBER:

Q With regard to the operations load monitoring program, the FAA program, do you record -- what are the parameters recorded, specifically with regard to lateral?

A I'm afraid I can't be very specific. I haven't yet had time to familiarize myself with everything that is in that database, but it does include NY.

Q Pardon me?

A It does include NY, the lateral acceleration.

Q It includes NY, does it include sufficient information that you can actually go back and compute fin loads?

A No, I don't think we have -- if we have the rudder angle, and I don't know if we do, then we could. But I'm afraid I can't answer your question, because I don't know that.

WITNESS OFFERMAN: The answer to that is no. We've looked at that database precisely to -- that evaluation, and we don't have any information on side slip angles, for one.

DR. LAUBER: Okay, thank you. That's all the questions we have.

CHAIRMAN CARMODY: Thank you. On to Allied Pilots, Captain Pitts.

CAPTAIN PITTS: Thank you. Gentlemen, you certainly have the qualifications to talk about a number of subjects, I hope I don't touch upon any that you're not comfortable in talking about now, if so, please just advise me. Seems a very complex topic. We've talked about natural vibration frequencies and loads and external excitations, and it's very difficult for us all to put together. Can either of you comment on what the approximate time required for Dutch roll to develop to an amplitude that would be recognizable to the pilot, such as the Dutch roll that's been spoken to earlier?

WITNESS OFFERMAN: My answer to that is no.

QUESTIONING OF MR. HOWFORD

BY CAPTAIN PITTS:

Q Mr. Howford?

A I was going to -- perhaps I could ask you to repeat the question, please.

Q The approximate time required for a Dutch roll to develop to the point where a pilot would be able to recognize it as a Dutch roll?

A I guess I could offer an opinion, but I'm not sure.

Q Okay. Could tangential entry into an external flow field, such as a wake vortices provide the necessary energy for the aircraft to initiate a Dutch roll?

WITNESS OFFERMAN: I'm going to take my crack at it. If the yaw damper was on, that would be a precluded event, I believe, unless -- no, if the yaw damper was on that would be precluded. For the initiation of a Dutch roll, any disturbance could initiate an airplane motion. If the disturbance was a -- at that frequency or harmonic of that frequency you could excite Dutch roll, but in the absence of continued disturbance, it would damp itself out. Dutch roll is slower than ...

WITNESS HOWFORD: I have a response also. The Dutch roll is being excited all the time, every time you fly through the atmosphere that isn't perfectly smooth, there is Dutch roll and that's why you have the yaw damper. So, undoubtedly, if you flew through some non-still air you probably will excite a degree of Dutch roll but this is a different phenomenon from having a forced Dutch roll, when you take that particular mode and excite it by a bit of a -- or force it with a rudder. I think it's probably quite different.

QUESTIONING OF MR. OFFERMAN

BY CAPTAIN PITTS:

Q Alright, now, were you present to hear the discussions about the different degrees per second travel rates of the rudder versus the yaw damper?

A Yes.

Q And are you familiar with the graph where we see the yaw damper move initially opposite rudder deflection and then after approximately two and a half swings, now moving in the same direction as the rudder?

A I remember the discussion of the plot.

Q Alright, sir. Would yaw damper in that mode help us avoid this situation that you spoke of, if the yaw damper were working?

A If I'm answering the question I think you're asking, there would be a noticeable or a calculable difference, but it wouldn't be significant. Some of the studies that have been done have the actions of the pilot in tune with the actions of the yaw damper such that you can get some coupling between the pilot and the yaw damper, but the effect is rather negligible.

FURTHER QUESTIONING OF MR. HOWFORD

BY CAPTAIN PITTS:

Q Mr. Howford? Would you have the same response?

A Is there a question as to whether or not the presence of a yaw damper upstream or downstream will have a beneficial impact on loads?

Q It was back referencing the tangential entry with the external flow field. The original question was that with a functioning yaw damper, the excitation to Dutch roll would be negligible. But if the yaw damper had now moved into a position or a condition, I should say, as we saw on the third swing of the rudder as depicted on the graph -- we can bring the graph back up if you need the visual of it --

A If it's going to be a controls systems issue, I'm probably not going to be able to help you anyway. If it's kind of a feedback, I -- I wouldn't know.

Q Okay. And I'm not asking you to comment on control design. Does the delay input/output lag -- first off, let me ask you this. You referenced the work by Mr. Brown, I believe you did, Mr. Offerman.

FURTHER QUESTIONING OF MR. OFFERMAN

BY CAPTAIN PITTS:

Q Would the delay input/output lag referenced in that document, and associated with the flight controls, does it help or hinder us in a Dutch roll recovery?

A I'm not qualified to answer that question.

Q Okay. You spoke a little bit about loads and once the loads developed and what a pilot could do, and it was a little shocking really. What recovery procedure, for the Dutch roll, what would it look like or consist of if they found themselves in this condition where they felt as if they had loaded the vertical tail plane to the point that they were approaching the ultimate limit?

A I couldn't even speculate on that. It's just an area that I have no expertise.

Q Is there a way that you, in terms of load relief, is there a way that you know to relieve the load? It almost appeared that -- from your discussion, that regardless of which way you moved, you were between a rock and a hard place.

A Under those conditions, an appropriate move would be to just release the controls and allow them to return to neutral. That would be one way to reduce it.

WITNESS HOWFORD: My comment also. Stop forcing it.

BY CAPTAIN PITTS:

Q Have you looked at how this structure load relieved?

A With regard to the computation of the loads?

Q Yes, sir.

A Yes. Again, it's -- I haven't gone into the checking of the mathematics of the work that the folks have done, but I have looked at the methodologies they've used and the data they generated.

Q Is there any difference of significance in the methods that manufacturers use for this vertical tail plane and how it may have been designed, or where the yield point may have been to have effected the outcome of this event?

A From my own personal experience in being involved in this, the methodology that was used was very appropriate and it was very sophisticated in analysis. With regard to the confidence in the data that came out of that, we believe it met the certification standards to Part 25.

Q Alright, sir, in reference to Part 25 and side slip requirements, do you know of any manufacturer that tests in excess of the FARs concerning reversal of the rudder at max beta?

A I have been involved in one test program like that in my life, and that was the application of a civilian airplane to a military application, and what were required to fly the military envelope and demonstrate the military maneuvers and we bent the aft fuselage.

Q Mr. Howford?

WITNESS HOWFORD: I'm not aware of any such case.

BY CAPTAIN PITTS:

Q With that in mind, we've spoken to this event as being somewhat remote, but rather severe maybe, arguably catastrophic. A quick assessment of the risk puts that fairly high. Would both of you please comment on your thoughts about the suitability of the FARs to protect us from such a condition and how they speak to this hazard?

A I think the first statement is that from the time of the accident, and the time the accident -- our knowledge of the accident evolved and some of the circumstances, we have seriously considered types of things that could be done to the regulations, if it was required, to preclude this accident from happening. And there are many approaches that cover the gamut from simply making the airplane stronger, to changing the way pilots are trained.

One of the things that we recognize is that a Part 25 airplane, designed to that specification, is intended for operation of Part 121 environment, and that includes the operational modes of the airplane, the operational limitations on the airplane, the training of the pilots, the maintenance of the airplane, and of course, Part 25 is the construction of the airplane, and Part 21 is the manufacture of the airplane. And it's all of these put together that create this safety level that we have today, and I certainly believe that as the -- when the NTSB Board -- the National Transportation Safety Board issues its findings, we will certainly evaluate the regulations throughout the entire range of those regulations and determine what will be the most appropriate way to improve the level of safety with regard to this type of accident, if it's believed that that's the right thing to do.

The thing that we don't want to do is make a change to the regulations that's a 'feel good' change, that ends up making everybody believe that the airplanes are safer, when in reality, they're not. I mean, for example, strengthening the airplane seems to be an obvious choice, but some of the things that have been proposed to put into regulation to strengthen it wouldn't have prevented that accident, and we certainly don't want to do that kind of thing.

But we're going to be waiting for the NTSB findings to determine what might be done. In the meantime, we certainly have started to put together a list of those things which could impact this or affect it.

FURTHER QUESTIONING OF MR. HOWFORD

BY CAPTAIN PITTS:

Q Mr. Howford?

A Yes, I agree with Mr. Offerman that obviously we've got a very serious accident here. We've got to look and see if there are any changes required.

I just want to offer one comment, and that is that when we do the rudder kick maneuver, it is of course a canned maneuver and it's stylized maneuver and we don't do a doublet, we do a single kick. But we do a number of things. We look over a speed range. We look at the maximum weight. We look at the worst weight. We look at the worst inertia, the worst altitude.

And in a number of situations that it's sufficient to provide strength to allow a doublet, and for evidence of that, look at the first three peaks of flight 587. In fact their rudder went, one, two, three, and I believe that the Airbus load prediction will show that the loads were still, at least on the second pulse, were still around -- not much above limit.

So there could be circumstances where, for instance, if you put a very fast rudder input in and then reverse it before the side slip has chance to develop, you will not get this big loading case. You get associated with putting the rudder in, allowing the side slip to build up and then reversing it in phase with a Dutch roll frequency. So timing is very important in getting those big loads, and there could be events where doublets would be okay.

What -- this regulation has been around since the 1950's, hasn't changed, not in any significant degree, and as Mr. Offerman said, we do not have a history of this kind of failure. So yes, we have to look at what -- certainly before this going in position, would be that we have had a satisfactory, certifiable criteria. We have to wait until the end of this hearing to find out where we want to be.

FURTHER QUESTIONING OF MR. OFFERMAN

BY CAPTAIN PITTS:

Q Thank you, and just one last question. In light of the previous discussion of gross weights of aircraft and that impact on the vortex strength, just from a loads -- but I might ask you to speculate a little bit about handling characteristics -- would you agree that we need to move forward in adjusting the regulations, if, in fact, that's what happens with greater knowledge of the impact and the overall effect of vortices?

A I can't answer that directly. I can tell you that there has been a very large transport group formed and one of their objectives is to study the impact of the larger airplanes such as the new 380 coming along, a million-pound plus airplanes, and the effect of those vortices. So it's not a subject which is disappearing or being ignored. Beyond that I can't make any further statements.

CAPTAIN PITTS: Any further comment? Mr. Howford? Thank you gentlemen very much. I have no further questions.

CHAIRMAN CARMODY: Thank you, FAA, Mr. Donner.

MR. DONNER: No questions. Thank you, ma'am.

CHAIRMAN CARMODY: Very good. Are there any additional questions from the technical panel? Seeing none, any additional questions from the parties? Let me just mention -- the Exhibit that American requested earlier will be added. It will be Exhibit 2-N as in Nancy and that's pages four a, b, and c.

The document, previously requested by American Airlines was marked as Exhibit 2-N, was entered into evidence.

CAPTAIN PITTS: Thank you, ma'am.

MEMBER GOGLIA: The Board?

CHAIRMAN CARMODY: The Board. I'm sorry.

The hour is late. Member Goglia.

MEMBER GOGLIA: I have a question for Hank.

CHAIRMAN CARMODY: It's a good thing somebody keeps me straight up here.

QUESTIONING OF MR. OFFERMAN

BY MEMBER GOGLIA:

Q Hank, I have a question. I need to ask you to help me answer a question that has been raised by many folks as I travel around. It's not -- it's a simple question, I don't think there's a simple answer. But how do we, the government, the protector of the traveling public, allow an airplane to be certified that can have a failure of primary flight control system, like simple operation of the flight controls, by a flight crew member? I have been unable to answer that question that's been asked to me.

Q I'm going to take a stab at that, and I hope I'm not getting myself into something I wished I hadn't. But the reality is that in the pitch plane, for example, the pilot can break the wings of an airplane by misapplication of the controls. I'm not sure about the roll axis, whether that's possible, but as we've discovered, it certainly is possible about the yaw axis, also.

And the regulations, again, are built around, for example, for Part 25 airplane, are built around Part 121 transportation operations and it is expected that the pilot is trained to stay inside those operation limitations, either implied or expressed. And beyond that, the system, at this point in time, up until this accident, has seemed to have resulted in airplanes that had a high degree of safety when operated that way, and beyond that point, I don't have an answer.

Q You did raise an interesting point, though, trained to stay inside. That would imply that there is some training in some limitations that are conveyed to the flight crew, and the manner in which it's received. You can say things and it's not received. In training you would expect that it is said in such a way that it is received.

A And I'm not a training person. I'm not really qualified to address it on behalf of the FAA. They have their own organization that handles that kind of thing.

MEMBER GOGLIA: Okay, thanks. I've been hammered by that. I just thought I'd share it. No further questions.

CHAIRMAN CARMODY: Member Black? No questions. I think we are through then for the evening. Let's resume tomorrow morning at eight o'clock. Thank you very much, Mr. Howford and Mr. Offerman for your contribution and your time and your testimony.

(The witnesses were excused.)

CHAIRMAN CARMODY: Adjourned until tomorrow.

(Whereupon, at 5:51 p.m., the hearing in the above captioned matter was adjourned, to be reconvened tomorrow morning, Thursday, October 31, 2002, at 8:00 a.m.)