NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

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In the Matter of: :
:
THE INVESTIGATION OF THE U.S. :
AIR FLIGHT 1016, DOUGLAS DC-9-30 :
:
CHARLOTTE, NORTH CAROLINA : DOCKET NO. SA-509
JULY 2, 1994 :
:
(DCA-94-MA-065) :
:
- -X

Charlotte Marriott Executive
Park Hotel
Charlotte, North Carolina

Thursday, September 22, 1994

The above-entitled matter came on for hearing pursuant to notice, at 8:05 a.m., before:

Board of Inquiry

John Hammerschmidt, Member, NTSB
Chairman

Ronald Schleede, Chief,
Major Investigations Division, Hearing Officer

Bud Laynor, Deputy Director of
the Office of Aviation Safety

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

Technical Panel

Gregory Feith, Investigator-in-Charge

Renee Mills, Operations Investigator

Barry Strauch, Human Performance Investigator

Hank Hughes, Survival Factors Investigator

Jim Ritter, Aircraft Performance Engineer

Sandy Simpson, Air Traffic Control Investigator

Nora Marshall, Senior Survival Factors Investigator

Larry Roman, Airport Investigator

John DeLisi, Aircraft Systems Engineer

Jack Young, Powerplant Specialist

Greg Salottolo, National Resource Specialist, Meteorology

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C O N T E N T S

ATLANTIC CITY, NEW JERSEY

P R O C E E D I N G S

(Time Noted: 9:00 a.m.)

CHAIRMAN HAMMERSCHMIDT: On the record. Please come to order. Good morning and welcome to the fourth day of this National Transportation Safety Board Public Hearing on U.S. Air Flight 1016, Saxton. Are there any questions, or comments of a procedural nature before we begin?

(No response.)

Hearing none, let's proceed with the next witness, who is Mr. Don Turnbull.

(Witness testimony continues on the next page.)

DON TURNBULL, MANAGER, TDWR PROJECT, FAA, WASHINGTON, D.C.

Whereupon,

DON TURNBULL,

was called as a witness and, after having been duly sworn, was examined and testified on his oath as follows:

MR. HAMMERSCHMIDT: Mr. Turnbull will be questioned by Mr. Gregory Feith.

MR. SCHLEEDE: Mr. Turnbull, please state your full name and business address for the record.

THE WITNESS: Donald H. Turnbull, Federal Aviation Administration, Washington, D.C.

MR. SCHLEEDE: What position do you hold with the FAA?

THE WITNESS: I am the Program Manager for Weather Radar.

MR. SCHLEEDE: Briefly describe your experience and education that qualifies you for your present position.

THE WITNESS: I have worked for the FAA for about 24 years as an engineer. All of that has been in radar. The last ten years, or so have been in weather radar and I have served as a Program Manager for about three years in the Weather Radar Program.

MR. SCHLEEDE: Thank you, Mr. Feith will proceed.

MR. FEITH: Good morning, Mr. Turnbull.

THE WITNESS: Good morning.

MR. FEITH: Could you describe for us the

TDWR Program, please? What it entails? Give us a little history and the evolution of the program, please.

THE WITNESS: Okay, the program is for the procurement of 47 doppler weather radars to be located in various -- around various airports in the United States. 45 will be operational to support -- the program is set to provide four products to the Air Traffic Controllers and Air Traffic Controller Supervisors.

The products are microburst detection, gust front detection, wind shift prediction and precipitation intensity. Those will be displayed to the Controllers and Controller Supervisors both in the tower and the tracon at the airports that are covered.

Historically, the program has -- was in the research and development phase through the early and mid-1980's. The procurement was initiated, specification written around the 1986-1987 time frame and the contract was awarded to Raytheon in -- around the end of 1988.

MR. FEITH: What was the planned time table for the installation of all 47 units?

THE WITNESS: All of the units originally were to be delivered by around the end of 1995.

MR. FEITH: Is that schedule on track?

THE WITNESS: No, we are approximately a year to a year and a half late on that.

MR. FEITH: Why?

THE WITNESS: The program has been stretched out primarily due to problems with land acquisition. We have -- we originally had a schedule of delivery of three units per month, and we have not been able to achieve that rate.

We have been delivering about a one per month over the last few months. We are moving into one and a half per month right now, and we anticipate that rate for the rest of the program. The driving factor is the availability of land.

MR. FEITH: What do you see as the problem there, the purchasing of the land?

THE WITNESS: There have been a number of problems in the area. We underestimated the magnitude of the job that it took to procure land. We have had a number of problems at different locations.

The environmental impact process, the

environmental impact statement, environmental assessment process certainly took a lot longer than we had anticipated and, you know, at various sites that has delayed particular specific installations, and in some cases we have not been able to come to terms with potential land owners and that has also created some delays in some locations.

MR. FEITH: Given the facts that you have given us about the -- some of the problems, how many TDWR units are installed today?

THE WITNESS: There are ten units that have been installed and accepted by the Government and another 13 units that are under construction in various stages. Some are about ready to be accepted, some are just starting the construction process.

MR. FEITH: When you say they are accepted by the Government, does that mean they are commissioned?

THE WITNESS: No, that means that the contractor has delivered them, the Government has said that the contractor has met their obligations in delivering the system and the Government has paid the contractor for them.

MR. FEITH: How many systems are fully

functional?

THE WITNESS: There is one fully commissioned system in Houston right now and the Denver system would be commissioned, but there were -- it covers the new Denver Airport and that system is awaiting the opening of the airport.

MR. FEITH: Have you had any problems with the installed unit at Houston?

THE WITNESS: Since commissioning, do you mean?

MR. FEITH: Yes.

THE WITNESS: Or, before commissioning? Since commissioning, there was one -- there has been one outage. The commissioning was in July, I believe the 21st of July. There has been one outage since then on a pedestal problem. We had to replace the gear box in the pedestal, but that has been the only outage, to my knowledge.

MR. FEITH: Can you tell us how you determine which airports will receive, or are slated to receive the TDWR?

THE WITNESS: Certainly. There was a priority list established based on four criteria. One of the criteria -- and it was done for a large number of airports.

One of the -- the first criteria was thunderstorm days at each of the locations; the second one was passenger count; the third one was aircraft operations; and the fourth criteria was a 20-year projection of aircraft operations at each of those airports.

That established the ranking order, and then a cost benefit study was applied against that to determine how many systems should be procured.

MR. FEITH: Where did Charlotte fall in that priority list?

THE WITNESS: If I recall, Charlotte was -- is -- in the priority list was in around 22-23, somewhere in that general area.

MR. FEITH: Given the publicity that the airport has received because of the accident, can you tell us what the problems were in the installation?

THE WITNESS: Okay. Charlotte -- let me clarify something first, that the priority list was determining who got them. Initially, Charlotte -- there was not the list that -- of order of installation. Charlotte was initially number five on that order of installation.

The problems here have been land acquisition. There were -- were negotiations with an initial landowner that we were not able to conclude, and we went to our -- sent to their second site after those were abandoned, and then we had to start the whole environmental process at that point for an environmental assessment and all of the requirements in the environmental area before we could even start negotiations with that owner. Those negotiations are ongoing right now.

MR. FEITH: What do you anticipate, then, will be the installation date?

THE WITNESS: I am not sure, because it somewhat depends on when we have access to the land. If the negotiations drag out, then that would, of course, impact the installation.

We are working with Raytheon to determine, you know, how fast Charlotte can come on line once we have the land. We also have a Congressional mandate to bring the Charlotte Airport on line by the end of 1995, and that -- and we are certainly striving to do that.

MR. FEITH: Just so I get a sense, from the time the airport is slated to have the installation, from the time they break ground to the time it is commissioned, what is that span?

THE WITNESS: Typically, nine months. The construction process takes about six months before the Government accepts it. The contract is what we call a turnkey contract where the Government provides the land and the contractor does all of the activities of clearing the land, building the roads into it, building the site, initial check-out of the site.

When all that is completed, then the Government accepts it, and that is typically about a six month process.

MR. FEITH: Did Houston follow that schedule?

THE WITNESS: Pretty much, yes. They were -- to my knowledge, the installation took about six months.

MR. FEITH: Given the fact that Denver International is not yet open, when it opens will that radar be functional and commissioned?

THE WITNESS: Yes.

MR. FEITH: Can you explain briefly what the plans are for integrating the TDWR and LLWAS systems?

THE WITNESS: Okay, there are two types of LLWAS systems. I was not here yesterday for that testimony. Was that clarified, the two different types of LLWAS systems?

MR. FEITH: The Phase 2 and Phase 3.

THE WITNESS: Okay. The Phase 2 system, that integration has already been accomplished. It is -- Raytheon, who is the terminal doppler weather radar contractor, performed that, and that is functional and operating in Houston.

The integration is a relatively simple one in that all of the warnings are issued by the terminal doppler weather radar, and the center field and boundary winds are provided by the LLWAS sensors. Like I say, that has -- that has been tested and that integration of that -- integration with LLWAS 2 has been completed.

With LLWAS 3 there is a limited number of sites that that is happening. The initial software has been coded. We are testing that now at the new Denver Airport, since we have a nice opportunity for a test bed which has an LLWAS 3 and has a terminal doppler weather radar and doesn't have an airport that it has to cover at this time. So, it is an excellent test site.

Those tests are ongoing. There are a couple of interface problems where the data is -- the two contractors that developed the data, you know -- I don't know, it is a software issue that needs to be resolved.

I expect that to happen probably over the next month or two, and then the LLWAS 3 integration should be completed and go into -- into final operational test.

MR. FEITH: But, an LLWAS system integration is planned for at least every installation that -- of those 47, I should say?

THE WITNESS: Yes, with the exception of two. The Andrews Air Force Base and Chicago Midway Airport do not have any LLWAS, but wherever there is an LLWAS there will be an LLWAS integration.

MR. FEITH: I did not write down, how many systems did you say were installed right now?

THE WITNESS: There are ten.

MR. FEITH: Are they up and functional right now?

THE WITNESS: No. The Houston system is up and functional, the others are waiting various spare parts. We just had a recent problem with lubrication. There is a question in gear boxes, whether they will -- all the gear boxes on the delivered systems have been properly lubricated. So, we have essentially shut down all the systems, except Houston, to do that investigation.

MR. FEITH: So, it is safe to say that those that aren't commissioned yet, but are installed, they aren't using them in any --

THE WITNESS: Not right at this moment. Although, they have been using them in several locations; Orlando and Memphis, specifically. There was another program that the FAA has for integrating weather data that used those systems, and as part of that evaluation they were being used all during the summer.

MR. FEITH: Can you give us an idea of what kind of training the Controllers are receiving and the Supervisors are receiving in TDWR?

THE WITNESS: Okay. The Controller training was established by Raytheon. It was -- the FAA established the requirements for the training. They were -- Raytheon developed the course, FAA reviewed the course, so at every airport that has a TDWR, after it is accepted by the Government the training is scheduled.

The initial phase is a three-day, essentially what we call a train the trainers' course. All the Air Traffic Control facilities have training -- air traffic training personnel there. Raytheon conducts the course, trains those people for three days and then they conduct follow on training for every Air Traffic Controller that works at the airport.

MR. FEITH: So, initially it will be contract training?

THE WITNESS: Well, yes, right. It -- but, under FAA guidance and requirements, and FAA reviewed the course as it was being developed and monitored the first courses.

MR. FEITH: Just for informational purposes, do you know if there is any information in the Airman's Information Manual, or in the Controller's Handbook regarding TDWR?

THE WITNESS: I can't speak -- I believe there is, but I can't speak with certainty on that.

MR. FEITH: Are you experiencing any other problems with the TDWR installation, other than land acquisition problems?

THE WITNESS: Well, the problem that -- the reason, basically, that the systems have not been -- that have been delivered have not been commissioned, is that we have had some reliability problems that have occurred during our initial testing.

They have ranged from a variety of ones. A large area was power. This is one of the few sites where the FAA has a full computer out at a remote facility, rather than at an airport facility, where the power is fairly well controlled.

We are finding that that power fluctuations at these remote facilities are far greater than the specification. You know, than what we had been led to believe would be normal power fluctuations. That interrupts the computer. The computer will reset, or shut the system down.

We have had to do a lot of software changes, a lot of tuning of the inputs into the power to make sure that that doesn't happen. So, that took a fair amount of time.

We have had nine parts that we have redesigned to address various problems. Probably the most lengthy, we are having new motors designed in the pedestal. The lifetime of the motors as they were initially delivered was not acceptable, and they were burning out at a rate that was not acceptable. So, the contractor has redesigned those.

That redesigned motor is in Houston. All of the new systems are being delivered with it, but we now have to upgrade our spares inventory, our depo spares, so that when we do commission more systems we will have the spare parts to support them.

The FAA has a policy of not commissioning systems without having all of the full supportability in place to insure that we could bring it up rapidly if it were to go down.

MR. FEITH: Do you anticipate any problems with the spare parts?

THE WITNESS: No, they have been -- they -- I should say, we have a system that is operating, so we have proven out that the new designs work. The contract has recently been awarded to upgrade all of the spares. I would anticipate early next year to have all of the site spares and the depo spares up to the revised configuration.

MR. FEITH: What would you say the reliability -- for lack of a better term, the reliability rate of the Houston system is? Is it 50 percent, 100 percent, 70 percent?

THE WITNESS: Um, like I say, we had one failure in three months, so that is -- that is about what we expect. We would not -- we would not expect more than a -- than a failure to bring the system down every two months, or so, was the specifications, and that gave us, I believe, about 99 percent reliability, 99.9 percent availability, and that is what the target is, to have the system operate at that level.

MR. FEITH: Have you had any contractor problems with delivery of the product?

THE WITNESS: No, Raytheon has been an excellent contractor. As I mentioned, the pedestal gear box, now, that is the -- that is a problem we are wrestling with this week. We know -- the problem is known and I think it can be resolved without any further -- further delays.

MR. FEITH: Just getting back to the land acquisition, considering that this seems to be the major hang-up, do you anticipate this is going to be a problem at the remaining installation sites?

THE WITNESS: We have -- it -- let me tell you how we addressed the land acquisition problem. What we did, basically, is, as we experienced problems with sites, we moved them down the priority list, so the last sites that we have are our biggest problems.

So, there will probably be a handful of sites that will be -- that will be difficult and that we will have to wrestle with. We do own the land that -- at a number of the remaining locations.

I can't tell you the exact number, but it is on the order of seven or eight that we still do not own the land. We are still in various stages of negotiations, considering the possibilities of condemnation at some sites, and there are three locations that we do not have a site right now.

We don't have a site for either of the New York airports, or for the Tulsa Airport right now.

MR. FEITH: Has anything in the program

changed since the U.S. Air 1016 accident?

THE WITNESS: The -- well, we have worked with the Congress, certainly, on the Charlotte situation. We have -- we are starting the process of seeing if we can expedite our review process to -- to install systems faster. That still has to be negotiated with the contractor and put into a contract mod, if that is possible.

We are looking at those possibilities, and it has added, certainly, an extra urgency in the public officials and Congress on the New York sites. We are in active discussion with Congressional representatives and staff members of the New York sites right now.

MR. FEITH: Does it take Congressional bumping to get the time tables moved up?

THE WITNESS: You know, that is kind of a difficult question. It is -- we have a process laid out that we think is a reasonable installation process. Whenever you move sites up you are impacting resources. You are driving up costs and you are essentially eliminating some of the reviews that people think are necessary.

So, we are -- it is a trade-off. You are --

any time you accelerate those sites, you are accelerating your risk, also, that something will go wrong, because it will not have properly reviewed.

MR. FEITH: Just an operational type question. There was some discussion about time lag in processing data and then depicting the data. Can you give me an idea of the time lag in this system for detection and then depiction of the information? Is it instantaneous?

THE WITNESS: Yes. The micro -- I assume we are talking microburst detection algorithm. The algorithm has -- well, excuse me, the radar has a one minute scan every minute over the airport down at the lower elevations. So, the micro -- it is looking for microburst, the pattern, microburst pattern, every minute.

If it sees two, it determines that the pattern is there for two consecutive scans. It will put out a warning of the location and strength of the microburst. So, there is a two minute time period in there. After the scan is completed, the data will show up on the screen within 20 seconds.

There is another feature in there that the --

when the radar is not looking down at the surface, it is looking at upper elevation -- up in the storm at higher elevations. There are certain features that are -- that are indicative of the formation of a microburst.

One of them would be a sinking reflectivity core, or rain starting to fall. Air inflow, because nature -- you can't have a vacuum if you have a down draft, you have got to have air coming in up at the upper elevations. So, we are looking for that.

We are looking for any kind of rotation of air. As it descends, it is kind of like water going down the drain, it doesn't -- when it descends, it will rotate typically. So, we are looking up at upper elevations for that type of -- of indication.

If any of that is detected that might be indicative of a microburst, we don't wait for the second -- the second scan. The first time the outflow is detected, the radar will issue a warning.

So, if there is upper altitude features present, then the warning will come out in a minute with the 20 second lag. If not, it could be two minutes with the 20 second -- additional 20 second lag to get to the display for the data to be processed.

MR. FEITH: If you have multiple alerts, is there a grace period when that system has to reset?

THE WITNESS: Not on -- each microburst is treated as a separate event.

MR. FEITH: Just one last question about Controllers, in that will there be a change, or an addition to phraseology used by Controllers in presenting information to pilots using the TDWR system?

THE WITNESS: The phraseology is identical to what is being used on the LLWAS 3 system, because we have provided the -- in fact, the TDWR Program has provided the displays to the LLWAS 3 Program, so there won't even be a display change-out.

It is also identical to what has been being used at various test locations that we have had, operational tests over -- since about 1988. Every summer we have conducted operational tests at an airport using a prototype system.

So, the terminology has been -- has been well established in those tests and in the LLWAS 3, and the TDWR uses that same terminology. It is quite a -- it is a very simple type of terminology in that the

Controller does not have to do any interpretation.

The warning is read in an alphanumeric format that can be -- or, is displayed in an alphanumeric format that can be read directly to the pilot.

MR. FEITH: That holds true for the four different items, the microburst, the gust, the wind shift and the precip intensity?

THE WITNESS: No, there are only two types of -- two of those products are warning products; the gust front and the microburst. So, what is -- actually goes to the pilot is either a microburst alert, or what we call a wind shear alert. If it is -- a gust front is called a wind shear alert in the terminology.

All of the other products -- all four of the products are displayed on a separate display for planning purposes for the Air Traffic Supervisors in the tower and the tracon, and that data is used to determine weather that is approaching the airport when traffic patterns may have to be shifted.

It essentially gives an advance warning to the Controllers that the airport configuration may have to be changed around, and it determines which approach and departure paths may be closed, or opened in the near future. So, it is a planning tool.

MR. FEITH: Who determined that it would just be micro and wind shear alerts? Wouldn't precip -- you know, levels of precipitation be good information to give to a pilot?

THE WITNESS: The requirements that were -- that were established by Air Traffic asked for the wind shear detection. This system -- there are other ways that precipitation is available.

It is available on Air Traffic Control radars where you have a correlation of where the weather is with relation to where the airplanes are, but that was never established as a requirement for terminal doppler weather radar.

MR. FEITH: Thank you, Mr. Turnbull. I have no further questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, Mr. Feith. Let me follow up on some of Mr. Feith's questioning, if I might at this point.

In the case of the Charlotte Airport, which is obviously our concern at this hearing, in terms of suitable TDWR sites, how many sites in the area surrounding the airport would be suitable for installing the doppler radar?

THE WITNESS: I really couldn't answer that. I don't -- I can tell you a little bit about how the process was developed, and that kind of leads into it.

MR. HAMMERSCHMIDT: Okay. Right, in terms of how far away from the airport and --

THE WITNESS: Oh, okay.

MR. HAMMERSCHMIDT: -- looking down runways, that type thing.

THE WITNESS: Yeah, okay, so you want to know the sighting criteria of how we determine the general area?

MR. HAMMERSCHMIDT: Yes.

THE WITNESS: Okay.

MR. HAMMERSCHMIDT: And if you could correlate that to Charlotte, if you have any information on this --

THE WITNESS: Okay.

MR. HAMMERSCHMIDT: -- specific case.

THE WITNESS: Yeah, I have just limited information on Charlotte, but the sighting criteria, typically we like to be eight to twelve miles from the airport.

The reason for that being that the terminal doppler radar does not look straight up, and if you put it on the airport, or close in to the airport, you don't see any of the weather developing on top of you. So, a microburst could form right on top of the airport and come down on top of the radar and you wouldn't know about it until after it had hit and -- and was already a threat.

So, we like to be eight to twelve miles away, like to be, ideally, looking along the flight path --

MR. HAMMERSCHMIDT: Excuse me, excuse me.

THE WITNESS: Yeah.

MR. HAMMERSCHMIDT: Just to clarify, eight to twelve miles from the --

THE WITNESS: From the center of the airport.

MR. HAMMERSCHMIDT: From the center of the airport.

THE WITNESS: Right.

MR. HAMMERSCHMIDT: Okay.

THE WITNESS: We ideally like to be looking along the flight paths of the runways that are major -- major runways being used in severe weather. Certainly, that is possible in some airports, it is impossible in others.

Atlanta, all the airports -- all the runways run the same direction, it is fairly simple. Chicago, they run every possible direction and, so, it is impossible. But, doppler radars only see winds towards and away from the radar, they don't see winds running horizontal to the beam. It is just the nature of the way the system is detected.

So, to see exactly what the winds that the pilot would experience are, you would like to be close to being -- to looking along the runway. That is not to say it is -- the data is worthless if you are not, it is just that you are inferring it from other aspects of the outflow, you are not seeing the exact winds that the pilot would experience. So, the second criteria is, ideally you would like to look along that, along the runway.

You certainly need coverage over the airport. You can't have hills, buildings, anything blocking coverage of the airport. In a rolling terrain, that certainly limits your sites. You can't be in any of the valleys. You are basically looking at the hilltops. Flat terrain, mid-west, you have certainly a lot more options.

So, you like -- you need coverage down to about 300 feet, ideally. Microbursts typically are about 1,000 feet high, so the criteria was established that it is desirable to see 300 feet over the airport, and it is required to see 600 feet over the airport.

So, it is kind of the very minimum acceptable is 600 feet coverage over the airport, but we would like to see 300. So, that is cranked in, the coverage over the airport.

You would like to be on the opposite side of the airport from the approach of the weather. The reason for this is that, again, as I mentioned earlier, the radar doesn't look directly above. If weather is approaching the airport, it goes over top of the radar.

You lose all that coverage directly above you and you have to pick it up again between -- after it passes overhead, between the radar and the airport. So, you know, ideally you would like to be on the opposite side. You can't do it in every case, but it is -- but, it is an ideal situation.

Then you have to consider all of the environmental factors; is it an urban area, is there likely to be growth, are they going to build buildings in the area, are there wetlands, are there hazardous waste situations in the area? All of the environmental issues also have to be considered.

So, taking all of that, you kind of -- you know, there is no formula that you can use. It is -- it is rather an art of determining the best trade-offs. Rarely is there one optimum site, and only one. Usually there are several sites that have various trade-offs.

In the Charlotte area a decision was made, and I don't really know the exact details of how that sighting was conducted, but the sites that they were looking at were to the north of the airport. They do give good coverage of the airport, they are looking along the two major runways, 18-left and 18-right, or conversely the 36th left and right coming in the other direction. So, you have coverage there.

It is not off to the side, so I think weather probably approaches from the west, but I don't know that for certain. It does at most areas in the United States. So, you are not really completely meeting that requirement, but you really would -- the one looking on the runway is more -- is a stronger requirement.

So, I think that the sighting pretty much drove either north or south of the airport and the sites that we have -- that we have been working on were both north of the airport.

MR. HAMMERSCHMIDT: Okay. Do you happen to know how many specific sites you were considering for this installation?

THE WITNESS: No, I don't.

MR. HAMMERSCHMIDT: Okay.

THE WITNESS: Typically, we look at, you know, 20 or 30 possible ones when you are just doing a map search, but then when you get out and actually look at them, that gets narrowed down pretty quickly. We usually narrow it down to about three that we look at in detail.

MR. HAMMERSCHMIDT: Um-hum, thank you. Let's move to the party questioning. National Air Traffic Controllers' Association?

MR. PARHAM: Thank you, Mr. Chairman.

BY MR. PARHAM: Mr. Turnbull, could you kindly explain which office headquarters you come under? I didn't really understand it.

THE WITNESS: I am in A&R, which is the acquisition. It is a subset of the NAAS (sic) development, Associate Administrator for NAAS (sic) development.

MR. PARHAM: Alright, thank you. In the TDWR Program, can you recall the original commissioning of the first site?

THE WITNESS: When it was, or --

MR. PARHAM: Yes, sir.

THE WITNESS: It was July 21st of this year in Houston.

MR. PARHAM: Was the Program Office for the TDWR aware of all the studies needed for land acquisition for the placement of the TDWR in the beginning of this program?

THE WITNESS: We certainly didn't appreciate the magnitude of the issues. We did not appreciate the difficulty of the environmental process. We though we did, but we didn't. We have now hired an environmental specialist on our staff. We were engineers trying to -- trying to do environmental work.

MR. PARHAM: How long was the OT&E, which I believe that is Operational Testing and Equipment, for this program?

THE WITNESS: There have been a number of different phases. There has been operational testing with a prototype system, not the production system, and that has been carried on every year since 1988. We have done it at Denver, we have done it at Kansas City, at Orlando. Those three airports have had operational testing using a prototype system.

The production system operational testing, after the delivery of the Memphis and the Houston systems, there was operational testing conducted at those two locations the summer of -- one of the problems is we can -- you can only do operational testing when there is weather, so we are somewhat limited.

Doing operational testing in the winter for microburst is rather futile, so we need to focus on the summer. So, the summer activities in '93 were done at Memphis and Houston, and then we have done -- after we upgraded the system to resolve those problems, we tested those out at Houston again this year.

MR. PARHAM: Thank you. Can you explain, then, why you have the gear box lubrication problem after the operational testing of this equipment?

THE WITNESS: That is a very frustrating problem. You can look at it two ways. You either have a very robust design because it has operated so long without failure with no lubrication, or you have a breakdown in quality control, and the answer is you probably have both.

There was probably a breakdown in quality control at the pedestal manufacturer, and the system runs without lubrication and has been running for quite some time, so it is -- you know, it is kind of encouraging that we have a fairly robust design. Imagine how long it is going to run when you do lubricate it properly.

MR. PARHAM: Do you know who established the training requirements for the TDWR?

THE WITNESS: It was Air Traffic, but I don't know the exact organization. We have Air Traffic representatives on the Matrix team that handle those activities and coordinate with people in the Air Traffic Organization in Washington.

MR. PARHAM: Do you happen to know how much training the Controllers that work the equipment got in the one operational facility we have?

THE WITNESS: I don't -- I know that the trainers got three days of training. I don't know how much training they then provided to the Controllers after that.

MR. PARHAM: I believe you stated that Charlotte was originally number five to be -- receive installation. When was it originally scheduled for installation in the original program when it was number five?

THE WITNESS: I don't have an exact date, but it was -- it was sometime early 1993 would be my best estimate.

MR. PARHAM: You testified that the last sites seem to be the ones that you all are planning on having the land acquisition problems?

THE WITNESS: Right.

MR. PARHAM: Was Charlotte moved from number 5 to number 22 because it developed land acquisition problems?

THE WITNESS: It was moved down there, I believe, when we had the -- you know, when the initial land problems came up, and then has moved since then to

38 as they have gotten more severe.

I am not sure exactly what all of the -- you know, what all of the cases were that caused the movement of Charlotte, but land has certainly been the major one.

MR. PARHAM: We have heard testimony here based on the doppler, the Nexrad doppler, which is 70 miles from here. We used this for storm position and size intensity, height of the storm, movement and duration, and even created a wind shear model from this information we received.

Given that information, we were able to go down, I believe it was somewhere between 300 and 500 feet. If that was that reliable, then wouldn't we have other sites available within, say, 20 miles of Charlotte that we could use?

MR. HAMMERSCHMIDT: Let me interject something. I think -- I think it was 3,000 to 5,000 feet.

MR. PARHAM: Was it? Okay.

MR. HAMMERSCHMIDT: Or, actually, 8,000 feet. Greg, is that --

MR. SALOTTOLO: The beam was 8,000 feet.

MR. HAMMERSCHMIDT: Yeah, the beam was at 8,000 feet at its lower limit.

MR. PARHAM: Okay.

MR. HAMMERSCHMIDT: Okay.

BY MR. PARHAM: But, within 20 miles, are there any other sites? I mean, at what point do we shift emphasis to other sites?

THE WITNESS: 20 miles is probably a little far away. 8 to 12 is ideal. The problem is that the further away you are, the less -- the beam can't go down as low because of curvature of the earth. The beam goes -- is at a higher elevation the further you are away from the airport.

The answer to your other question, when we go, is, when we had problems with the initial landowner and were not able to come to terms, then we went and started the operation on the next -- the next one, and we have been working with trying to get that issue resolved.

MR. PARHAM: How large an area are you talking about --

THE WITNESS: We need a hundred and --

MR. PARHAM: -- to put the site in?

THE WITNESS: We need 150 feet square. The actual fenced in area is 110 feet square, and then with access you have to have a road that goes in there, or can be built in, and you have to have a telephone line and power available.

MR. PARHAM: Does the FAA have the authority to invoke the doctrine of imminent domain?

THE WITNESS: Yes, we do, and that is one of the options being considered in this site.

MR. PARHAM: Has the FAA considered the process, and at what -- I guess you would say stage is that in. I mean, at what point do you make that decision? What determines it?

THE WITNESS: This is a little out of my area, since I am not a real estate expert, and the real estate people make those determinations at the regional office, but normally imminent domain has been a last choice.

It is not -- you know, it is not normally, certainly, your first choice. You would get tied up in court for -- you can get tied up in court for a considerable period of time when you use that process, so ideally you would like to negotiate an acceptable agreement first, and then that is usually the last resort.

MR. PARHAM: Do you know if it has been used at any other sites?

THE WITNESS: I am not aware of it having been used at any site.

MR. PARHAM: I have no further questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, Mr. Parham.

(Pause.)

I might mention just for clarification that I believe one of our previous witnesses was using that information at the -- at the 8,000 foot lower limit and extrapolating down, so -- to achieve that other data. Right, that is for the next round.

Honeywell?

MR. THOMAS: No questions, thank you.

MR. HAMMERSCHMIDT: Airline Pilots Association?

CAPTAIN TULLY: No questions, thank you.

MR. HAMMERSCHMIDT: Okay. U.S. Air?

MR. SHARP: I have no questions, thank you.

MR. HAMMERSCHMIDT: Douglas Aircraft?

MR. LUND: No questions, thank you, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Pratt & Whitney?

MR. YOUNG: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Okay. Association of Flight Attendants?

MS. GILMER: No questions, thank you.

MR. HAMMERSCHMIDT: Thank you, Ms. Gilmer. International Association of Machinists?

MR. GOGLIA: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, Mr. Goglia. Dispatcher's Union?

MR. SCHUETZ: Yes, I do have two questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Okay.

BY MR. SCHUETZ: The first one is, do you have any Controller feedback, positive or negative, in Houston?

THE WITNESS: I have not seen any. So, you know, there may be, but I have not seen any.

MR. SCHUETZ: Okay, and you testified about a Congressional mandate for Charlotte. Is that post-accident, or prior?

THE WITNESS: Post-accident.

MR. SCHUETZ: Post-accident? Thank you very much. No further questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, sir. National Weather Service?

MR. KUESSNER: No questions.

MR. HAMMERSCHMIDT: Okay. Federal Aviation Administration?

MR. DONNER: No questions.

MR. HAMMERSCHMIDT: Thank you, Mr. Donner. Mr. Feith?

MR. FEITH: I just have two follow up questions. Mr. Turnbull, can you tell us what groups had input into the TDWR Program from outside the FAA?

THE WITNESS: When we were initially establishing the requirements, there was a user group set up to determine what data was required, what format they wanted, et cetera.

There were representatives from FAA, Air Traffic Airway Facilities, and then outside the FAA, National Transportation Safety Board was a member of that, Air Traffic Association.

There were representatives from pilot unions, both, I think, the American Airlines Pilot Union and ALPA (sic). There were representatives from the Air Traffic Union.

MR. FEITH: Any airlines involved in that?

THE WITNESS: There were representatives in ATA, Air Traffic Association. The airlines are represented by that organization, so they are -- the representatives there were actually from -- were employees of airlines, yes.

MR. FEITH: One last question. Given the fact that we haven't had a fatal wind shear accident since August of '85, do you think that that lag has slowed down the TDWR Program in the last couple of years?

THE WITNESS: No, we have proceeded as rapidly as we could with the resources and the data that we had, you know.

MR. FEITH: I have no further questions. Thank you.

MR. HAMMERSCHMIDT: Thank you, Mr. Feith. Mr. Laynor?

MR. LAYNOR: Just a couple, Mr. Turnbull.

After this accident, we read in the paper about lower cost alternatives to the TDWR that could be located on site with shorter range capability. Can you elaborate, at all, on any of those systems?

THE WITNESS: Not in great detail. My job is to acquire the TDWR and I am no longer in the research organization, although I used to be. So, the issue, though, that needs to be answered, I know there are a number of systems out.

I am aware that there are tests going on. I have not seen any data from those tests. I understand there is some limited data, but the critical issue that needs to be addressed -- and when you are looking at any of these systems -- is the issue of how precise is the data, what do you expect the pilot to do when they receive that type of warning and what are the false alarms.

Because, basically, if the system is giving out false alarms, you are telling a pilot to -- that there is a severe condition and that they ought to break off an approach, and they could go around, or abort a take-off. So, it is a fairly serious situation.

The detection part is the easy part. The eliminating false alarms is a difficult part of the design of the systems.

MR. LAYNOR: Okay, next. You have been talking about the environmental impact. Is there a radiation hazard associated with the sighting?

THE WITNESS: No, there is not. The radiation from the system, certainly it is a -- it is a radio transmitter. Like many other radio transmitters, the beam is quite focused above the ground, and we have determined that there is a national standard that is acceptable and the radiation on the ground is several hundred times lower than what the national standard considers acceptable.

MR. LAYNOR: In answering Mr. Feith, you were talking about the TDWR and LLWAS integration. Is the LLWAS Phase 2 integration with TDWR such that the Controller has only one sensor and one message to present to the pilot?

THE WITNESS: Yes, the -- when the TDWR is installed, the LLWAS 2 display is removed from the tower.

MR. LAYNOR: Is there any effort to integrate the weather processor on the ASR-9 with the TDWR information?

THE WITNESS: There is a future program called the Integrated Terminal Weather System that is in the research stage right now that integrates TDWR, Nexrad, ASR-9, lightning protection systems, ASSO's (sic), all of the available weather information is integrated.

Now, that is primarily directed to the planning function, as opposed to the warning function.

MR. LAYNOR: A final question. Are you in your position associated with the doppler add-on to the ASR-9 and any research and development and plans to follow up on that program?

THE WITNESS: That is not my program. I try and remain somewhat familiar with what is going on, but that is not my responsibility, no.

MR. LAYNOR: Thank you, Mr. Turnbull.

MR. HAMMERSCHMIDT: Mr. Schleede?

MR. SCHLEEDE: Yes, sir. You mentioned that -- regarding training -- that the trainers get three days of train -- trainers get --

THE WITNESS: Right.

MR. SCHLEEDE: -- three days. Who provides that training?

THE WITNESS: Raytheon.

MR. SCHLEEDE: You weren't aware of what the trainees at the facilities receive?

THE WITNESS: I am not personally aware of it, but I know that they -- that the trainers do conduct a course for all of the Controllers at the facility.

MR. SCHLEEDE: Do you know how the effectiveness of the training is evaluated?

THE WITNESS: No, I don't.

MR. SCHLEEDE: Is the -- is training and evaluation of the effectiveness of the training part of the contract that the FAA lets to Raytheon?

THE WITNESS: No, the contract was to develop the course and to actually conduct the course at each facility. The FAA experts in -- excuse me -- in this area monitor the development of the course, approve the course and, so -- but, to my knowledge there is not a specific evaluation of the effectiveness of it.

MR. SCHLEEDE: Is the training that is conducted at the facilities coincidental with the commissioning of the facility, or is it --

THE WITNESS: It is before commissioning and after acceptance. It is at the discretion of the Air Traffic Supervisor. Once the system is commissioned, they request a date when they would like to have that training occur.

MR. SCHLEEDE: Okay, and one last area regarding procedures for the use of the TDWR. I think you mentioned the display and format and the Controller phraseology will be virtually identical to LLWAS?

THE WITNESS: It is the same as LLWAS 3, yes.

MR. SCHLEEDE: It is the same. We had testimony earlier -- I know that you weren't here -- regarding the procedures for advising flight crews of ASR-9 weather of VIP levels.

It was apparent from the Controllers' and the Supervisors' testimony that the advising of the VIP level three from an ASR-9 is discretionary, taking precedence to separating aircraft. Is advising of information from the TDWR mandatory, or discretionary for a Controller?

THE WITNESS: That is -- I am not really sure. I mean, it is my understanding that it is

mandatory, but I
don't -- but, I don't speak with authority on that.

MR. SCHLEEDE: Will the data from this unit be recorded for quality assurance evaluation, or other evaluations? Will it be retrievable following an event?

THE WITNESS: There is a recording capability right now that the last hour of data is always maintained in the event of an incident. There is a selection, and that is held in archiving. There is a modification coming in as part of this next LLWAS 3 integration, when that gets finalized, to add 15 days of recording capability.

MR. SCHLEEDE: Okay, thank you very much, Mr. Turnbull.

MR. HAMMERSCHMIDT: Okay, does anyone have any other questions for this witness?

(No response.)

Okay, Mr. Turnbull, thank you very much for your participation in this public hearing and for the important work that you do at the FAA.

THE WITNESS: Thank you, Mr. Chairman.

MR. HAMMERSCHMIDT: You may step down.

(Witness excused.)

Let's see. We will proceed to our next witness, Mr. William Rickard, who will be questioned by Mr. Jim Ritter.

WILLIAM RICKARD, GENERAL MANAGER OF AERODYNAMICS AND ACOUSTICS DOUGLAS AIRCRAFT COMPANY, LONG BEACH, CALIFORNIA

Whereupon,

WILLIAM RICKARD,

was called as a witness and, after having been duly sworn, was examined and testified on his oath as follows:

MR. SCHLEEDE: Would you please state your full name and business address for the record?

THE WITNESS: Okay, one moment, please.

MR. SCHLEEDE: Take your time.

(Pause.)

THE WITNESS: I have written my name down on a piece of paper in case I forget it. Yes, I am William Rickard. I am General Manager for Aerodynamics and Acoustics at the Douglas Aircraft Company in Long Beach, California.

For my curriculum vitae, I am a native of Charlotte. I grew up here, attended school here, went on to North Carolina State University where I got a Bachelor of Science degree in Aeronautical Engineering.

I was then selected for a NASA sponsored Ph.D. Program called Interdisciplinary System Design. From college I went on to Cornell, their Nautical Laboratories where I worked in Flying Qualities Research under Bob Harper who is known as the co-inventor of the Cooper-Harper scale for Flying Qualities pilot ratings.

Then I went to Douglas Aircraft where I continued my work in Flying Qualities research, applying that to Transport Aircraft, published a number of papers, continued my education with short courses. Among those were a course at the Von Karmen Institute in Brussels on Active Control Technology and a few courses at the University of Southern California on Parameter Identification.

I was invited by the French Government to lecture on Flying Qualities at their version of NASA, which is called ENRON (sic). I have taught aerodynamics courses at the California Polytechnic State University, and taught some of those courses at Douglas, as well.

I joined the MD-11 Team in 1985 to apply my experience on that airplane program. I was the Douglas representative on the Ad Hoc Wind Shear Committee that came up with the model of the microburst. I was also part of the FAA sponsored program to develop wind shear training tools and techniques for the airlines, and I participated in a number of accident investigations, both as the working level guy and as the manager and, as I said today, I am the General Manager for Aerodynamics and Acoustics.

MR. SCHLEEDE: Thank you very much, sir. Mr. Ritter will continue.

MR. RITTER: Thank you. Good morning.

THE WITNESS: Good morning.

MR. RITTER: First, I would like to ask you some questions about Exhibit 13(c) which contains a series of graphs showing the flight data recorder data, or FDR data, estimated winds and simulated results that were provided by Douglas Aircraft Company.

(Document proffered to the witness.)

(Witness complies.)

Pages 1 and 2 of Exhibit 13(c) show the FDR information from the accident flight, is that correct?

THE WITNESS: Yes, they do.

MR. RITTER: Okay. Were these data provided by the NTSB to your company?

THE WITNESS: Yes, they were.

MR. RITTER: The FDR on the accident airplane used the alternate pitot/static system. Would this make the FDR indicated air speeds that we see here on page 1 appreciably different from the air speeds shown on the cockpit indicator?

THE WITNESS: No, they wouldn't be appreciably different. There are small differences in the instrument calibrations, but they are small.

MR. RITTER: Were the air speeds used in the calculations made by Douglas for the accident flight corrected for the alternate system?

THE WITNESS: Yes, we did use the instrument calibrations for those instruments.

MR. RITTER: Pages 3 and 4 of Exhibit 13(c) show the wind estimates for the horizontal and vertical winds estimated for U.S. Air Flight 1016. Can you explain briefly how these wind estimates were generated?

THE WITNESS: Yes. To get wind, one way to calculate wind is to take the difference between air speed and ground speed. The flight data recorder contained records of air speed, but not ground speed.

There are two ways to get ground speed from the data that was available to us. You can take the radar data, which gives position versus time and differentiate it. That gives you velocity.

The flaw with that is it is bad practice to differentiate a noisy signal, you amplify the noise. Another problem with that is the data was spaced too far apart in time, so there would be too much time averaging in the data. It would wind up being noisy and coarse.

There is another approach available to us with the data that was recorded. We have enough recorded data to construct what amounts to an inertial navigator. We can take the accelerometer data and the gyrodata and produce inertial navigation type signals.

We integrate the accelerometers to get velocities, and there you have ground velocity. Good thing about that is the data was recorded at a fairly high frequency and, also, it is well known that if you integrate a noisy signal, the noise is reduced, so it is a higher fidelity signal.

The flaw there, the problem there, is that accelerometers always have biases, or zero shifts that you have to account for. Well, we were able to account for that here by doing a second integration to get position and compare the position calculated to the position recorded by the radar. You can then use that information to determine accelerometer biases.

When you factor those biases in, you have a very good signal for ground speed, and the difference between air speed and ground speed is the wind.

MR. RITTER: Okay. Is this a fairly standard method that was employed?

THE WITNESS: Well, it uses fairly standard physics and mathematics.

MR. RITTER: Okay. I know that the FDR recorded normal acceleration and longitudinal acceleration. Was lateral acceleration recorded?

THE WITNESS: No, that was not recorded. We accommodated that by setting that signal to zero. This seemed reasonable because it is unlikely that lateral accelerations were very large and they are -- the integral of the lateral accelerations was probably near zero.

MR. RITTER: Okay. So, if the airplane wasn't in a significant side-slip, then that is a pretty good estimation, or pretty good --

THE WITNESS: Yes.

MR. RITTER: -- approximation?

THE WITNESS: Yes, and we were able to reconstruct the path.

MR. RITTER: Okay. Page 3, again of Exhibit 13(c), gives the plot of the calculated wind vectors for the last 70 seconds of the accident flight. Referring to the middle graph, what was the change in head wind component during the final 15 seconds, approximately, of the flight?

THE WITNESS: The head wind component of the wind peaked around 35 nauts, then it -- of head wind -- and declined to about 25 nauts of tail wind.

MR. RITTER: Okay, and that is over approximately 15 seconds?

THE WITNESS: Yes, it is.

MR. RITTER: Referring to the same graph, what was the approximate change, or history of vertical wind during the same time period?

THE WITNESS: Well, the vertical wind varied a bit there, but the peaks are generally in the range of 10 to 15 nauts, declining to around 5 nauts toward the end of the record.

MR. RITTER: Okay. In your opinion, do these wind estimates indicate that Flight 1016 experienced a significant wind shear?

THE WITNESS: Yes, they do.

MR. RITTER: If we go to the next page of the exhibit, page 4 of 13(c), we have a graph. Could you explain this graph briefly?

THE WITNESS: Yes. This shows the calculated wind vector as it was calculated at each point in time, attached to the aircraft position at that point in time.

MR. RITTER: Okay. If we look at this graph and look at the wind vectors shown on this graph, would you expect the tail wind to increase further if the airplane had been able to continue flying to the southwest?

THE WITNESS: Well, there has been an assumption, I believe, and probably some testimony, that this wind source was a microburst. From a knowledge of the structure of microbursts, you can deduce that it is unlikely that the wind magnitude will increase as the aircraft travels away from the center.

It is also unlikely that it will shift anymore to the head wind/tail wind direction, because it is already almost exactly on the tail. The interesting thing, as you see along the path here, the wind magnitude doesn't vary greatly, it is the wind direction that is changing. We have now reached the point where the wind is almost exactly abeam.

MR. RITTER: Okay, and then as you travel further from the source of the out-flow, I guess it stands to reason that the wind velocity would decrease?

THE WITNESS: Yes, that would be logical, and I guess it -- since it is the shear that is significant for performance, now that we have reached an area where the magnitude and direction are almost constant, that would be a shear of zero.

MR. RITTER: Okay.

THE WITNESS: So, we are getting into an area where the shear is declining.

MR. RITTER: I understand that in addition to these estimates of winds that Douglas developed a computer simulation of the DC-9 for this accident. Can you explain briefly what work was done?

THE WITNESS: Yes. The Performance Group asked Douglas to attempt some "what if" simulations. To do that, we needed to develop and validate a simulation, and pages 5 and 6 show the result of that simulation model.

We put together an aerodynamic model of the airplane and a model of the engine, and then calculated a time history to see if we could match the recorded data, and you will see on pages 5 and 6 the results of that. It is a fairly good match.

MR. RITTER: Did you include wing configuration in this work, flaps and slats?

THE WITNESS: Okay. We drove the model at this point with pitch, roll and yaw as inputs. EPR, engine pressure ratio, was an input, the flap and slat configuration, the gear position, the weight of the airplane and, of course, as I just said, the aerodynamic data and the engine deck.

MR. RITTER: Then, you -- I guess in addition to this you have input the wind data?

THE WITNESS: Yes, we did. We took the winds calculated in the previous step and used that as an input.

MR. RITTER: Okay. So, this effort plotted here on pages five and six, I guess in effect it is a validation of the simulation model that you developed?

THE WITNESS: Yes. In fact, it is a necessary first step in doing the "what if" scenario calculations.

MR. RITTER: Okay. I notice that we have some roll attitudes when the airplane turned to the right. You have had a chance to review the FDR data. Do you feel that the magnitude of the roll attitudes experienced by Flight 1016 would have significantly affected the climb gradient?

THE WITNESS: No, those bank angles are fairly small. I believe they are under 15 degrees.

MR. RITTER: Okay. Okay, let's go to pages

7, 8 and 9 of Exhibit 13(c).

(Witness complies.)

Can you explain briefly what these pages contain?

THE WITNESS: Yeah, this is what I just described as a "what if" calculation. The "what if" we simulated here was a use of a specific procedure, wind shear procedure, and using that procedure we calculated the various parameters using our simulation model.

MR. RITTER: At what point -- now, you -- we are calling it a wind shear procedure, I guess. At what point did the procedure begin in the simulation?

THE WITNESS: Of course, one of the problems in doing a "what if" is deciding where to start it and, so, there was some effort made to figure out a place to start it. The Performance Group asked Douglas to start this at the point where the crew in question made a decision to change strategy.

Since this changing to a wind shear procedure is a change in strategy, we just wanted to find a spot where that might have been made, or -- and that was the spot where a decision was made, so we did it there.

MR. RITTER: So, there could be further work done in this area in terms of alternate scenarios for the simulation work?

THE WITNESS: Yes. Certainly, there is probably a multitude of "what if" simulations you could do.

MR. RITTER: What was the result? If we look at page 7 here in terms of altitude, what was the result of this -- of the wind shear simulation?

THE WITNESS: Okay. As you can see from the traces, the strategy, or the procedure that was used was to advance the throttles to their mechanical limit, which we refer to as firewalling the throttles. We made no configuration change in terms of the flaps, or the gear.

The airplane was pitched up to an attitude of 15 degrees and then held there. This strategy is essentially what is outlined in the Douglas Flight Crew Operating Manual and the U.S. Air Training Guide.

Within -- we will hold the pitch attitude at 15 degrees and we would back off of that if there was a stickshaker activation. There was not in this calculation. At the end of the time, the time history, altitude is -- let's see, where is that?

(Pause.)

Altitude is about 500 feet above terrain, air speed has gone to a fairly low level, but still above stickshaker, and I guess you can see the other parameters.

MR. RITTER: When you ran this simulation, and I guess what I would like to ask you is, how were the winds applied to this simulation?

THE WITNESS: Okay. Our only knowledge of wind is from the flight recorder data. So, we had the wind along the path Flight 1016 actually took. We then applied those winds, and it is wind versus time in this simulation. We didn't have any other source of wind information.

MR. RITTER: Okay. So, the -- if the -- I guess the -- the conclusion is if you take a different flight path, if you choose a different flight path, you might have had different winds than were used in this simulation?

THE WITNESS: Yes.

MR. RITTER: I mean, a different flight path from the accident flight?

THE WITNESS: Yes.

(Pause.)

MR. RITTER: On page 9, we noticed -- I -- there is a plot of flap deflection. There is two different flap schedules. Could you explain that?

THE WITNESS: Okay. The -- in the actual flight, Flight 1016, the crew retracted the flaps. In a wind shear procedure, that is not done. The advice to the pilot in a wind shear procedure is to make no configuration changes.

MR. RITTER: So, that would include flaps, landing gear, when you say configuration?

THE WITNESS: Yes.

MR. RITTER: Has Douglas included the effects of heavy rain in any of the simulations given here in Exhibit 13(c)?

THE WITNESS: Well, in looking at the information already provided to the Safety Board on the effects of heavy rain, we did calculate the effect for this event. The data shows that there was -- for this event, there would be no significant effect, so we didn't modify the aero data to reflect a change.

However, you could say that implicitly we have matched the -- that effect. If there was any effect on the airplane, it would be in the flight recorder data, so when we did the validation of the simulation, the fact that you -- you get a reasonable match, at least implies that if the effect was there, it was accounted for.

MR. RITTER: Alright, thank you.

MR. RITTER: I have no further questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, Mr. Ritter. Let's see, going to the party questioning, Federal Aviation Administration?

MR. DONNER: Yes, sir, just one question. You mentioned that you initiated the model where -- at the point at which the crew changed strategy. I am not clear on that. Could you explain to us exactly at what point that was?

THE WITNESS: Okay. The crew, in making the landing, you could say, was pursuing the strategy of, "Let's land the airplane." When they went to the new strategy of, "Let's not land the airplane," that is a change in strategy, so it was --

MR. DONNER: Is that a -- at the point they elected to go around?

THE WITNESS: Yes.

MR. DONNER: Okay, thank you. Thank you, sir.

MR. HAMMERSCHMIDT: Thank you, Mr. Donner. Mr. Parham, National Air Traffic Controllers Association?

MR. PARHAM: We have no questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Honeywell?

MR. THOMAS: We have no questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Airline Pilots Association?

CAPTAIN TULLY: Yes, just a few questions. Mr. Rickard, I believe that in response to a question by Mr. Ritter about the pitot/static inputs to the DFDR, you stated that they came from the alternate system. Is that really the case?

THE WITNESS: Yes.

CAPTAIN TULLY: Well, where does the pitot input come from? Isn't it a fact that that comes from the pitot tube in the rudder limiter?

THE WITNESS: It is that -- pitot is located in the vertical tail.

CAPTAIN TULLY: So, it is -- the pitot source is not the alternate static -- alternate pitot/static port, it is the port for the rudder limiter, right?

THE WITNESS: That is correct.

CAPTAIN TULLY: Could you tell us briefly what an engineering simulator is?

THE WITNESS: An engineering simulator, well, that is a rather wide open question. Simulators --

CAPTAIN TULLY: Well, how does it differ -- okay, if that is kind of nebulous, how does it differ from, say, a flying simulator?

THE WITNESS: Well, simulations come in all forms and degrees of complexity. Some of them are run on mainframe computers, some of them are run on dedicated computers, real time, non-real time and at different degrees of complexity.

CAPTAIN TULLY: Well, some people, I think, might have the idea that an engineering simulator is some kind of flying test bed when, in fact, it is really, basically, a computer.

THE WITNESS: It is a calculation using a math model of the airplane, the same basis as is used in a training simulator.

CAPTAIN TULLY: In these simulations, I think the first point I want to make is here. You indicate a starting point for the simulations as where the crew changes strategy, is that correct?

THE WITNESS: The starting point for the wind shear procedure?

CAPTAIN TULLY: Um-hum.

THE WITNESS: Yes.

CAPTAIN TULLY: Well, in point of fact, weren't there two strategy changes on the part of the crew? One was to start the go-around and, at sometime prior to the impact, to begin executing a wind shear escape.

THE WITNESS: It -- I guess I can't comment on that. That is not what my --

CAPTAIN TULLY: Well, I am just suggesting --

THE WITNESS: -- my expertise is.

CAPTAIN TULLY: If you are going to choose a change in strategy point, wouldn't the change in strategy point more appropriately be when the crew decides to execute the wind shear escapement over -- as opposed to the go-around?

THE WITNESS: I guess I don't have any opinion on that.

CAPTAIN TULLY: Okay. Alright. Do the -- in your simulations, do you take into account any human factors like recognition time, reaction time, or time to interpret flight instruments?

THE WITNESS: No, this was not a simulation of the persons, this was a simulation of the airplane.

CAPTAIN TULLY: Okay. Was this a mathematically perfect airplane? Would that be a fair description?

THE WITNESS: I don't -- perfect is an interesting word to use here. I guess I wouldn't claim that anything I have ever done is perfect.

CAPTAIN TULLY: Well, I mean, are you using new engines, are you using a worn air frame, do you apply any penalties for mis-rigging, or anything like that?

THE WITNESS: The way we accommodate possible variations is by doing the validation of the simulation and to show that the math model we used would accurately reflect and describe Flight 1016.

CAPTAIN TULLY: Okay. You mentioned that due to the fact that there was no lateral acceleration data available, you assumed the lateral acceleration to be zero, is that correct?

THE WITNESS: That is correct.

CAPTAIN TULLY: Okay. Given the dynamic nature of this microburst and some indications that we have that this is a complex microburst, doesn't this introduce at least some level of uncertainty into the assumptions?

THE WITNESS: You are referring now to the calculation of the wind?

CAPTAIN TULLY: Yes.

THE WITNESS: Well, the -- that was accommodated by showing that we could reproduce the ground track as recorded by the radar.

CAPTAIN TULLY: Does the model account for unusual stick forces that might be encountered by a pilot?

THE WITNESS: Again, the model that we use for simulation was just a model of the airplane. We didn't attempt to model the human.

CAPTAIN TULLY: Would you go to Exhibit

13(c), please, page 9?

(Witness complies.)

I believe one of these -- I believe one of these traces here is thrust, is that correct?

THE WITNESS: Yes.

CAPTAIN TULLY: Okay. In your simulation, it seems to me that your simulated engines attain a thrust level considerably higher than the maximum firewall power thrust levels achieved by the accident airplane. How do we account for that?

THE WITNESS: Well, actually, the way we got that thrust level was to look at the flight data recorder traces, and we, as Douglas, don't really know what firewall throttle, or firewall EPR is.

So, we looked at the traces to see how far EPR actually went. We picked the highest spot on the EPR trace, 2.09, and used that. It could be that firewall is even farther, but we just went by the evidence we had.

CAPTAIN TULLY: I have no other questions. Thank you.

MR. HAMMERSCHMIDT: Thank you, Captain Tully. U.S. Air?

MR. SHARP: We have no questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, Mr. Sharp. Douglas Aircraft Company? Oh, excuse me, that's right. Pratt & Whitney?

MR. YOUNG: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Let's see, Association of Flight Attendants?

MS. GILMER: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: International Association of Machinists.

MR. GOGLIA: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Dispatchers Union?

MR. SCHUETZ: Mr. Chairman, no questions.

MR. HAMMERSCHMIDT: Thank you. National Weather Service?

MR. KUESSNER: No questions.

MR. HAMMERSCHMIDT: Back to the Douglas Aircraft Company.

MR. LUND: Yes, Mr. Chairman, just one question. Mr. Rickard, who selected the point at which we started the simulation?

THE WITNESS: That was the input from the

Performance Group.

MR. LUND: Thank you, I have no further questions.

MR. HAMMERSCHMIDT: Thank you, Mr. Lund. Anymore questions from the Technical Panel? Okay, Mr. Laynor?

MR. LAYNOR: A couple, Mr. Rickard. I would like to follow up on a question from Captain Tully. I understand you haven't done any studies on -- in this particular case -- on control forces, but can you discuss in generalities the problems confronting a pilot in aircraft control during a microburst penetration, in generalities, particularly referring to trim changes and control forces?

THE WITNESS: Well, I would like to help you with that, but I am afraid that wouldn't be my area of expertise, and if I did try to help you with that, I would probably get it wrong.

MR. LAYNOR: But, you do have the theoretical data to do such an analysis to determine what control forces would be, based upon an initial trim and the changes that take place?

THE WITNESS: We could add to our simulation model to go work backwards to the stick inputs required and the stick forces, yes, that -- we can do that calculation.

MR. LAYNOR: Okay, and I also understand in response to Captain Tully's questioning that your analysis uses a math model, but in that math model you don't attempt to accurately replicate pilot response, is that true?

THE WITNESS: That is correct, there is no pilot -- there is no pilot model in the simulation.

MR. LAYNOR: Could that be accomplished in an actual simulator with pilot subjects?

THE WITNESS: Okay. To do a piloted simulation, you would need a -- for example, a training simulator that represented this airplane.

MR. LAYNOR: Can you introduce three dimensional wind models in most of those?

THE WITNESS: Yes, you can.

MR. LAYNOR: How do you validate the simulator, a training simulator, with the actual flight parameters, flight test parameters, or whatever?

THE WITNESS: Let's see, I will take a stab. If I misunderstood your question, you can tell me.

MR. LAYNOR: Well, my question is, I know that the engineering simulators include sufficient software to do a fairly good replication of the aircraft performance as you get toward the edges of the envelope, but I question whether training simulators are designed for that purpose.

THE WITNESS: Well, in my experience, you would use an FAA approved training simulator and to get the FAA approval, you go through a fairly rigorous series of check-out activities to prove the validity of the simulator.

MR. LAYNOR: Okay, if we desire to go further in that area, do you think we could pursue that?

THE WITNESS: We would have to find a DC-9 Series 30 training simulator.

MR. LAYNOR: Alright, thank you, sir.

MR. HAMMERSCHMIDT: Mr. Schleede?

MR. SCHLEEDE: No questions.

MR. HAMMERSCHMIDT: Okay, just one last question. Would you clarify for me again what effect, if any, the -- during the go-around procedure that bank had -- that the bank angle had on aircraft performance and, in specific, on lift?

THE WITNESS: Yes.

MR. HAMMERSCHMIDT: As shown from the data.

THE WITNESS: Yeah, in a bank the lift vector produced by the wing is tilted out of the vertical plane, and to support the weight of the airplane you need to produce more vertical force. That means an increase in lift.

That goes with a cosine of the bank angle. At 15 degrees it is a small effect.

MR. HAMMERSCHMIDT: Mr. Laynor?

MR. LAYNOR: Unless you had a three degree -- three dimensional wind model, based on what you saw from -- or, what Mr. Proctor presented yesterday -- could you determine whether the winds would have been more severe had he not banked?

In other words, if you were to simulate and look at the difference in considering the changes in lift due to bank, would you feel it appropriate to have to look at the wind vectors that would have been encountered had the airplane continued straight?

THE WITNESS: Well, the effect of bank on performance is easily modelled without regard to the wind vector, and we can -- we can do that. If someone developed a three dimensional model of this event, that could then be added to the simulation and we could calculate its effects.

MR. LAYNOR: Okay, thank you, sir.

MR. HAMMERSCHMIDT: Mr. Rickard, thank you very much for your participation in our hearing and for sharing your expertise with us. You may stand down.

THE WITNESS: Thank you.

(Witness excused.)

(Pause.)

MR. HAMMERSCHMIDT: Well, let's -- at this point, let's take a ten minute break and resume with the next witness who will be Mr. Robert Mazzawy. Off the record.

(Whereupon, a brief recess was taken.)

MR. HAMMERSCHMIDT: On the record. Let's please come back to order. The next witness is Mr. Robert Mazzawy. Mr. Mazzawy will be questioned by NTSB Power Plant Specialist, Jack Young.

(Witness testimony continues on the next page.)

ROBERT MAZZAWY, DEVELOPMENT ENGINEER, PRATT & WHITNEY, E. HARTFORD, CONNECTICUT

Whereupon,

ROBERT MAZZAWY

was called as a witness and, after having been duly sworn, was examined and testified on his oath as follows:

MR. SCHLEEDE: Mr. Mazzawy, would you please state your full name and business address?

THE WITNESS: It is Robert S. Mazzawy. I work at Pratt & Whitney Aircraft on Main Street in East Hartford, Connecticut.

MR. SCHLEEDE: What is your position, present position at Pratt & Whitney?

THE WITNESS: I am Manager in charge of the aerodynamic design and testing of compressors for new engines.

MR. SCHLEEDE: Please describe your experience and education that qualifies you for your present position.

THE WITNESS: Okay. I have a Masters degree in Mechanical Engineering. I have worked at Pratt & Whitney for 29 years in various areas dealing with engine design, development and operation. I have considerable experience in dealing with operation with rain and hail, icing conditions.

I was part of an industry-wide study that was formed in 1988 by the Aerospace Industries Association in conjunction with the FAA to investigate engine operation in inclement weather and, as part of that study, I chaired a committee that provided information to the FAA that led to modifications of the regulations used to certify engines.

MR. SCHLEEDE: Thank you very much. Mr. Young will proceed.

MR. YOUNG: Good morning, Mr. Mazzawy.

THE WITNESS: Good morning.

MR. YOUNG: When was the JT8D engine first certificated?

THE WITNESS: In 1963.

MR. YOUNG: In 1963, is it true there was not a requirement for water ingestion testing in the regulations at that time?

THE WITNESS: That is correct.

MR. YOUNG: Did Pratt & Whitney subsequently -- when those regulations were amended to include water ingestion, did Pratt & Whitney subsequently test the JT8D?

THE WITNESS: Yes, they did, in 1977.

MR. YOUNG: What was the criteria at that time that the regulation required?

THE WITNESS: You had to test the engine with a four percent water to air ratio by weight at idle power and at take-off power.

MR. YOUNG: That was at steady state conditions?

THE WITNESS: Steady state conditions, yes.

MR. YOUNG: The engine successfully met that criteria?

THE WITNESS: That is correct.

MR. YOUNG: What was notable with the performance of the engine during that ingestion?

THE WITNESS: Probably the most notable change had to do with the amount of fuel that is required to operate the engine at steady state. We deal in terms of parameters which relate to the relationship between fuel flow and burner pressure as relative to the given rotor speed, the high rotor speed and, two, that the engine is operating at.

At a given power setting, or PLA angle, there is a certain level that is typically required for the engine at dry conditions. When we operated with the 4 percent water, that increased somewhat, approximately 15 to 20 percent.

That still left considerable margin for the engine to accelerate beyond that, because generally you have at least 50 percent margin beyond the steady state condition so that you have acceleration capability within the engine.

MR. YOUNG: When you say a 50 percent margin, do you mean the capability of at least 50 percent more fuel available?

THE WITNESS: That is correct.

MR. YOUNG: For the acceleration?

THE WITNESS: More than is required to operate steady state.

MR. YOUNG: Did -- during any of that testing, or any other, did you, in fact, test the engine under transient, or acceleration conditions during water ingestion?

THE WITNESS: We did not. That was not a requirement.

MR. YOUNG: So, this is -- this is just calculated data based on the design of the fuel system?

THE WITNESS: It is measured data from the test which shows that the increment in fuel is consistent with a certain amount of water coming in and verifying that there is, again, still significant margin for the engine to accelerate.

MR. YOUNG: Then, at take-off -- or, at the take-off thrust, that was at the rated thrust of the engine?

THE WITNESS: That is correct, it was nominally between 1.9 and 2.0 EPR.

MR. YOUNG: Did that -- did it maintain that during the water ingestion, as you established a thrust in ingested water? Did that -- the thrust level stay there?

THE WITNESS: Actually, the thrust level increases, because part of the manifestation of the added mass flow causes a rise in the burner pressure of the engine and also the EPR, so thrust increase is when we add water.

MR. YOUNG: After that testing, has there been any further water ingestion testing that you are aware of with JT8D?

THE WITNESS: Not for the JT8D, itself. The past 200 Series has undergone water testing, but not the 8D.

MR. YOUNG: That was at .4 percent -- or, 4 percent by weight, water to air. You said one of the most notable things was some of the fuel required was to deal with the addition of the water to the air flow?

THE WITNESS: That is correct.

MR. YOUNG: Now, in Exhibit 5(g) on page 3 -- well -- yeah, it is on page 3.

(Witness complies.)

THE WITNESS: Yes.

MR. YOUNG: The Safety Board Meteorologist has used the radar data from the day of the accident and calculated liquid water content, and he has estimated anywhere from .4 to .8 of a percent, which -- how would the engine react to that amount of water?

THE WITNESS: As I mentioned, when we ran with 4 percent we documented approximately about a 15 percent increase in the fuel requirement for the engine to operate steady state.

We have developed information not only from that engine test, but from a number of other engine model tests which tell us approximately how much fuel is required for a given amount of water presented to the engine.

For this level, you would have approximately a percent increase in the fuel flow. So, much less of the incremental requirement then was demonstrated during that test series.

MR. YOUNG: With this amount of ingestion, what would you expect the acceleration response of the engine to be?

THE WITNESS: It would be essentially the same as a dry engine. The variability from engine to engine is well within this -- one percent is well within the variation from engine to engine in trimming and so on, so to the pilot it really would be undetectable.

MR. YOUNG: It would be, I am sorry, undetectable?

THE WITNESS: Undetectable any difference between operating characteristics dry, or with that small amount of water.

MR. YOUNG: The thrust levels that he would be expecting to achieve in terms of EPR?

THE WITNESS: It would be, again, whatever normal settings he would ask for, he should be able to get. It wouldn't affect the ability of the engine to make power.

MR. YOUNG: I don't have anymore questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, Mr. Young.

Going to the parties, Federal Aviation Administration?

MR. DONNER: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Okay, National Air Traffic Controllers Association?

MR. PARHAM: We have no questions, sir.

MR. HAMMERSCHMIDT: Thank you. Honeywell?

MR. THOMAS: No questions, thank you.

MR. HAMMERSCHMIDT: Airline Pilots Association?

CAPTAIN TULLY: No questions, thank you.

MR. HAMMERSCHMIDT: Thank you. U.S. Air?

MR. SHARP: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. McDonald Douglas?

MR. LUND: No questions, Mr. Chairman, thanks.

MR. HAMMERSCHMIDT: Okay, Association of Flight Attendants?

MS. GILMER: No questions, thank you.

MR. HAMMERSCHMIDT: Okay, International Association of Machinists?

MR. GOGLIA: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Dispatchers

Union?

MR. SCHUETZ: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. National Weather Service?

MR. KUESSNER: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, and Pratt & Whitney?

MR. YOUNG: No questions, thank you.

MR. HAMMERSCHMIDT: Okay, thank you, Mr. Young. Mr. Laynor? Oh, anymore -- oh, excuse me. Mr. Feith?

MR. FEITH: Just two quick questions. You had made a statement that because of the mass increased with water flow into the engine it would subsequently increase thrust?

THE WITNESS: Yes, sir.

MR. FEITH: Could you give us a relation of approximately how much? Is it significant, being a one percent, two percent, or five percent increase?

THE WITNESS: If I could refer to some information here?

(Pause.)

For the four percent water air test that we conducted, it looks like about a seven, or eight percent increase in thrust. So, again, since the amount of water ingested was significantly lower, it wouldn't be anywhere near that amount.

MR. FEITH: During the course of your review of the exhibit materials in preparation for the hearing, did you have an opportunity to review the flight data recorder information?

THE WITNESS: Yes, sir.

MR. FEITH: Specifically, the engine parameters?

THE WITNESS: Yes, sir.

MR. FEITH: Did you have -- was there any evidence based on your observation of the parameters from the FDR that would indicate reduction in power at any time?

THE WITNESS: No, none that I could see from the data.

MR. FEITH: That's all, Mr. Chairman, thank you. Thank you, Mr. Mazzawy.

MR. HAMMERSCHMIDT: Okay, let's see. Thank you, Mr. Feith. Mr. Young?

MR. YOUNG: Yes, sir. Mr. Mazzawy, the

document you were just referring to to answer Mr. Feith's question about thrust, is that Exhibit 8(b)? I want to be sure that we have that in --

THE WITNESS: That is Exhibit 8(b).

MR. YOUNG: Okay, then we have it already.

THE WITNESS: I used page -- page 9, which shows the dry and the wet condition, level of EPR versus various other engine parameters.

MR. YOUNG: Okay. I just wanted to be sure that was something we already had in the record.

THE WITNESS: That is correct.

MR. YOUNG: Thank you.

MR. HAMMERSCHMIDT: Thank you. Mr. Laynor?

MR. LAYNOR: Just one, Mr. Mazzawy. In responding to Mr. Feith in the answer about an increase in thrust as you get into a water ingestion situation, that would be evident on EPR indications, also, would it not?

THE WITNESS: That is correct, yes.

MR. LAYNOR: Okay, thank you.

THE WITNESS: That is how we would determine how much thrust would be increased, based on the EPR change.

MR. HAMMERSCHMIDT: Mr. Schleede?

MR. SCHLEEDE: No questions.

MR. HAMMERSCHMIDT: Okay, any other questions for this witness?

(No response.)

Mr. Mazzawy, we thank you for your participation in this public hearing, and you may stand down, unless there is anything else you would like to add for the record.

THE WITNESS: I have nothing else, no.

MR. HAMMERSCHMIDT: Okay, thank you, again.

THE WITNESS: Thank you.

(Witness excused.)

MR. HAMMERSCHMIDT: The next witness is Mr. Michael Lewis. Mr. Lewis, would you please come forward?

(Witness complies.)

Mr. Lewis will be questioned by NTSB Systems Investigator, John DeLisi.

MICHAEL LEWIS, DEPUTY PROGRAM MANAGER, WINDSHEAR PROGRAM - NASA, LANGLEY, VIRGINIA

Whereupon,

MICHAEL LEWIS

was called as a witness and, after having been duly sworn, was examined and testified on his oath as follows:

MR. SCHLEEDE: Mr. Lewis, please state your full name and business address.

THE WITNESS: My name is Michael Lewis and I am employed by NASA Langley Research Center in Hampton, Virginia.

MR. SCHLEEDE: What is your position at NASA?

THE WITNESS: I am a Research Engineer and Program Manager.

MR. SCHLEEDE: Could you describe your background, experience and education that qualifies you for your current position?

THE WITNESS: Yes, I graduated from Princeton University in 1983 with a Bachelor of Science and Engineering and Mechanical and Aerospace Engineering. I subsequently went to go to work at NASA Ames Research Center.

I received a Masters from Stanford University in Aeronautics and Astronautics. After about five years, or so at NASA Ames doing helicopter flight controls and flight test and simulation studies, I went to headquarters and was a Program Manager for Aeronautical Guidance Controls, and then subsequently in about 1989 moved to NASA Langley Research Center where I became the Flight Test Project Engineer and Deputy Program Manager for Langley's Airborne Wind Shear Sensors Program.

MR. SCHLEEDE: Thank you very much. Mr. DeLisi will proceed.

MR. DELISI: Thank you. Good morning, Mr. Lewis.

THE WITNESS: Good morning.

MR. DELISI: As background, can you give us an explanation of the difference between a reactive wind shear warning system and a predictive wind shear warning system?

THE WITNESS: Sure. A reactive wind shear warning system attempts to measure the wind shear environment immediately surrounding the aircraft. It is also called an in-situ type sensor system, meaning that the sensor, itself, is in the environment it is trying to measure.

A reactive system, by its nature, cannot detect immediately what the wind shear environment is, because it has to allow for gust filtering and so forth and, so, therefore, the term reactive, gust filters typically take four to five seconds, or so to smooth out the winds and avoid false alarms.

A predictive sensor attempts to look ahead of the aircraft and measure the wind field and wind shear environment anywhere from 10, to 30, to 60 seconds, or so ahead of the airplane and attempt to give a potential wind shear warning prior to the aircraft entering the wind shear environment.

MR. DELISI: Yesterday, we heard a little description in terms of F-factor in describing the intensity of a wind shear. Can you explain a little more to us about F-factor?

THE WITNESS: Sure. I think that is an important thing, since so much of this investigation is focused on wind shear and its effects on aircraft. The F-factor hazard index was developed by personnel at NASA Langley Research Center, chiefly Dr. Rolland Bowles, and it is a quantitative measure of wind shear in a hazard index form that relates directly to aircraft performance.

Typically, the equations of motion for an airplane in a no-wind situation is that the potential flight path angle equals the thrust minus drag over weight of the aircraft.

In a wind shear environment, the potential flight path angle equals thrust minus drag over weight minus this F-factor hazard index. So, for typical sorts of situations, the -- well, in steady state conditions, normal flight thrust equals drag and the flight path angle is zero.

A typical twin engine aircraft might have a thrust minus drag over weight ratio of .15 to .17, or so and that is in rating, so you multiple it by about 60, you get degrees of potential flight path angle. That is about -- I don't know, ten, or so degrees of potential climb angle.

Therefore, an F-factor of wind shear, sustained wind shear with an F-factor of about .15, would take away all of that aircraft's potential flight path angles, so the thrust minus drag over weight minus that F would, therefore, equal zero.

So, an aircraft flying through with an installed thrust minus drag over weight capability of .15 flying through a wind shear field of .15 would at maximum power be able to only hold air speed and hold altitude.

If the wind shear was greater than .15, by its very nature, even at full power, that aircraft, the pilot would be forced to give up some altitude, or air speed.

The typical, or the current warning level for both reactive and predictive type systems established by the FAA with -- which we worked with them some, is established at .105.

Any wind shear above .105 you would want to warn an airplane away from, and that number was arrived at for predictive systems, anyway, by looking at aircraft performance and seeing that about .15, or so is the maximum that you would want to ever allow an airplane to go into and, therefore, backed away some from that. So, this particular shear of .3 was relatively severe.

MR. DELISI: Thanks. When did NASA first get involved in the study of airborne wind shear detection?

THE WITNESS: In about the mid-1980's NASA had a program that was going -- going along looking at trying to model in simulation atmospheric effects on aircraft and, also, it had an independent sort of activity going that was looking at developing airborne radar systems for wind shear measurements, or wind field measurements.

About the time the Dallas/Fort Worth accident happened in coordination with the FAA and in consultation with the FAA, NASA at Langley got involved in putting together, or helping the FAA put together a broad national plan on looking at the whole wind shear question.

Langley subsequently focused chiefly on this hazard characterization, the development of the F-factor index and also looking into airborne sensors which would be able to predict wind shears ahead of an aircraft and warned the crew before entering the field.

MR. DELISI: What sort of technologies were considered in the study of airborne detection?

THE WITNESS: We ended up looking at essentially five different systems and with them bringing them all to evaluation on board our 737 research airplane. Three of those were on board predictor type systems, one an infrared device looking ahead trying to detect temperature changes that a microburst might have and trying to recognize a characteristic signature and relate that to the F-factor index.

The second was an airborne lidar system which sends out a laser beam and tries to measure the wind field environment from the return from a -- doppler return from a lidar.

Third was an airborne radar sending out radar beams and measuring the reflective return and wind speeds and F-factor index from that. In addition, we developed an advanced reactive system, primarily so that it could be the truth measurement for our flight test, validating the predicted measurement, and as the aircraft subsequently flew on through, measuring precisely what the actual wind shear conditions were.

In addition, we expanded our program somewhat to look into an automatic data link of TDWR ground radar information and up-link to the airplane and display in the cockpit.

MR. DELISI: We will talk in a minute about the results of your flight test program, but in general terms, what were some of the pros and cons of the technologies that you considered for forward looking detection?

THE WITNESS: Starting with the infrared device, the pro is that it is relatively simple and inexpensive, and infrared devices are.

The con is that it simply -- it tries to make too simple of a measurement trying to look ahead and detect a temperature change and relate that somehow to velocity changes and then relate that somehow to the F-factor hazard index, and it was a bit too much of a stretch for that device.

The lidar system using laser works reasonably well with relatively dry type conditions, not much rain, but moisture in the atmosphere tends to attenuate the lidar beam, so its range ahead of the aircraft gets substantially reduced in even light to moderate rain.

The radar system is somewhat contrary to the lidar. It works well when there is moisture present in the atmosphere, because that is what radar energy reflects off of. It starts to run into its limitations in dry type atmospheric conditions where there is not much rain and, also, since it is on board an airplane looking down towards the ground, it is affected by ground return, or ground clutter.

Cars and trucks moving on the highway reflect a signal back to the airplane measured at 50 to 60 miles per hour, so, right in the neighborhood of the wind field measurements you are trying to make.

So, the focus of much of the Langley work was to minimize and hopefully eliminate the effect of ground clutter so an accurate measure of the wind field could be made.

A reactive device, while accurate, only gives a reaction to wind shear and, thus, because of its gust filtering and so forth, supplies a warning to the crew that is anywhere from three to five, or so seconds after the shear hits.

The TDWR system supplies potentially somewhat old information up to the airplane, as much as 30 seconds to a minute. It has to go through either a verbal, or -- or, we were looking into an automatic data link up to the airplane.

MR. DELISI: So, would you say that the radar system was the technology that showed the most promise for advanced detection of airborne wind shear?

THE WITNESS: That is correct. The results of our tests were that the radar system performed extremely well in both dry and wet type environments.

MR. DELISI: Then, before we get into the flight testing, can you give us an idea of how you developed the reactor system that you used? What was the concept behind it?

THE WITNESS: Again, the reactive system was developed primarily to be the truth measurement for our flight testing. It was -- the reactive system developed at Langley utilized the full three dimensional equations of motion for wind fields and wind shear detection and wind shear measurement.

It attempted to use the on board aircraft instrumentation; accelerometers, angle attack, air speed, ground speed and so on to come up with an accurate picture of the total wind shear field in three dimensions around the airplane.

MR. DELISI: How does that type of reactive system compare to what was eventually developed by industry?

THE WITNESS: Devices developed by industry were developed -- some of them, in fact, prior to and concurrent with NASA developing its reactive type system.

My understanding is that typically what is in the field right now is a somewhat simplified version of the full set of equations and so forth to get the full three dimensional in-situ wind shear index and typically restricts the equations to assuming that the airplane is flying in a two dimensional field that is just in a horizontal, or a vertical plane.

MR. DELISI: So, the concept behind reactive wind shear systems like the one you developed is sensing a difference between the air mass/air speed of the airplane and its inertial acceleration?

THE WITNESS: Correct, you are trying to sense the difference between the air mass -- the rate of change of the air mass velocity of the aircraft with the inertial velocity of the aircraft and also adding in the vertical component of the winds.

MR. DELISI: Okay. Can you tell us a little bit about what type of flight testing was then conducted by NASA?

THE WITNESS: We installed all of these different types of systems on board NASA's Boeing 737 research airplane, and following relatively substantial sorts of safety reviews and simulations prior to going out into the field, we flew the aircraft in 1991 and 1992 in both Orlando, Florida and Denver, Colorado looking for microburst wind shears, attempting to line the airplane up in front of that shear by about three to five miles, or so, making a remote measurement and flying the aircraft at a relatively low altitude through the shear.

Our safety constraints for the flight test were that we would fly as low as, but no lower than 750 feet above the ground and no slower than 210 nauts of air speed, so we would maintain a healthy both altitude and air speed margin for the aircraft, and our F-factor limit by any prediction from the ground TDWR system that we were using to bound our flights was set at .15.

MR. DELISI: So, you would not have penetrated the wind shear if you expected it to be greater than .15?

THE WITNESS: That is correct.

MR. DELISI: Can you give us an idea of how the predictive wind shear technology compared to the reactive technology?

THE WITNESS: As a result of the test?

MR. DELISI: In your results, right.

THE WITNESS: The -- going through the sensors, the infrared device was relatively prone to false alarms and over-warning and was not considered highly accurate.

The lidar device was fairly new technology. In some cases, with the relatively dry atmosphere, it predicted in advance and was confirmed by the in-situ sensor accurate wind field and wind shear measurements; however, in the heavy rains of Florida where you get 45, 50 and plus DBZ sorts of events, the lidar system was effectively attenuated and blinded.

The radar system in both the dry atmosphere of Denver and the very tropical and moist atmosphere of Florida, in our opinion, performed extremely well in predicting as much as 70, 80 seconds ahead of the aircraft, and we were flying at fairly high speeds, very accurate advanced measurements of both velocity and wind shear environments, and those were subsequently confirmed by the reactive system.

MR. DELISI: So, that the radar system in particular would predict up to a minute, or so in advance that there was dangerous levels of wind shear in your flight path?

THE WITNESS: That is correct.

MR. DELISI: Once you did encounter the wind shear and you penetrated it, what were your results as far as how quickly the reactive system told you that you were in that wind shear?

THE WITNESS: Our reactive system performed well in that we, in subsequent analysis, confirmed that it accurately measured the wind shear environment; however, in general terms, given the speed that we were flying, the number -- the reactive output, or the output of the reactive system was about equivalent to a backward looking thousand meter average of what the wind shear was that the airplane was flying through.

So, it would -- in looking at any given time, you could tell what the wind shear was for the last kilometer, or so that the airplane flew through.

MR. DELISI: Did you find that the reactive systems were able to indicate the presence of wind shear before the pilots flying the airplane sensed through other cues that they were in a wind shear?

THE WITNESS: In our experiments we had pilots in both simulation and flight test who were obviously -- knew what we were looking for and were therefore very much alert in looking for potential wind shear effects.

I would say that the typical well-aware pilot on final approach, or so would also be relatively alert and, typically, there is not much difference between when the pilot typically recognizes a shear and when the reactive system would go off.

In fact, for the most part, the pilot is ahead of the reactive device.

MR. DELISI: Okay. In just a minute we will show the video tape that you brought along that describes some of your flight test results. Before we show it, though, can you sort of preview what displays we are going to see on the video?

THE WITNESS: Sure. I want to show three different runs from our tests in 1991 showing -- the main display that you will see is the up-link from the TDWR system and other aircraft parameters that the airplane is -- that we are displaying for research purposes.

Inset into that is an output of the research radar system, and also inset into that is a shot from a forward-looking camera, our video camera looking ahead of the airplane, and I will try and pause it and go through what things look like.

MR. DELISI: Great, thanks. If we could,

let's show the video.

(Audio/visual aid displayed.)

THE WITNESS: Okay, let me just pause it for a second here and just show you what is happening. This -- these race track looking icons are up-linked from the TDWR ground system and show some velocity divergences, as measured by the TDWR on each one of these three race track looking ovals.

MR. DELISI: So, Mike, excuse me, that is a flight test display to help --

THE WITNESS: Correct, correct, only for flight test purposes.

MR. DELISI: Okay.

THE WITNESS: There is other displays up here. If you look at this any number of times, you will always see more and more information, but this is the aircraft symbol. This little noodle extending in front of the aircraft symbol will show its 30, 60, 90 second prediction of flight path.

Where this range ring -- I believe here it is about five -- five miles -- and, so, this event is five miles ahead of the aircraft. This first -- I will show it again, three different events.

One, is this one where we approach a microburst in Florida. You can see the wind field -- and it is a rather lousy video picture right here -- and it displays some of the characteristics of what a micro -- kind of what classic microbursts are.

You can see some of the bowing out of the wind field as the -- or, of the rain shaft as the velocity extends horizontally as it nears the ground. From this picture you -- it is relatively obvious that you are flying into a pretty healthy thunderstorm and microburst.

The second run that I will show is after we flew through this particular microburst and did a 180 degree turn and came back through again, and it is not at all obvious, because the aircraft is flying through some intervening rain and so forth, that there is imbedded a relatively strong shear.

This particular run, this shear was just under what a reactive system would alert at. It was about a .1 shear and we were set to alert at .105. You will see when the radar display gets insert right here that the radar picks out a small area that is above threshold; however, that was not on the particular flight path that we went through.

As we come around again and do our return run, it is well over threshold and you will see both radar and a reactive alert.

MR. DELISI: Mr. Lewis, just one more thing, the weather radar display that is not yet shown on that video, that is really the one that would be of most interest to us. The other displays in the center were all just for flight test purposes.

THE WITNESS: Correct.

MR. DELISI: Okay.

THE WITNESS: I will start it up again here.

(Audio/visual aid displayed.)

See, there is the radar display and, again, this is a research display. This is a wind shear map where the blues are performance increasing, the reds are performance decreasing and the blues, again, on the back side are performance increasing.

This is a wind vector showing a 12 naut cross wind.

So, the radar is showing a very small alert just to the right of the flight path here now.

Here is our -- the output of the in-situ system right here showing a bit. It is negative, so that means performance increase. It will go positive as the winds turn around. Here is a 15 naut head wind, and the aircraft is obviously in the rain here.

So, now the head wind starts to go away. In-situ is positive, .08 and .09; .1, just under alert threshold.

You see the tail wind now is up to ten nauts, or so.

So, we did a left 90 and right 270 and came back through that event from the other direction, and that is this run here, and it is not at all clear what the -- that this is anything other than a typical rain shower.

The radar is looking -- is picking up the alerts. I can't read the numbers here anymore, but I think that is 2, 4, 6, 8, or so kilometers ahead of the airplane, almost a minute ahead of time, or more than a minute ahead of time.

MR. DELISI: So, that box that we are seeing in the red portion of the display tells you that it is dangerous wind shear?

THE WITNESS: Correct, and it is clear as it tracks right on in to the airplane that it is right ahead.

This TDWR alert means that we are within a certain threshold of our displayed microburst from the TDWR.

MR. DELISI: Where should we look to see when the reactive system senses that wind shear?

THE WITNESS: You will see the reactive system go off with an alarm with a bright red circle around this aircraft symbol here.

You see about a 22, or so naut tail wind coming up the other side. Now, the last run that I will show is one where we were in Orlando, again, and we are approaching a microburst that was well ahead -- well in -- over our flight test limits, and I will skip ahead to show that.

There is a couple of similar sorts of runs in between here.

(Witness adjusts audio/visual aid.)

Okay. This is Orlando Airport right here. We are approaching the 1-8 left, I believe, and this particular cell which the radar is alerting on has an F-factor of about .25, I believe.

If you listen to the audio you will see that as we get closer it is not going below our flight test limits and we do a left break to avoid the shear. If you could turn the audio up some?

(Witness adjusts audio/visual volume.)

These are measured about 50 naut winds inside of that particular microburst.

That's it.

MR. DELISI: Very good, thank you.

BY MR. DELISI: (Resuming.)

MR. DELISI: Back to some additional questions. Were the results of your flight testing made available to industry?

THE WITNESS: Yes, they were. We, in fact, continuously throughout the life of the program we were in very, very close contact with all levels of industry and FAA as we both informally, through sometimes weekly telephone conversations and site visits and so forth, and formally, through yearly conferences that Langley sponsored where all airborne technology types of personnel from various companies and industry and government got together yearly, typically, at Langley. Research papers, and so on.

MR. DELISI: During your flight testing, was there a -- I am talking about the reactive system now. Was there a problem with false detection? Did it ever tell you you were in a wind shear when, in fact, you weren't?

THE WITNESS: No, we did not have a single case with our reactive system where we -- where it false alarmed. We extensively evaluated and, in fact, tried to make the system false alarm prior to the field testing by flying the aircraft through up to 60 degree, 2-G sorts of turns, doing turns in relatively high, steady state wind field conditions, maximum accelerations, decelerations and so forth to try and see if we could introduce noise into the system and get it to false alarm, and it never did.

MR. DELISI: Did that include things like configuration changes on the airplane, such as moving the flaps, or raising the gear?

THE WITNESS: In all of our runs and all of our field tests the system was always on and, so, for every approach that we went through, the full range of gear up and down and flaps up and down, spoilers in and out and so forth, and did not get abnormal readings.

MR. DELISI: Mr. Lewis, the current federal regulations applicable to the DC-9 require that the airplane be equipped with, as a minimum, an approved airborne wind shear warning system, but the regulations also allow for the airplanes to be equipped with an approved airborne wind shear detection and avoidance system, or a combination of the two systems.

In your opinion, if there had been a wind shear detection and avoidance system in the Flight 1016 scenario, what sort of information do you think it would have provided to the flight crew?

THE WITNESS: Oh, I think that in this particular case with the amount of rain that was in front of the aircraft, there is no question, at all that the radar would have been able to see it well in advance of the aircraft flying through.

In fact, we performed some simulations with Fred Proctor's meteorological model with the winds that this aircraft flew through, superimposed a relatively standard clutter map before the radar and then ran a radar simulation, and the radar detected the hazardous shear, bumping over the threshold probably about a minute ahead of time, clearly over threshold 30 to --

or, 45 seconds, or so ahead of time.

In this particular case, this is one of those cases where this shear was so strong that if -- even if the perfect reactive system had been operating and gave its normal alert four or five seconds after the aircraft entered the performance decreasing shear, there was nothing that could have been done.

MR. DELISI: To your knowledge, have any predictive wind shear systems been certified for operation by the FAA at this point?

THE WITNESS: My understanding is that Allied Signal Bendix just got their certification from the FAA earlier this month for their airborne radar system. I don't think it has been -- I am not the expert on certification, but types certificated for anything but their own airplane right now, although I assume that that is shortly to follow.

MR. DELISI: Very good. Thank you, Mr. Lewis.

MR. DELISI: No further questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Okay, thank you, Mr. DeLisi. Going to the parties for questioning, Federal

Aviation Administration?

MR. DONNER: No, we have no questions, thank you.

MR. HAMMERSCHMIDT: Thank you. National Air Traffic Controllers Association?

MR. PARHAM: Mr. Chairman, we have no questions.

MR. HAMMERSCHMIDT: Thank you. Honeywell?

MR. THOMAS: Yes, sir, we have a couple. Did the NASA reactive systems utilize side scope angle that is debated to determine the three dimensional aspect of detection?

THE WITNESS: Yes, that was an input to the system. Not a major sort of effect on the system, but it was certainly an input into the algorithm.

MR. THOMAS: Okay, thank you. The second one, was the reactive system designed for use in typical day to day airline operations, or was it primarily for verification of the look-ahead systems?

THE WITNESS: It was developed solely for our own purposes for a truth measurement for our research systems.

MR. THOMAS: Okay, thank you. That is all we have.

MR. HAMMERSCHMIDT: Thank you. Airline Pilots Association?

CAPTAIN TULLY: No questions, thank you.

MR. HAMMERSCHMIDT: Thank you. U.S. Air?

MR. SHARP: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Douglas Aircraft Company?

MR. LUND: No questions, Mr. Chairman, thank you.

MR. HAMMERSCHMIDT: Thank you. Pratt & Whitney?

MR. YOUNG: No questions, thank you.

MR. HAMMERSCHMIDT: Thank you. Association of Flight Attendants?

MS. GILMER: No questions, thank you.

MR. HAMMERSCHMIDT: Thank you. International Association of Machinists?

MR. GOGLIA: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Dispatchers Union?

MR. SCHUETZ: Mr. Chairman, no questions, thank you.

MR. HAMMERSCHMIDT: Thank you. National Weather Service?

MR. KUESSNER: No questions.

MR. HAMMERSCHMIDT: Thank you. Mr. Feith?

MR. FEITH: Just a couple questions, Mr. Lewis. You said that your system was designed for your purposes in doing the research. Can you give us a bit of a comparison, if you can, based on your information, with a normal line aircraft system versus a system that was on your airplane? Did you have the same sort of biases to prevent nuisance alerts and things like that?

THE WITNESS: Yeah, I think that the algorithm could be readily adapted to a line aircraft. I think you would -- certain aircraft are better sensor suites available.

The later aircraft have the better accelerometers and visual data and so forth, but the full set of in-situ equations, my belief is that they could be implemented on any airplane.

MR. FEITH: You said that your system didn't give you nuisance alerts and you tried to get --

THE WITNESS: That is correct.

MR. FEITH: -- false alerts?

THE WITNESS: That is correct. I mean, there were certainly gust rejection filters and so forth included in the NASA reactive system to avoid those false alerts.

MR. FEITH: Along those same lines, you said that in -- when you were talking about your system, you said that it was always on during aircraft configuration changes. Were there grace periods where the flaps were in transit where that system was cut out until the flaps established themselves at a certain position?

THE WITNESS: No.

MR. FEITH: Thank you very much. That is all I have.

MR. HAMMERSCHMIDT: Thank you. Okay, Mr. Schleede?

MR. SCHLEEDE: No questions.

MR. HAMMERSCHMIDT: Well, very good. Mr. Lewis, we thank you very much for your presentation, for sharing your expertise with you -- with us, and is there anything more you would like to add for our public record that maybe we haven't asked?

THE WITNESS: No thanks.

MR. HAMMERSCHMIDT: Okay, thank you again, and you may step down.

(Witness excused.)

The next witness is Mr. Terry Zweilfel. He will be questioned by Mr. John DeLisi.

TERRY ZWEILFEL, SENIOR FELLOW, HONEYWELL, INC., PHOENIX, ARIZONA

Whereupon,

TERRY ZWEILFEL,

was called as a witness and, after having been duly sworn, was examined and testified on his oath as follows:

MR. SCHLEEDE: Mr. Zweilfel, please give us your full name and business address for our record.

THE WITNESS: My name is Terry Zweilfel. I work for Honeywell, Incorporated in Phoenix, Arizona.

MR. SCHLEEDE: What is your position at Honeywell?

THE WITNESS: I am a Senior Fellow.

MR. SCHLEEDE: Would you please explain your experience and education that qualifies you for your present position?

THE WITNESS: Yes. I graduated from the University of Arizona with an Aerospace Engineering degree. I subsequently went to work for Lockheed and I worked in the Advanced Development Projects, commonly known as the "skunk works".

I also worked on many military aircraft during that time, and Lockheed at that time sold commercial airplanes which was the L-1011. I was the Technical Manager for the Flight Management System on the L-1011 and also the Group Engineer for the Flight Controls and Auto Land System.

After leaving Lockheed, I went to work for Simmons Precision where I was Chief Engineer of the Flight Dynamics Division. About 19 -- I believe it was '81, I joined Sperry, which is now Honeywell, and during my course of employment there worked on performance management systems, flight management systems, flight control systems and wind shear systems.

MR. SCHLEEDE: Thank you very much. Mr. DeLisi will proceed.

MR. DELISI: Thank you. Good morning, Mr. Zweilfel.

THE WITNESS: Good morning.

MR. DELISI: Can you please tell us what wind shear warning system the accident airplane was equipped with?

THE WITNESS: Yes, it was equipped -- excuse me. It was equipped with what we refer to at Honeywell as the standard Douglas wind shear computer. Let me refer to my notes here. The part number for the box was 4068048-901 with a serial number of 92030308.

MR. DELISI: That is, in fact, a reactive wind shear system?

THE WITNESS: That is correct.

MR. DELISI: If you would, please, refer to Exhibit 9(b).

(Witness complies.)

THE WITNESS: Yes.

MR. DELISI: Then, page 3 of that exhibit.

(Witness complies.)

THE WITNESS: Very well.

MR. DELISI: I would like for you to give us a brief description of how that computer works, and I thought perhaps you might start with this diagram, explaining what some of the inputs to the wind shear computer are.

THE WITNESS: Yes, we -- as you can see from the exhibit, some of the prime inputs are angle of attack, pitch and roll attitude, flat position, the engine speed, RN-1 (sic) and the ram air temperature.

We also get discreets. The go-around switch is on the throttle, for example. The landing gear position and a leading edge flap deployment, the self test which is basically a ground test, discreet from the pilot doing the self test, whether the temperature probe is being de-iced, or not.

There is one on here that says wind shear enunciation inhibit. That is actually in error. That is not used on the DC-9, 30 series.

MR. DELISI: Okay.

THE WITNESS: And weight on wheels. We also interface with the aircraft's pitot/static system. The wind shear computer, itself, has its own built in air data computer and also contains both normal and longitudinal accelerometers.

MR. DELISI: Then, the middle block on this diagram is the wind shear computer which does its processing, then?

THE WITNESS: Yes.

MR. DELISI: We will talk about that in a moment. Then, on the output side, what are some of the outputs that the computer is capable of?

THE WITNESS: Basically, we output two levels of cautionary and warning alerts. Cautionary alert is basically for those situations in which the airplane has encountered an updraft or a head wind shear. Those are generally described as performance increasing shears.

We also have a red warning alert which is for those cases where the shear is decreasing the performance of the airplane and would be a result of a tail wind shear, or down draft. With the red warning we also have a synthetic voice chip within the computer that generates the word "wind shear" which is repeated three times.

We also, because of priority considerations by the FAA, the wind shear always has the highest priority over any other message, including the ground proximity warning system in TCAS, so we inhibit those signals when we are attempting to broadcast the wind shear message.

We also have some other 429 buses which are basically used for test equipment and for diagnostic purposes.

MR. DELISI: Good, thank you. Now, to try to understand a little bit about how the computer processes and detects a wind shear, if you would, please refer to Exhibit 9(e).

(Witness complies.)

THE WITNESS: 9(e), very well.

MR. DELISI: In particular, page 2 of Exhibit 9(e).

THE WITNESS: Correct.

MR. DELISI: The simple question is, how does the computer sense whether or not it is in a wind shear?

THE WITNESS: Well, as I think was mentioned earlier in discussing reactive systems, basically the principal behind them is to measure the acceleration of the airplane relative to the air mass and also relative to inertial space, or the ground, if you like.

The difference between those terms is a direct measure of the wind shear. The computer uses the sensors that it has, those that were just enumerated, to compute what the wind rate is. Within the computer we have thresholds, and they are illustrated here on this diagram.

MR. DELISI: Okay.

THE WITNESS: To give you an idea of what those thresholds are, they vary between the vertical and longitudinal axis. For the longitudinal axis, they are typically .04G. That corresponds roughly to .8 of a naut per second.

The vertical axis, it can vary somewhat, depending on the adaptations that are made due to temperature, lapse rate and surface temperature estimations. They are of the order of .02G, which is roughly .4 of a naut per second.

When we are measuring a shear and it exceeds the threshold, basically what we do is start timing at that point.

MR. DELISI: Okay.

THE WITNESS: The wind shear measurement, itself, is directly proportional to the energy rate loss, or gain in the case of a head wind, of the airplane. So, what we are in essence doing is saying given that we have this energy rate, how long can we sustain that before it is necessary to alert the pilot, and that is what this timing curve that is labeled on here does.

It is based on research we had done of how much energy could be lost before we alert the pilot. So, in essence what we are doing is taking energy rate over a given period of time, which then gives us a delta energy term.

MR. DELISI: Very good. So, the figure on page 2, the wind rate curve that is drawn on there, I just want to be sure we understand that is just a sample just to show us --

THE WITNESS: Yes.

MR. DELISI: -- how the --

THE WITNESS: It is simply an illustrative example.

MR. DELISI: So, as the detected wind rate begins at about five seconds there, it gets above the threshold. That is when the timing curve kicks in?

THE WITNESS: That is when we begin the timing.

MR. DELISI: So, the point where the timing curve and the wind rate on this chart intersect and the word "wind shear" is printed, that is just an example of when wind shear detection would be enunciated to the pilot?

THE WITNESS: Correct. If it were a lower level of wind shear than is shown there, looking at the timing curve you would see that it would take a longer time to detect it, simply because it is a lower energy rate. Therefore, it can be endured for a longer period of time.

MR. DELISI: What would be the shortest time? For the most extreme wind shear, what would be the shortest time that the timing curve would say it had to be present before detection?

THE WITNESS: The very shortest time is two seconds.

MR. DELISI: Okay.

THE WITNESS: The reason for the two second limit is simply that it gives our built in test equipment, that is, that that part of the algorithms that are testing the sensors to make sure they are valid, and internal parameters within the computer a chance to determine whether they are true, or not and whether this is a valid case, or not. So, there is always the two second limit.

MR. DELISI: Very good. Is this wind shear computer capable of generating flight guidance commands to the crew?

THE WITNESS: Yes, it is.

MR. DELISI: To help them fly an escape maneuver?

THE WITNESS: That is correct.

MR. DELISI: Is that option -- was that option activated in the U.S. Air installation?

THE WITNESS: Wind shear guidance was not activated on Flight 1016.

MR. DELISI: The Federal Aviation Regulations require that the airplane be equipped with an approved wind shear warning system. Is this, in fact, an approved system?

THE WITNESS: Yes, it is. The original system was certified by the FAA on -- via a supplemental type certificate in this DC --

MR. DELISI: Okay.

THE WITNESS: -- on 1, December, 1989, I believe. It was subsequently updated for the U.S. Air fleet on 15, July, 1991.

MR. DELISI: Prior to the FAA granting approval, STC approval to the system, what type of testing did they put the system through?

THE WITNESS: Well, we went through what, to me at least, seemed like an incredible number of tests. When I was involved in it earlier, I know for a fact that we did over 1,200 runs on it, including all types of CG flap positions, weights, the whole envelope encompassing --doing things like pitch maneuvers, roll maneuvers, go-arounds, take-offs, the whole shot. It was an incredible number of testing.

MR. DELISI: These were all simulator runs?

THE WITNESS: Yes.

MR. DELISI: Right.

THE WITNESS: That is correct. That number has subsequently decreased, basically because the wind shear computer has, in essence, maintained those same algorithms throughout the whole program, so there is no need to keep doing 1,200 tests --

MR. DELISI: Okay.

THE WITNESS: -- on every single one.

MR. DELISI: So, additional systems that you certified for other installations didn't go through that?

THE WITNESS: Not that complete a test.

MR. DELISI: Right.

THE WITNESS: They still go through a

rigorous test, but it is not 1,200 runs, for example.

MR. DELISI: Do you know what sort of a guideline the FAA had in mind for how quickly the system should detect a severe wind shear?

THE WITNESS: At the time of the original development there were no hard and fast guidelines for it. One of the big concerns -- and still is -- is the system producing nuisance or false alerts? To differentiate between those two, a nuisance alert is the case where the aircraft has actually encountered a wind shear, but it is not of sufficient magnitude, nor duration to threaten the airplane.

Some examples of that might be a gust. I think there was some testimony earlier that it is quite common, for example, to see a ten naut increase on approach. It is almost a day to day activity. So, surely you wouldn't want the wind shear system coming on every time that happened. What will eventually happen, of course, is the flight crew just loses total credence in the system and doesn't believe it.

The other potential problem you have with nuisances is in the event that the pilot is already in a potentially hazardous situation, as for example maneuvering to avoid traffic, or an engine out during take-off and that sort of thing, clearly you don't want to complicate his problem by giving him a wind shear alert when it is simply not needed. So, there was a great deal of emphasis in the early days of making sure that we had minimized that.

The false alert is a little bit different. That means, in essence, that something has failed. The airplane is not in a wind shear, it is simply either a sensor has failed, or it is interpreted by the computer as a wind shear and would be alerted.

The guidelines on those are roughly -- I am stretching my memory a bit, here. As I recall, the FAA does not want a false alert no more than once in every 10,000 flights and a nuisance alert no more than once every 1,000 flights.

MR. DELISI: Okay. Getting back to the certification testing simulation that was done, if your computer was exposed to a severe wind shear, how quickly should it have detected that? I guess there was no established requirement at that point, but --

THE WITNESS: No, it was based on the timing curve. The timing curve has been there since -- well, day one might be too strong, but it has been there for a long time. So, it is going to depend, obviously, on what the magnitude of the shear was.

The way it was evaluated, by the way, was bringing in FAA pilots and also line pilots subsequently to determine their evaluation. Is this thing detecting quickly enough to be of use to the pilot?

I should point out, it was never the intent to design these systems to beat the pilot. I mean, we just heard some testimony that oftentimes the pilot can see it beforehand. That was never the intent so that we could always beat the pilot at it, because you can't and probably you don't even necessarily want to.

The system is designed more as a tool for the pilot in conjunction with other systems such as LLWAS, radar, visual observation, pilot training. All of these in combination are tools to help deal with the wind shear phenomenon.

MR. DELISI: You mentioned that certification testing was done at all different flap settings.

THE WITNESS: Correct.

MR. DELISI: Do you recall if tests were

performed with the flaps in transition?

THE WITNESS: Yes, we did those tests.

MR. DELISI: Are you familiar with --

THE WITNESS: I --

MR. DELISI: I am sorry?

THE WITNESS: However, a little caveat on that; I don't specifically recall doing any test that would duplicate the Flight 1016 scenario. We did do such test, but I can't think of one that was exactly the same.

MR. DELISI: Are you familiar with Technical Standard Order C-117 which is entitled "Airborne Wind Shear and Warning Guidance -- Escape Guidance Systems for Transport Airplanes"?

THE WITNESS: Yes, I am. In fact, Honeywell had some input into the derivation of that document.

MR. DELISI: The certification that your box went through was before the issuance of this TSO?

THE WITNESS: Yes, in fact, it was. To my knowledge, currently, even today, there is no requirement for you to apply and acquire a TSO for the box. All our boxes were done under the FAA Advisory Circular 2512, which was the latest advisory circular for a wind shear system.

We have, by the way -- some of our boxes have now been -- received a TSO.

MR. DELISI: So, a supplemental type certificate is one way to certify your system, and complying with a TSO is another means of certifying your system?

THE WITNESS: Correct. The real advantage of the TSO resides particularly in selling to foreign carriers who almost insist that you have a TSO. That is not necessarily the case in domestic carriers.

MR. DELISI: Thank you. If we could go to Exhibit 9(e), page 3, I think that would be of some help for the next few questions.

(Witness complies.)

Does the system have a pilot initiated self test feature?

THE WITNESS: Yes, it does. Yes, it does, and -- maybe rule is too strong. It is my understanding this test is supposed to be exercised once a day, or after a crew change.

MR. DELISI: There is a list on page 3 of this exhibit of the procedure that the box goes through. Could you highlight for us what sort of indications will appear if there is a failure of the box during a pilot initiated self test?

THE WITNESS: Well, let me start by kind of explaining the general philosophy of the test. From the moment power is put on the wind shear computer, it starts a continuous self test. That is there, always, until the power is subsequently turned off, so it is always checking itself and doing those tests that it can, given the situation that it is in.

There are some things, for example when you are stationary on the ground, that it cannot test. One of those things is a comparison between the angle of attack indicators, for example, because they may be at any random position since there is no air flow. So, it doesn't do that type of test.

But, basically it is testing everything it possibly can. That test is running always. When the pilot initiates the self test, additional things are performed during the first four seconds after he pushes the button which is located in the overhead panel. We flash the amber caution lights. These, again, are those that say you have a performance increase in shear.

In the next four seconds we flash the red lights. These are located, by the way, on either side of the cockpit. Simultaneous with the red flashing lights, we give an oral enunciation one time of the word "wind shear". By the way, at a reduced level so we don't startle passengers in the back.

MR. DELISI: If during the course of a flight the computer sensed a failure during the continuous built-in test, how would that be enunciated to the flight crew?

THE WITNESS: Actually, in two ways. There is a wind shear in-op amber light in the overhead panel, roughly about in this area (indicating), and also at the wind shear test panel, which is less accessible to pilots. It is more kind of behind both of those lights. It also is an amber light. Both of those lights would be illuminated.

MR. DELISI: If those lights were illuminated, then the computer is off-line?

THE WITNESS: That --

MR. DELISI: It indicates that it is --

THE WITNESS: That is correct, it is not

operational.

MR. DELISI: Okay. I would like to shift gears now to the specifics of Flight 1016, and you might want to make Exhibit 9(b) available to help with that discussion.

(Witness complies.)

THE WITNESS: I have it.

MR. DELISI: The Safety Board did provide Honeywell with data from the flight data recorder, and could you tell us in general terms what type of analysis you performed with that data?

THE WITNESS: Yes, we actually did two types of analysis. The first one was taking the flight data recorder data and running it through an emulation of the wind shear detection software.

By an emulation, I mean that we have a program which is resident on my PC and others that duplicates the algorithms that are performed in the detection algorithm, including compensations that are used, the whole shot. We ran it through that and also used that particular emulation to drive and calculate the winds that were encountered during the flight.

The second analysis we did was on AR

Engineering 6 Degree of Freedom Simulator, which we call a DITS, for development and integration test station. This is the same simulator we used, by the way, in the certification process and has met FAA approval on its performance and is a conformed simulator.

In that particular analysis, we took three primary inputs from the flight data recorder; pitch, roll and engine pressure ratio as our control variables. In essence, we pumped those into the simulator and forced it to fly those.

The other control variable was flap position which we took from data that the NTSB supplied us as to when the flaps were retracted from 40 to 15 degrees. Using that and after some indurations on the derived winds we had, to make a long story short, it turned out there were some biases on the normal accelerometer and the flight data recorder that we had to correct for. But, we were able to finally derive the vertical winds.

We were able to duplicate quite closely the flight path of Flight 1016.

MR. DELISI: So, based on the results of your study, how should the wind shear warning system have operated in Flight 1016?

THE WITNESS: Both the software emulation and the simulator runs show that there should have been a wind shear warning that occurred, and it should have been accompanied by the oral enunciation, "wind shear, wind shear, wind shear."

Both analyses agreed within the second, which is about the resolution of the data that we had to work with as to when that alert should have occurred.

MR. DELISI: If you would, Mr. Zweilfel, please turn to page 14 of Exhibit 9(b).

(Witness complies.)

In particular, figure 22 in the lower right hand corner.

THE WITNESS: Okay.

MR. DELISI: Can you explain that figure to us?

THE WITNESS: Yes, that figure is an output from the simulation. Actually, from the wind shear computer, itself. The simulation was driving a Douglas wind shear box with the same part number that was on the aircraft, and that is when the alert would have occurred.

MR. DELISI: On figure 22, when did impact occur?

THE WITNESS: I believe it occurred approximately at 40 seconds.

MR. DELISI: So, at about 40 seconds. So, this figure shows that the wind shear detection should have occurred about three, or so seconds prior to impact?

THE WITNESS: Three to four, yes.

MR. DELISI: That is the point at which the red warning lights and the oral wind shear caution should have been?

THE WITNESS: That is correct.

MR. DELISI: We know from previous testimony that the crew didn't see, or hear those warnings, and we know that the cockpit voice recorder did not pick up the oral wind shear warning. What types of faults might have prevented your system from issuing those warnings?

THE WITNESS: Actually, there is a whole series of things that could occur. One of them is power. For example, if we lose power to the box. As I understand from reading some of the reports, the wind shear AC circuit breaker was found popped. When that happened, I don't know.

Other things that could happen is a sensor failure. It could shut down the box. Or, some internal failure within the computer. As of this date, I have no real knowledge of which one of those it had been.

MR. DELISI: Sure. What type of fault history is stored in the computer?

THE WITNESS: We have what is called non-volatile memory. In essence, that means that we store this data whether power is on the box, or not. In essence, I guess -- well, maybe going on ad infinitum is a little stretching it, but we can store at least, like, 96 flights worth of failure data.

MR. DELISI: In addition, we store other system performance parameters. We store the maximum and minimum shears that were seen in both the vertical and horizontal axis. We store any wind shear alerts that occurred and the mode that they occurred in, take-off or approach, and we also stored data showing when we got within 50 percent of an alert and 75 percent of an alert.

All that data is stored on this, what is called an E-Prom card, and we refer to it as the A-1 card.

MR. DELISI: A-1 card. For the record, the wind shear computer broke apart during the impact sequence, and several efforts to recover that A-1 card were unsuccessful, and we were able to locate some of the other cards that came from the wind shear computer, but our efforts at the accident site, or at the wreckage storage site, did not produce this A-1 card.

If we had been able to find it, how would that have helped our investigation and our understanding of how the system worked?

THE WITNESS: I think it is very likely it would have told us what the problem had been.

MR. DELISI: I would like to go back to figure 9(b) at this time and, once again, starting on page 14, looking at figure 22, that indicates the time at which the detection criteria were satisfied. If you flip back a page to page 13, also in the lower right hand corner, figure 18 --

THE WITNESS: I seem to -- I seem to have a blank page here. I am not sure if it is --

MR. DELISI: I am sorry about that.

THE WITNESS: I think I am okay. I think it is just -- I think it is just --

MR. DELISI: So, we are looking for figure 18.

(Witness complies.)

THE WITNESS: Yes. Yes, I found it, thanks.

MR. DELISI: Okay. Can you describe to us the longitudinal wind that is plotted out on that chart?

THE WITNESS: Yes. That was the wind that was derived from the computer emulation analysis that we did. We have subsequently -- the performance team, Mr. Ritter and Mr. Terpstra from Douglas -- have all compared the results that we came up with and, in the case of longitudinal wind, I believe they agreed quite closely.

MR. DELISI: Starting at about the second 25 on figure 18, there is a big shift in the wind. It begins to go initially from about a 34 naut head wind. The slope of that curve takes it up, then, to about a 25 naut tail wind over a course of about 13, or so seconds.

If you look, then, at figure 22, the wind shear computer didn't meet the detection criteria until about second 37?

THE WITNESS: That is correct.

MR. DELISI: Some, approximately 12 seconds, or so after this rapid change in wind speed.

THE WITNESS: Yes.

MR. DELISI: I was wondering if you might be able to explain to us why it took 12 seconds for the detection criteria to be satisfied?

THE WITNESS: Yes, I think I can. In reviewing the flight data recorder and seeing the sequence of events that occurred, the pilot, or first officer had initiated the go-around prior to actually encountering the shear.

The power had been advanced, I believe, somewhere around 1.8 EPR and he had begun his pitch up and was somewhere in the neighborhood of 15 degrees, and during all this they were retracting the flaps.

Now, there is in the wind shear computer a flap compensation term. Basically what this is for is, we have found in our studies that rapid changes in flaps can, in fact, produce short term errors in some of the sensors that we see. So, to account for those errors, we have a gain factor that we multiply the measured wind shear values by. This gain factor is always between .5 and 1.

In essence, what that means is we don't shut down detection when that is occurring, we simply desensitize the system so that these errors that are produced by these rapid configuration changes don't result in nuisance, or -- well, in this case it would be a nuisance alert. So, that is what happened here.

He had done the go-around, pulled up the flaps and this compensation term had come in which caused a delay in the detection.

MR. DELISI: So, the compensation term lowered the magnitude of the sensed wind shear which, as we saw earlier, therefore meant that it was going to take longer before it intersected the timing curve to meet the detection criteria?

THE WITNESS: That is correct.

MR. DELISI: Are you -- we talked a little bit earlier about the FAA certification testing. Are you aware of any runs that were performed where the flaps were put in transition and then the airplane experienced a severe wind shear?

THE WITNESS: Yes, we did do those in the early days, and we did detect it.

MR. DELISI: If the flaps had not been in transition, if they were at a constant setting, the detection criteria would have been met sooner?

THE WITNESS: Yes, that is correct. In fact, we did such a run on the simulator to determine what the difference was. It was approximately five seconds of delay that was caused by it.

MR. DELISI: So, the wind shear would have met the detection criteria five seconds earlier, approximately, if --

THE WITNESS: Well, I want to qualify that a bit. Again, we are dealing with iteration rates where we get the data in one second intervals, so you are talking two seconds, conceivably, difference.

MR. DELISI: Okay.

THE WITNESS: Potentially.

MR. DELISI: Thank you, Mr. Zweilfel.

MR. DELISI: I have no further questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Okay, thank you, Mr.

DeLisi. Let's see, going to the parties, Federal Aviation Administration?

MR. DONNER: No, we have no questions, thank you.

MR. HAMMERSCHMIDT: Thank you, Mr. Donner. National Air Traffic Controllers Association?

MR. PARHAM: We have no questions, sir.

MR. HAMMERSCHMIDT: Okay, we will go next to Airline Pilots Association?

CAPTAIN TULLY: Thank you. Just to clarify one issue, you stated earlier that the wind shear guidance was not activated on the accident aircraft. Could you confirm that? What that means is that the equipment capability was not installed or available to the flight crew on this aircraft.

THE WITNESS: None of the U.S. Air DC-9's have guidance activated on them.

CAPTAIN TULLY: It is not required by the regulation, is it?

THE WITNESS: No, that is correct, it is not an FAA requirement on the older airplanes to have guidance activated.

CAPTAIN TULLY: Okay. At any rate, even in those airplanes which might have active systems, unless the system is in alert, you don't get the guidance?

THE WITNESS: That is correct.

CAPTAIN TULLY: So, in this case, had the system been installed, because there was no alert there would have been no guidance?

THE WITNESS: Well, yes, that is correct.

CAPTAIN TULLY: Okay.

CAPTAIN TULLY: No more questions, thank you.

MR. HAMMERSCHMIDT: Thank you. U.S. Air?

MR. SHARP: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Douglas Aircraft Company?

MR. LUND: No questions, thank you, Mr. Chairman.

MR. HAMMERSCHMIDT: Pratt & Whitney?

MR. YOUNG: No questions, thank you.

MR. HAMMERSCHMIDT: Okay, Association of Flight Attendants?

MS. GILMER: No questions, thank you.

MR. HAMMERSCHMIDT: Okay, International Association of Machinists?

MR. GOGLIA: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Okay, Dispatchers Union?

MR. SCHUETZ: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: National Weather Service?

MR. KUESSNER: No questions.

MR. HAMMERSCHMIDT: Okay, Honeywell?

MR. THOMAS: Yes, we have a couple here that we would like to ask.

MR. THOMAS: Terry, Mr. Lewis earlier discussed an alert threshold for the NASA reactive system of .105 for the F-factor. Is that the threshold used in the Honeywell system?

THE WITNESS: No, it isn't. Our system is not based on the F-factor. The F-factor basically is a measure of energy rate. We are using an energy term. We actually -- our thresholds for starting to time are much lower than .105.

Talking in terms of an equivalent to an F-factor, they are more in the neighborhood of .04 F-factor, and .02 F-factor where we would begin the timing.

MR. THOMAS: Could you discuss a little bit the difference between these two?

THE WITNESS: I am not sure I know what you mean.

MR. THOMAS: Why don't we use the .105, and we use an equivalent .04?

THE WITNESS: Basically, because it allows us to detect lower level shears. For example, if you have a shear out there that is running .08, obviously if I have any trip I will set at .105, I am never going to detect it. Our system will, in fact, detect that low level shear.

MR. THOMAS: Okay. Secondly, have there been any validated wind shear detections in actual revenue service?

THE WITNESS: Yes, we have had numerous, and I don't recall the exact number, but during the early days of deployment of the wind shear system we had a program wherein pilots would inform us whether they had nuisance alerts, false alerts, or alerts at all, and if they were valid.

We had several pilot reports that were not quite favorable to the system. In fact, we put them up on our board in the wind shear group to help boost morale that the system was, in fact, performing as designed.

Kind of ironically, the very first airplane that the system was installed on, which was a Piedmont airplane many years ago, the very first flight that it had encountered a wind shear going into Chicago, and the wind shear system did detect and alert the pilot and he flew out of it successfully.

MR. THOMAS: Okay, that is all we have, Mr. Chairman. Thank you.

MR. HAMMERSCHMIDT: Okay, thank you, Mr. Thomas. Mr. Laynor? Oh, excuse me. Mr. Feith?

MR. FEITH: Just two questions, sir. Mr. Zweilfel, are there any overriding oral warnings in the cockpit that would override a wind shear alert; stickshaker, or any other alert in that cockpit that would override the wind shear alert that you know of?

THE WITNESS: The stickshaker, to my knowledge, is not an audio alert, it is simply a shaking, or a vibrating of the stick.

MR. FEITH: Bad example.

THE WITNESS: For oral warnings, the wind shear has the highest priority over TCAS, GPWS and the rest.

MR. FEITH: It has highest priority?

THE WITNESS: Yes, by FAA rule.

MR. FEITH: In the event that a wind shear alert does activate in the cockpit, what is the duration of that alert, and can it be manually cancelled, or is it cancelled automatically by the computer?

THE WITNESS: No, the duration will depend on how long the airplane is in the shear, and it cannot be cancelled by the pilot. It will extinguish when we drop below our threshold levels. Once we have timed out, it stays as an alert until we drop below. Again, in the longitudinal axis, that would be .04 G's.

MR. FEITH: Very good. Thank you, sir.

MR. HAMMERSCHMIDT: Along that line, in your data in Exhibit 5 -- Excuse me, in Exhibit 9(b), on that figure 22, how many seconds is represented in --

THE WITNESS: How long was the alert on?

MR. HAMMERSCHMIDT: In the alert, yes.

THE WITNESS: Actually, the alert stopped when the airplane impacted the ground.

MR. HAMMERSCHMIDT: Okay, but how many seconds is represented in that depiction?

THE WITNESS: I would say roughly two.

MR. HAMMERSCHMIDT: Two seconds? Okay, thank you.

THE WITNESS: Two, or -- you know, possibly three.

MR. HAMMERSCHMIDT: Okay. Mr. Laynor?

MR. LAYNOR: Mr. Zweilfel, just for clarification, on the description of the timing curve and the criteria for presenting an alarm, does that apply to both the caution and the warning logic?

THE WITNESS: Yes, that is correct. They are both set at the same levels.

MR. LAYNOR: If the wind shear rate changes from positive to negative, or, I guess on this chart it would be negative to positive, but increasing to decreasing, does the timing curve for sensing that change fall in with this logic?

THE WITNESS: I am not sure if I understand.

MR. LAYNOR: In other words, if you have a yellow light indicating that you are in an increasing performance environment and you enter a decreasing performance environment, does the timing curve start over?

THE WITNESS: Yes, it would start when you went to the negative shear at that point. Actually, that is not quite true. In take-off we would actually take it from the peak of the cautionary alert, but in most cases what you said is correct.

MR. LAYNOR: Okay, and referring again to figure 22, you don't have to refer to it, but would you agree that even had the system functioned as designed, it would have been of very little, or no value to the pilot in this scenario?

THE WITNESS: I don't know, that would be speculation on my part. I think it would depend on what he did at that point.

MR. LAYNOR: Well, looking at the same figure, figure 22 is directly below figure 20, which shows the aircraft's angle of attack, and perhaps you can just compare those charts.

However, let me ask my other question. As a result of the review of the accident scenario, are there any plans to review the algorithms and the logic of the system?

THE WITNESS: We are always doing that, reviewing the results of what happened.

MR. LAYNOR: Do you anticipate any changes?

THE WITNESS: I don't know yet, we haven't even begun that review.

MR. LAYNOR: Alright, thank you, sir.

MR. HAMMERSCHMIDT: Mr. Schleede?

MR. SCHLEEDE: I think earlier you mentioned about the wind shear AC circuit breaker being popped. Do you have any opinion as to what may have caused that? Do you think it is impact-related, or not?

THE WITNESS: I don't know. It is certainly conceivable it is impact-related.

MR. SCHLEEDE: If that were to pop in flight, would there be an indication to the pilot?

THE WITNESS: Yes, the wind shear and op light should have been illuminated.

MR. SCHLEEDE: That is the one you referred to that is overhead?

THE WITNESS: Yes.

MR. SCHLEEDE: Does that light, if it comes on in flight, also illuminate the master caution?

THE WITNESS: No, it does not.

MR. SCHLEEDE: I am not sure this is in your area of responsibility, but did Honeywell develop flight crew training and procedures for use of the wind shear system?

THE WITNESS: To my knowledge, we did not directly do that. We do furnish the airline the documentation of the system and also write the section for the airplane flight manual that is subsequently approved by the FAA which describes the system.

It is my understanding -- and, again, you are right, this was a little bit out of my field. It was my understanding the training program is left up to the airlines, per se.

MR. SCHLEEDE: How about the installation in simulators? Is Honeywell involved in the installation in the system any simulators?

THE WITNESS: Yes, we support all the airlines in installing the boxes and giving them interface diagrams on what they need to do that.

MR. SCHLEEDE: How about U.S. Air DC-9 simulators?

THE WITNESS: I can't speak from any personal knowledge on that.

MR. SCHLEEDE: Thank you very much.

MR. HAMMERSCHMIDT: Are there any other questions of this witness? Oh, Mr. Lund?

MR. LUND: I was just wondering if that circuit breaker that was popped powers anything else, or is it exclusively for the wind shear computer, or would there be another system that might be detected on the flight recorder, for instance, that would indicate when that circuit breaker popped?

THE WITNESS: It is my understanding that is the wind shear AC circuit breaker, so -- I am certainly no expert on the electrical distribution, but that is my understanding.

MR. LUND: Thank you.

MR. HAMMERSCHMIDT: Mr. Zweilfel, we thank you very much for your participation in this public hearing and for sharing your expertise with us. You may stand down.

THE WITNESS: Thank you.

(Witness excused.)

MR. HAMMERSCHMIDT: I believe we are at a good point to break for lunch. We are about to enter our interest areas of emergency response and survival factors. So, why don't we return at 1:00, and the next witness will be Mr. Wesley Weaver. Off the record.

(Whereupon, at 11:45 a.m. a luncheon recess was taken.)

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

(Time noted: 1:05 p.m.)

MR. HAMMERSCHMIDT: On the record. Let's please come to order. The next witness is Mr. Wesley Weaver. Mr. Weaver will be questioned by NTSB Investigator, Larry Roman.

WESLEY WEAVER, ON-SCENE COMMANDER, BATTALION CHIEF, CHARLOTTE, NORTH CAROLINA

Whereupon,

WESLEY WEAVER,

was called as a witness and, after having been duly sworn, was examined and testified on his oath as follows:

MR. SCHLEEDE: Mr. Weaver, would you please state your full name and business address for the record?

THE WITNESS: Harold Wesley Weaver. I work at 9400 Nations Ford Road in Charlotte.

MR. SCHLEEDE: By whom are you employed?

THE WITNESS: Charlotte Fire Department.

MR. SCHLEEDE: What position do you hold there?

THE WITNESS: Battalion Chief.

MR. SCHLEEDE: Would you briefly summarize your background that qualifies you for this present position?

THE WITNESS: Yes. I have served with the Charlotte Fire Department since March 8th, 1972, approximately 22 and a half years. I have attended Central Piedmont Community College and majored in Fire Science and Technology.

I participated in the Charlotte Fire Department's Officer Candidate Program and I have taken numerous college accredited courses at the National Fire Academy, one of which was command and control of major operations.

Approximately three years ago I took a 40 hour class on "Commanding the Air Crash Scene" and I was involved in the crash of the Eastern Airlines flight approximately 20 years ago.

MR. SCHLEEDE: Were you on scene commander for the crash involving U.S. Air 1016?

THE WITNESS: Yes, I was.

MR. SCHLEEDE: Thank you. Mr. Roman will continue.

MR. ROMAN: Good afternoon, Chief Weaver. Chief, I think for our purposes it would be helpful to us if we can begin by just asking you if you would describe the events that transpired on the day of the accident surrounding the emergency response.

THE WITNESS: Okay. At the time the call was received I was in the Communications Center of the Charlotte Fire Department on Caldwell Street downtown. We received the call that there was a light plane down in the area, in the neighborhood of Highway 160 and Wallace Neal Road with approximately five souls on board.

I responded in that direction from Fire Station #1 where the Communication Center is located by Wilkinson Boulevard. The first company, Engine 30, arrived at the scene and confirmed that we did have a plane down. It was a DC-9. He also, then, I believe, concerned -- confirmed that there were five souls on board.

About this time, they pulled the additional response box. Anytime we have a confirmed incident, additional companies are dispatched to give additional manpower to work the incident, and I encountered extremely heavy rain on Wilkinson Boulevard, and it made driving extremely difficult at that time.

Just prior to entering the rain cell, I could see the black smoke off to my left in the direction of the airport, and I saw the smoke begin turning white, indicating that they were having some effect on putting out the fire at that time.

Then, enter the extremely heavy rain. During my route to the scene, the number of victims on board, the reports to me fluctuated several times on the radio. Driving and fighting a heavy rain storm, it was difficult to remember who were -- who were giving the reports, but it went from 5, to 87, to 46, and I think the last report I got before I arrived at the scene was 46.

I then arrived at the scene. I found the captain who had assumed command at the scene. That is, Captain Alan of Blaze-5. I was briefed by him and assumed command of the scene. I established -- I initiated instant command system and established a search and rescue officer.

Dr. Blackwell, head of EMS for Mecklenburg County, arrived at the scene. About that time, I told him I had seen no other EMS folks and made him medical operations, or asked him to become medical operations and assume that role.

I started setting up my command system. We started running short on water about this same time, and I activated a mutual aid and had Still Creek and West Meck Volunteer Fire Departments dispatch to help us with our water supply.

A few minutes after that, Chief Davis arrived at the scene. He relieved me of command. After a briefing, he took command himself and moved me down to operations officer, leaving me in charge of running the fire and rescue operation at the scene.

From that point on, I provided the folks that I had put in those positions whatever they needed to do the job.

MR. ROMAN: Okay, Chief, about when did Chief

Davis assume command from you, about how far into the incident?

THE WITNESS: About probably 15 minutes into the incident, 15 to 20 minutes into the incident.

MR. ROMAN: After your arrival?

THE WITNESS: Yes.

MR. ROMAN: Okay. By that -- at that point in time, can you describe what the conditions were at the scene?

THE WITNESS: At that time, we had all major fires put out, we had covered all exposed fuel with foam blankets to reduce the chance of re-ignition, we had a rescue operation going in the tail section of the plane. I think at that time we still had not determined how many victims we had to deal with.

MR. ROMAN: Okay. You mentioned also that you were getting low on water. Did at any point you run out of water?

THE WITNESS: No, I did not at any point run out of water. I did activate mutual aid and got additional tankers from both Still Creek and West Meck Volunteer Fire Departments, and we were able to maintain a constant water supply throughout the incident.

MR. ROMAN: Okay. You also mentioned conflicting -- a number of conflicting reports of the number of persons on board the airplane. When did you finally -- when was that finally resolved, or was it, in fact, resolved?

THE WITNESS: Well into the incident -- and I am not exactly sure of the time frame -- well into the incident a person walked up and identified himself as being from the airlines, and he had a passengers manifest in his hand and told me there were 55 people on board.

MR. ROMAN: Did that cause you any difficulties in performing and responding, from an emergency standpoint, the confusion of victims -- numbers, rather?

THE WITNESS: Not really, because the scene was as such that we could not get an accurate count on persons, anyway. There were persons that were not found for several days after that. So, really, no, it did not affect.

It may have caused us to mount additional searches, but I doubt it, because we would have had to have done it anyway. We just -- there was no way of determining how many people that were there that we could account for.

MR. ROMAN: Were you apprised of any infants, lap babies, as they are referred to, during the response, or at a later time?

THE WITNESS: No, but due to my training, I was aware that lap babies were not part of the passenger manifest a great deal of the time.

MR. ROMAN: Okay, now, with respect to notification of the airport units and the downtown units, as it were, can you describe what -- how that occurred and if there were any problems, or difficulties involved with that initial notifications?

THE WITNESS: Yes. As soon as the tower lost the plane on radar, they notified our Station 17, which is the Air Crash Rescue Units, that they had lost a plane on radar.

They immediately manned the trucks and rolled them out on the apron and then asked for additional instructions. I think that they were told by the tower then that they were not sure exactly where to look. So, they started off looking for a downed plane.

A minute, or two after that, they heard the initial box, where the rest of the Fire Department was dispatched, and ascertained that it was probably in the area of Highway 160 and Wallace Neal Road. So, they headed toward Gate 36 to gain access to a street to carry them to Wallace Neal and Highway 160.

MR. ROMAN: Was there, in effect, a hesitation or a delay incurred because of the lack of precision on the location to the airport units?

THE WITNESS: Would you repeat the question?

MR. ROMAN: Is it your understanding that there was a hesitation, or some delay that was incurred because of the lack of the precise location for the airport units, fire units?

THE WITNESS: I am unable to answer that. I doubt that -- I doubt there was any delay. I can't answer that for sure. The Fire Department Communications Center was notified through a 911 call from a mobile phone that -- I am really not sure that there was a delay.

MR. ROMAN: Okay, we -- it is our understanding, also, that there was -- the airport's units would come from Station 17, is that correct?

THE WITNESS: That is true.

MR. ROMAN: Okay. Did -- when they responded, they were trying to exit via the airport gate, Security Gate 36, and that -- they had some difficulties in getting through that gate. Could you -- do you have -- are you aware of that situation, and could you tell us about it?

THE WITNESS: Yes, I am, I have knowledge of that. They arrived at Gate 36, and all exit gates from the airport property are operated by a I.D. card process and electronic opener that operates off the I.D. card.

You slide it through a slot, a downward motion that decodes your magnetic strip on the I.D. card, sends it back to the computer and it lets the computer know whether or not to open the gate.

The gate opened, the first company went through -- or, the first one or two companies went through and then the following companies could not get the gate to open again for them. It closed -- it closed back behind each company that goes through, and they could not get the gate to open again, so they decided to crash the gate, which they did.

MR. ROMAN: Was any estimated delay incurred as a result of that?

THE WITNESS: Possibly 30 seconds.

MR. ROMAN: Do you have personal experience of having watched these gates operate --

THE WITNESS: Yes.

MR. ROMAN: -- at the airport? I think this may be a bit of a loaded question, if it were, but do they operate rapidly enough for a successful egress by a fire truck going to an emergency, even if they are working properly?

THE WITNESS: Not to my satisfaction.

MR. ROMAN: Okay. Did your department confer with the airport about the difficulties with the gate after the accident?

THE WITNESS: Yes, I think that has been done.

MR. ROMAN: What is your understanding of what the airport came up with?

THE WITNESS: It is my understanding -- and this is purely speculation, that there is no change -- that there is no -- there is no change in order at this time.

MR. ROMAN: Was the gate found to have been malfunctioning?

THE WITNESS: No, the gate was found to be functioning properly. I think the firemen in their haste to open the gate were sliding the cards through faster than the computer could decode them.

MR. ROMAN: Could you describe briefly for us the triage, characterize the triage operations from your viewpoint as an incident commander?

THE WITNESS: I will try. Once we established command of the force we all -- we set up search and rescue and suppression. We established a water supply officer and we -- of course, rescue being our first priority, we commenced to try and rescue the people on board.

We found that under the -- this is July 2nd -- under the heat and humidity of that day, that about an hour is as long as you can expect a person to work in fire fighting equipment, so we had to rotate a lot of people, establish a rehab area, rotate our people through it and, basically, the operation went as well as I think we could have expected it to have gone.

MR. ROMAN: Are you speaking of triage in this case, or --

THE WITNESS: Okay, we were -- I was the operations officer and I had established a medical operations officer who was over triage, treatment both major and minor, and transportation. It is my understanding from the people who were in those positions that things went well there.

We had a communication problem, and it took us awhile to establish communication between the fire and rescue phase and the medical treatment and transportation phase.

MR. ROMAN: Your department -- as a matter of fact, all the departments involved held a post-disaster critique on this event, did they not?

THE WITNESS: That is correct.

MR. ROMAN: Can you tell us just what improvements, or problems were recounted and discussed as a result of the critique?

THE WITNESS: Well, we found that security could use some work initially in the operation, and we found that we did have a communication breakdown between fire and EMS, and we are currently working to work those problems out.

We are currently in the process of reviewing our air crash SOP's to see if there is possibly anything we can do to improve our procedures there.

MR. ROMAN: Have there been any changes implemented to procedures or equipment as a result of your experiences for this response?

THE WITNESS: Not as yet, but we are still looking into it.

MR. ROMAN: Okay. I think right now I would just like to ask you, and you may have touched upon this a bit earlier, but how would you characterize this overall, the response, looking at it from a qualitative viewpoint?

THE WITNESS: For the fire and rescue part, which is the part that I was in command of, everything went as well as we could expect it to go. Our primary job there is to save lives. I feel that every victim that was alive when we arrived at the scene also left the scene alive, and that is all we can ever hope to expect.

MR. ROMAN: Did you have a disaster drill recently, prior to this accident?

THE WITNESS: Yes, we did. If I can refer to my notes, we had a disaster drill on November 6, 1993 near Old Dowd Road near the Berry Hill Baptist Church, which was actually just a short distance from where the crash occurred.

MR. ROMAN: Did you find that to -- would you attribute that to have been beneficial to those responding for the accident?

THE WITNESS: Yes, I would.

MR. ROMAN: Okay, I think that is all I have. Thank you, Chief.

MR. HAMMERSCHMIDT: Okay, thank you, Mr. Roman. Any other questions from the Tech Panel?

(No response.)

Okay, I guess we will go to the parties first. Federal Aviation Administration?

MR. DONNER: No questions, thank you, Chief.

MR. HAMMERSCHMIDT: National Air Traffic Controllers Association?

MR. PARHAM: I have no questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Honeywell?

MR. THOMAS: No questions, thank you.

MR. HAMMERSCHMIDT: Airline Pilots

Association?

CAPTAIN TULLY: No questions, thank you.

MR. HAMMERSCHMIDT: U.S. Air?

MR. SHARP: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Douglas Aircraft Company?

MR. LUND: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Pratt & Whitney?

MR. YOUNG: No questions, thank you.

MR. HAMMERSCHMIDT: Okay, Association of Flight Attendants?

MS. GILMER: Yes, Mr. Chairman. If you would turn to page 3 of Exhibit 15(a)?

THE WITNESS: 15(a)?

MS. GILMER: Yes.

(Witness complies.)

THE WITNESS: Okay.

MS. GILMER: It states here that the Ground Controller East transmitted to Blaze-5 that there were 50 souls on board plus five crew members, is that correct?

THE WITNESS: That is what it states there. The information did not get to me as the instant commander. I do not have a radio that monitors tower traffic, tower radio traffic, and that was done on the airport radio that does monitor air radio traffic and the information was not passed along to me immediately.

MS. GILMER: Okay, I understand. Do you know where the Ground Controller East would get that information, the count?

THE WITNESS: No, I sure don't.

MS. GILMER: Okay, because if you look at the transcript of 15(f), 16 minutes into the rescue effort, Blaze-5 still apparently doesn't know how many souls are on board.

THE WITNESS: What are you referring to, now?

MS. GILMER: 15(f).

THE WITNESS: I don't have 15(f).

MS. GILMER: Oh, well, on page 5 of 15(f), at the bottom, at 18:56 and 41 seconds Blaze-5 still is thinking that there are five souls on board.

(Document proffered to the witness.)

(Witness complies.)

MR. HAMMERSCHMIDT: Ms. Gilmer, let's -- now he has the exhibit in hand -- let's --

MS. GILMER: Okay.

MR. HAMMERSCHMIDT: Let's make that reference again, please.

BY MS. GILMER: (Resuming.)

MS. GILMER: Okay.

THE WITNESS: Okay, what page was this on?

MS. GILMER: Six, at the bottom of the page.

THE WITNESS: Page 6?

MS. GILMER: Uh-huh.

THE WITNESS: Okay, now, what is the question again?

MS. GILMER: Just one second. Okay, and bear with me, you know, I don't understand engines and all of this communication, but I am just trying to understand.

Blaze-5 at 18:58 and 8 seconds is saying, "Blaze-5, copy that, we will need to confirm that with the tower." That is 16 minutes into the -- or, 16 minutes after that accident.

I am just wondering from Exhibit 15(a) that I pointed out first, in the first paragraph, it appears as though Blaze-5 had that information of 55 souls on board and 5 crew members.

THE WITNESS: At this --

MS. GILMER: But, we don't -- I am sorry, go ahead.

THE WITNESS: Excuse me, I am sorry. I didn't mean to cut you off.

MS. GILMER: No, that's okay.

THE WITNESS: At this point, I think is where Blaze-5 actually did call the tower and ask for that information. I think that is where this is in the incident.

MS. GILMER: Right, because it -- there is just no indication in --

THE WITNESS: Yeah.

MS. GILMER: -- in that first paragraph as to when they got that information.

THE WITNESS: Yeah. I read the transcripts, and apparently one of the flight attendants had a -- gave someone at the scene a manifest out of her shirt pocket.

MS. GILMER: Right.

THE WITNESS: I do not know who that person was, or what happened to that one, either.

MS. GILMER: Right, I understand.

THE WITNESS: But, that information still did not get to me.

MS. GILMER: Okay. Is there -- sir, is there a plan in place whereby any carrier would, through a representative, provide in an accident situation like this a correct count of souls on board? Do you look to one particular person in a position for that information?

THE WITNESS: We expect a representative from the airline, generally, to contact us with that information, which is what happened and was where I got the information.

MS. GILMER: Right. So, it is not in a rescue plan, per se?

THE WITNESS: It may well be. Although I have read the rescue plan and I am familiar with it, I am human and I don't have it memorized word for word, and it may well be.

MS. GILMER: Right. Well, do you -- correct me if I am wrong, but I think you said something like the fact that you didn't have an accurate count did not affect your rescue efforts.

THE WITNESS: I think not, because as scattered as the scene were and where some of the victims were hidden and compressed into areas of the airplane, even if we had had an accurate passenger count, it would have been totally impossible for us to locate and account for every person that should have been on the airplane.

Also, some people were transported as we were arriving at the scene, or shortly after we arrived at the scene, that we may not have had -- may, or may not have been able to have records of, so I really don't think it affected one way or the other us doing our job.

MS. GILMER: So, if you thought there were just five souls on board and you could account for five souls, would you continue your rescue effort?

THE WITNESS: Well, when engine 30 arrived and Captain Cadieux found three deceased victims and then two more walked out of the house, he immediately reported that he had accounted for all five souls. Then, more walked out of the house and he ascertained right then that the five count was not proper. So, he assumed there were more than that.

MS. GILMER: So, am I to understand that you would just keep looking until you found no more surviving passengers?

THE WITNESS: That is correct, and that is exactly what we did.

MS. GILMER: Okay, thank you very much.

MR. HAMMERSCHMIDT: Thank you. International Association of Machinists?

MR. GOGLIA: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Dispatchers Union?

MR. SCHUETZ: Mr. Chairman, I have no questions.

MR. HAMMERSCHMIDT: Thank you. National Weather Service?

MR. KUESSNER: No questions.

MR. HAMMERSCHMIDT: Okay, let's see, Mr. Feith?

MR. FEITH: Yes, sir. I just have several questions. Just to refresh my memory, Chief, your initial call that a small aircraft had gone down with five souls on board, where did that information come from?

THE WITNESS: That came from the 911 line that was transferred to us from the EMS service. They received a call and transferred it to the Fire

Department.

MR. FEITH: While you were en route, you stated that the number of passengers kept changing. Who was updating that information to you with those changing numbers?

THE WITNESS: The companies on the scene, and I was not keeping track of which particular company was talking at the time.

MR. FEITH: Do you recall how many number changes you had heard en route?

THE WITNESS: I recall, and in the transcripts I find, that there was at one time a report of 87, and that was the Captain when he was told that there were 46 by -- I think the pilot, I am not sure.

When he started to say 46, 87 came out some way, and then he came back in a moment and corrected himself, and that is where the 87 came from, and I think the actual count that we got prior to my arrival at the scene was 46.

MR. FEITH: In just going back to 991 calls, do you know how many 911 calls were received regarding the accident?

THE WITNESS: No, it is in the transcripts, but --

MR. FEITH: Multiple?

THE WITNESS: Multiple, yes. Some 911 calls were transferred to us by CPD, or the City Police Department. Some were transferred to us through the County, which is EMS.

MR. FEITH: Site security, when you arrive on the scene -- or, site command -- who is responsible for sit command?

THE WITNESS: I was the first Chief officer on the scene and I assumed command of the entire site when I arrived at the scene.

MR. FEITH: Is that a coordinated effort with airport crash fire rescue people, also?

THE WITNESS: Yes, it is. The airport crash fire and rescue folks are a part of our department and, yes, it is a coordinated effort. We have a County "all hazards plan" that is County-wide that tells what everyone's role should be at this type of disaster.

MR. FEITH: Did you find a problem with assuming command and controlling both parties?

THE WITNESS: No, I did not find any problem with that.

MR. FEITH: Site security, is that a coordinated effort with you, also, or is your primary function crash fire rescue?

THE WITNESS: My primary function is crash fire and rescue, but once I assume command of the incident, I am responsible for all facets of the incident for everything that goes on there. In the "all hazards plan", it calls for law enforcement to assume the responsibility and duties of security and, early in the incident, I assumed that they were doing just that.

MR. FEITH: Were you approached by anyone, a police commander, or a commander handling the police operation, so your efforts would be coordinated so as not to interfere with each other's work?

THE WITNESS: Early in the incident I saw a sergeant there, and it was some time after that that I saw the first ranking police officer.

MR. FEITH: Regarding the operation of the gates, just I guess out of my own ignorance, why is there a key card required to get out of that gate?

THE WITNESS: I think it is an FAA regulation that has something to do with airport security.

MR. FEITH: I could see possibly getting into it, but coming off the airport?

THE WITNESS: You will have to ask the airport that question.

MR. FEITH: Okay.

THE WITNESS: I have no idea.

MR. FEITH: Would it be prudent to say that there should be some kind of manual override, or the ability to manually override that system out there?

THE WITNESS: It would be good, since the computer opens them anyway if -- when there was a crash, they could push a button in the tower that would automatically open them. It seems like a reasonable plan that, again, you would have to check with the airport. They have to meet FAA regulations and I am not familiar with those.

MR. FEITH: Who coordinates the effort to have Medivac, Airborne Medivac arrive on the scene? Is that part of your responsibility?

THE WITNESS: That can be done by either one of the agencies that arrive at the scene. If it is needed, any agency in the County can request it and, traditionally, it would be done by the operation -- or, the Medical Operations Officer since transportation of patients falls in his realm of authority.

MR. FEITH: Thank you, Chief.

MR. FEITH: That is all the questions I have, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, Mr. Feith. Okay, Mr. Schleede?

MR. SCHLEEDE: Just one area where I may have missed it. When do you estimate the first emergency services arrived on the scene from the time of the accident?

THE WITNESS: The first fire truck, Engine 30, arrived on the scene in approximately four minutes.

MR. SCHLEEDE: I don't know the proper terminology; at what point do you estimate that the fire was knocked down, or under control?

THE WITNESS: They estimated -- Captain Allen who was on Blaze-5 in charge of the air crash rescue operation estimated three to four minutes past that. I was on the scene in six minutes from the original dispatch. The fire was out when I arrived at the scene.

MR. SCHLEEDE: Okay. I believe you mentioned there is problems with security that you had identified during your critique. Just in general, what were the problems with security?

THE WITNESS: There were a lot of people allowed to enter the scene that should not have been allowed to enter the scene, both civilians that came -- the civilians who were there before the emergency services did a tremendous job of helping the survivors of the crash, but these were people that came after the fact; spectators, do-gooders, which is a bad term. People desiring to help, that is a better term.

They just came and walked in and added to our problems by creating a hazard for themselves. They were not properly attired to work in that area. There was a danger, although we were dealing with it as best we could, of flash fires and that sort of thing. No one needed to be in the area that was not properly attired for that type work.

MR. SCHLEEDE: In your disaster drill in 1993, was that type of scenario conducted where there is -- the scene is roped off, secured by the security forces?

THE WITNESS: I can't answer that. I,

myself, was not involved in the '93 disaster drill.

MR. SCHLEEDE: Okay, thank you very much, Chief.

MR. HAMMERSCHMIDT: Even though you were not involved in that '93 drill, what type of accident were the rescue units responding to, what type of accident was being simulated?

THE WITNESS: It was a downed plane crash, but, again, beyond that I can't -- I don't know.

MR. HAMMERSCHMIDT: Would you have any idea if the same units -- Fire Department units -- responded in the drill that responded to this accident?

THE WITNESS: Yes, sir, the exact same Fire Department units -- or, not the exact same, but most of the same Fire Department units did respond, yes.

MR. HAMMERSCHMIDT: Okay. Any other questions for this witness?

(No response.)

Mr. Weaver, we thank you very much for your participation in this hearing. You may step down.

(Witness excused.)

Let's proceed to our next witness, Mr. Richard DeMary, who will be questioned by Safety Board

Investigator, Nora Marshall.

(Witness testimony continues on the next page.)

RICHARD DeMARY, "A" FLIGHT ATTENDANT, USAir, INC., PITTSBURGH, PENNSYLVANIA

Whereupon,

RICHARD DeMARY,

was called as a witness and, after having been duly sworn, was examined and testified on his oath as follows:

MR. SCHLEEDE: Would you please state your full name and business address for the record, sir?

THE WITNESS: Richard Dale DeMary, Pittsburgh International Airport.

MR. SCHLEEDE: By whom are you employed?

THE WITNESS: U.S. Air.

MR. SCHLEEDE: In what position?

THE WITNESS: Flight Attendant.

MR. SCHLEEDE: How long have you been a Flight Attendant with U.S. Air?

THE WITNESS: Two years.

MR. SCHLEEDE: Would you briefly describe your training and background as to prepare yourself as a Flight Attendant at U.S. Air?

THE WITNESS: Yes. New hire training as a Flight Attendant consists of five weeks of training, as well as initial observation flights, and yearly recurrent training of eight and a half hours.

MR. SCHLEEDE: Thank you. Ms. Marshall will proceed.

MS. MARSHALL: Good afternoon, Mr. DeMary.

THE WITNESS: Good afternoon.

MS. MARSHALL: Could you please describe your duty day the day of the accident when you began working in the segments that you flew that day?

THE WITNESS: Um-hum. I picked up that trip on Friday night from our future crew scheduling, and Saturday morning we had a 9:45 check-in with our first departure at 10:45.

That day we were scheduled to go from Pittsburgh to LaGuardia, LaGuardia-Charlotte, Charlotte-Columbia. We began the day at approximately, then, 40 minutes prior to departure, boarding the airplane.

We had a briefing with the Captain and then I provided a briefing to the other Flight Attendants. At that point, about 30 minutes to departure, we started boarding the airplane.

MS. MARSHALL: Can you describe the flight from Columbia to Charlotte, briefly?

THE WITNESS: Yeah, Columbia to Charlotte, it was just a very standard flight. It was -- up until the go-around, it was, to me, a very normal flight, very short. Our service was not such that we spent a lot of time with the passengers.

MS. MARSHALL: Okay. At what point did you realize something was wrong?

THE WITNESS: Initially, on the go-around when we started to go around, and just because that is not normal. We started going around and then somewhat of this sinking feeling, just feeling like we weren't going anywhere.

MS. MARSHALL: At that time, was the seat belt sign on, and where were you?

THE WITNESS: Yes. The Captain approximately ten minutes to landing gave an announcement for the passengers to remain seated and for us to clear the cabin, which just consists of doing a standard announcement and walking through assuring that everybody's seat belt is fastened, and we were in a jump seat, yes.

MS. MARSHALL: Okay. Was your seat belt fastened?

THE WITNESS: Yes, it was.

MS. MARSHALL: Okay. When you realized something was happening, did you do anything to your seat belt?

THE WITNESS: Yeah, when we initially started the go-around and it just seemed a little bit different as far as the acceleration forces, maybe, I just -- I gave my seat belt a little extra tug.

MS. MARSHALL: Okay. Can you describe that seat belt? How does that seat belt operate?

THE WITNESS: The particular seat belt that I was in is one continuous loop, so to speak. It is one long seat belt that fastens, basically, in the middle around your waist.

MS. MARSHALL: Okay. Do you have to adjust the buckle to insure that it is in the middle of your waist?

THE WITNESS: Yeah, it is not only adjusting the buckle, but also adjusting the straps around your shoulders.

MS. MARSHALL: Is that seat belt different than other seat belts on the airplane?

THE WITNESS: Yes, it is.

MS. MARSHALL: Other Flight Attendant restraints?

THE WITNESS: It is different than a few others, yes. Three come to mind at this time, three different types.

MS. MARSHALL: Okay. Can you describe some of the other types?

THE WITNESS: Yes. For instance, on the back of the
MD-8 -- or, excuse me, the DC-9 -- there is a jump seat that is a four point jump seat. It fastens in four separate places, so it is always centered in the middle of you, and I believe on some of the Boeing airplanes you buckle it -- you buckle the strap around your waist and then the shoulder adjustment comes from adjusting right at the shoulder.

MS. MARSHALL: Okay. Okay, can you then tell me what happened, what is the next thing you remember after the go-around, what stands out?

THE WITNESS: This -- everything? Everything that I remember?

MS. MARSHALL: Um-hum.

THE WITNESS: We started to go-around and simultaneously the nose came up and the power was applied, and I remember at that time just looking out the window and seeing such heavy rain. It was almost a streaking
of -- it wasn't a streaking of the window, it was -- it just covered the window.

Anyway, we started going around and it just didn't feel right, and I felt a sinking feeling, and shortly after -- or, actually, during the sinking feeling, because I was sitting next to the cockpit, I heard "terrain, terrain, terrain," and at that point I knew, because we were going around, that it just was not right. At that point and then shortly after -- shortly after hearing, "terrain, terrain, terrain," we impacted the ground for the first time.

The first impact was not as severe as the second impact that followed immediately. The second impact, it was so severe that I remember it opening up the airplane. It swung my part of the cabin around to the left. I remember the wind and the rain. Just the feeling, the noise, and then shortly thereafter it coming to a stop.

MS. MARSHALL: Once the airplane stopped, what did you do then?

THE WITNESS: Once the airplane came to a stop, Shelly and I immediately and instinctively started yelling our standard command of "release seat belts and get out, release seat belts and get out."

As we were calling "release seat belts and get out," we started to release our own seat belts, and

I had a difficult time actually finding my seat belt buckle, because when I had adjusted it on the start of the go-around it had moved from my center of the waist to my left hip. It was just a matter of looking down and actually seeing where it was.

Once I released my seat belt I stood up, and as I stood up I saw the Captain come out of the cockpit area. He looked over at us, and I believe Phil then -- the -- First Officer Hayes, came out right behind him, and as I stood up, then Shelly was continually yelling "release seat belts and get out." Then she said, "I can't get out of my seat belt." Her legs -- she said her legs were broken.

So, I immediately turned around, I believe I had to kick a few things out of the way, just some debris, and I at that point unbuckled Shelly's seat belt, the seat -- Flight Attendant, and basically bear-hugged her and pulled her away from the airplane, and then she fell and I just simply -- just grabbed her hand and just drug her away to a safe area, or a place that I thought was safe.

At that time there was noticeably a lot of fire, and so we just -- now, I happened to mention to the Captain, "Where is Karen?" Karen was the girl that was flying in the back of the airplane, the B-Flight Attendant, and at that point nothing looked familiar.

I had at that point proceeded to the back side of the airplane, or the cockpit area that I thought that I would find the rest of the airplane, and at that point when I got back there, there was nothing there, and I remember then looking around and thinking that -- and noticing that we were in a residential neighborhood, and I initially couldn't find the rest of the airplane, so I --

I looked over and I saw smoke around the tail section, and at that point, then, I am not exactly sure how I got to the tail section that was imbedded in the house, but I was there. At some point I got there, and I was continually yelling, "release seat belts and get out, release seat belts and get out".

We are trained that just to if somebody is traumatized, or frozen that that might give them some direction. It will give them something to start with, and I was continually yelling, "release seat belts and get out," is why I was doing that, and then shortly after that a woman appeared.

MS. MARSHALL: Where did she appear?

THE WITNESS: A woman appeared up in -- just -- she appeared in a hole in the fuselage, basically just in front of the right engine in the back of the airplane and, so, I noticed her and I simply just -- she had a baby with her.

She was crying, "help me, help me," and I simply grabbed her baby and sent her baby over a fence just a short distance, and then I went back and I basically had to lift her out of the hole, out of the fuselage, and at that time, then, I proceeded to take them clear away from the wreckage into the back yard, I assume it was.

At that point, then, I went back and was still yelling, "release seat belts, release seat belts and get out," and another woman appeared who was more hysterical. She was, once again, yelling, "I need help, please help me, I can't find my baby."

MS. MARSHALL: Where did she appear?

THE WITNESS: She appeared in the same break in the fuselage as the first lady, just directly in front of the right engine, and she said, "Help me, help me, I don't want to die. I can't find my baby."

So, I helped her out, then, and she was -- she was more of a struggle to get out, but I got her out and also got her away, and at that point is when I got to the section of back yard that the other two passengers were located. There were evidently some -- a couple from the neighborhood that was there to assist them.

So, at that point I went back and was still yelling, "release seat belts," still yelling commands, and nobody else appeared. At that point, I felt that it was becoming a very dangerous situation to be right there so close to the fire. Everything was hot. That is -- I believe that is where I got my burns, was trying to brace myself to take these people out of the airplane.

MS. MARSHALL: Where did you get burned?

THE WITNESS: My left arm, yes, and I believe it was burned on the right engine. At that point I just felt like I needed to get away. Common sense told me that I
just -- I needed to get away.

I kept hearing popping sounds, small -- almost like small explosions, and everything was so hot. There was fire. So, I proceeded then around, I believe, to the back yard area and jumped a fence.

At that point I was over what later was the triage area, and I remember seeing the Captain, and the Captain says, "She's okay," and he was referring to Karen, and at that point, then I saw Karen.

Karen suffered severe burns to her hands and arms and she didn't have her shoes on. She said she had glass in her feet and, so, at that point I knew she was okay.

I happened to see a young boy. I assume he was from the neighborhood, 12, or 13, or 14, something like that, and I asked him to -- "Is there anybody home? Is there anybody in the house?" He basically shook his head, he didn't know.

So, not knowing if there was anybody in the house, we proceeded to basically kick in the front door, walk inside of the house and look to our left and right, and it looked vacated at the time, and so we went to the -- to the dining room area.

There was a kitchen table set and there was a small door that was an entrance to the garage. We opened that door and I broke in the glass of the screen door. The screen door opened to the outside which, because of the debris, there was no way it was going to open.

So, at that point I knew somebody was in the house, or in the -- in the debris, because I could hear somebody yelling, "Please help me, I can't breathe." At that point, there was nothing I could really do for him, because I first of all couldn't see him and all I could do was hear him, and the smoke for me was extremely heavy and almost toxic.

At that point, I just -- I yelled for him, "Cover your mouth if you have anything to cover your mouth with, try to relax and breathe slowly." At that point, I believe fire and rescue were arriving and I knew that there was nothing more I could do with him.

So, I vacated the house and went out to try to assist anyplace else, and the fire truck, first initial fire truck, couldn't get through. There was a downed telephone pole, or electrical pole in the middle of the street. So, myself and one other person just basically lifted it and swung it aside so that the truck could get through.

After that, I think I helped them roll out some fire hose and then I was just simply asked to get away -- to get away.

MS. MARSHALL: When you opened that screen door from the house to the garage area, what could you see when you looked in there? Could you see anything, or was the smoke --

THE WITNESS: Nothing looked familiar. I could see things. There was -- next to the door was one of the tires from the aircraft and it was just -- nothing made sense.

MS. MARSHALL: I wanted to go back and ask you about getting out of your jump seat. Were you square on the jump seat? Were you leaning one way or another?

THE WITNESS: The way that the airplane came to rest, we were tilted. I was tilted to my left and I was basically leaning on Shelly.

MS. MARSHALL: Okay. Also, something you mentioned about your seat belt, where you felt the need to reach down and tighten it tighter?

THE WITNESS: Um-hum.

MS. MARSHALL: If you had been in a different type of seat belt, would you -- if you had been on the back jump seat, would you have done anything to that seat belt?

THE WITNESS: Probably, I would have still given an extra tug, but to adjust that one you pull on both straps around your waist and it remains centered, the buckle remains centered.

MS. MARSHALL: You were flying as the A-Flight Attendant. Do you always fly that position?

THE WITNESS: I don't always fly it. It is a change, it -- no, I don't.

MS. MARSHALL: Okay.

THE WITNESS: Not always.

MS. MARSHALL: You said that the Captain briefed you. Did he give you any instructions about counting passengers?

THE WITNESS: Yes. Captain Greenlee asked me in his briefing to the Flight Attendants to provide him with a passenger count.

MS. MARSHALL: Okay. When do you do that count?

THE WITNESS: Prior to departure, just -- that would be the last thing that we would do before closing the doors, to confer with the agent that brings the count down.

MS. MARSHALL: Okay. Do you remember how many in-lap children were on Flight 1016?

THE WITNESS: I knew at the time that there was one.

MS. MARSHALL: Are you familiar with infant boarding passes?

THE WITNESS: I know what they are, but I am not -- I don't see them very often.

MS. MARSHALL: Okay.

THE WITNESS: Yeah.

MS. MARSHALL: Can you just briefly describe what they are, an infant boarding pass?

THE WITNESS: I believe an infant boarding pass would be the agent's responsibility to basically place on the boarding pass to inform anybody that a passenger was travelling with a lap child.

MS. MARSHALL: Okay. As a Flight Attendant, do you normally check passenger boarding passes?

THE WITNESS: No.

MS. MARSHALL: Okay. If the Captain had not asked you to count passengers as part of his briefing, would it be a U.S. Air policy for you to do that, to count the passengers?

THE WITNESS: No.

MS. MARSHALL: Okay. How do you feel your training prepared you for this accident?

THE WITNESS: This situation was so different than the training that we have, our hands on emergency drills, but because we have the hands on emergency drills we are -- I believe all the Flight Attendants were able to draw on those, the basic foundation of training, instinctively, with good judgment provided.

MS. MARSHALL: In addition to the burns that you described, did you receive any other injuries in the accident?

THE WITNESS: Yeah, I had an injury to the back of my head and I had severed nerves in my foot.

MS. MARSHALL: Okay. Do you have any idea how you hurt the back of your head?

THE WITNESS: I am not sure, I am not sure.

MS. MARSHALL: I have no further questions, Mr. Chairman. Thank you very much, Mr. DeMary.

THE WITNESS: You're welcome.

MR. HAMMERSCHMIDT: Thank you, Ms. Marshall. Let's see, going to the parties, Federal Aviation

Administration?

MR. DONNER: We have no questions, Mr. Chairman, thank you.

MR. HAMMERSCHMIDT: Thank you. National Air Traffic Controllers Association?

MR. PARHAM: We have no questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Honeywell?

MR. THOMAS: No questions, Mr. Chairman, thank you.

MR. HAMMERSCHMIDT: Airline Pilots Association?

CAPTAIN TULLY: Thank you, no questions.

MR. HAMMERSCHMIDT: Okay, we will go to Douglas Aircraft Company?

MR. LUND: We have no questions, Mr. Chairman, thanks.

MR. HAMMERSCHMIDT: Okay, Pratt & Whitney?

MR. YOUNG: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Okay, International Association of Machinists?

MR. GOGLIA: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Dispatchers Union?

MR. SCHUETZ: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: National Weather Service?

MR. KUESSNER: No questions.

MR. HAMMERSCHMIDT: Association of Flight Attendants?

MS. GILMER: No questions, thank you.

MR. HAMMERSCHMIDT: U.S. Air?

MR. SHARP: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Oh, Mr. Feith?

MR. FEITH: Just several questions, sir. Mr. DeMary, do you recall at what point in the flight you did your final cabin walk for checking to see that safety belts were fastened? Prior to you sitting down, do you have any time reference?

THE WITNESS: No, I don't. It was -- it was probably immediately after the Captain made the announcement for us to prepare for landing.

MR. FEITH: Do you recall hearing, or seeing any rain at that time --

THE WITNESS: Not at that time.

MR. FEITH: -- as you were doing your walking around?

THE WITNESS: No.

MR. FEITH: Did you notice any turbulence? Was the flight smooth?

THE WITNESS: No, I didn't.

MR. FEITH: You stated in previous testimony that when you sat down in your jump seat you did have access to a window, or you could see through a window?

THE WITNESS: Yes, the passenger entry door.

MR. FEITH: Was it raining at the time when you sat down to buckle in for the final approach?

THE WITNESS: I didn't notice it, but once the heavy rain started, it -- I did notice that.

MR. FEITH: Then you stated that you heard the oral warning from the ground proximity warning, you heard the "terrain" warning. Do you recall hearing any other oral warnings, other than the "terrain" warning?

THE WITNESS: None.

MR. FEITH: How often would you say that you are asked to count passengers when you are on a flight by the Captain?

THE WITNESS: I have -- in my flying A, I have never been not asked to provide a count. I am always asked to provide a count.

MR. FEITH: Is it my understanding that you all are now under a new procedure where you are not required to count passengers?

THE WITNESS: That is correct.

MR. FEITH: Considering the fact that you have never not been asked to count passengers, do you find this a good change, or a bad change in procedure?

THE WITNESS: It really has not been a change, at all, because we still provide a passenger count, not only for ourselves, but for the Captain.

MR. FEITH: But, it is not required now?

THE WITNESS: But, it is not required.

MR. FEITH: Do you think it should be?

THE WITNESS: In the aspect of knowing how many passengers are on board for our reasons, yes.

MR. FEITH: One last question, do you recall after the accident when you were evacuating your seat, can you recall what the weather conditions were? Was it still raining hard, was the wind still blowing, did you have visibility restriction?

THE WITNESS: I don't recall.

MR. FEITH: Thank you, Mr. DeMary.

THE WITNESS: You're welcome.

MR. HAMMERSCHMIDT: Thank you, Mr. Feith.

Mr. Schleede?

MR. SCHLEEDE: Just one question. Does your hands on training, or training program, include any kind of a crash simulator?

THE WITNESS: Are you asking did it provide maybe something mechanical that provides a jolt?

MR. SCHLEEDE: Right, or smoke, or noises?

THE WITNESS: Yeah.

MR. SCHLEEDE: Your training?

THE WITNESS: Nothing as far as a jolt, but simulating darkness of a cabin, smoke. Yes, there was.

MR. SCHLEEDE: Okay, thank you.

MR. HAMMERSCHMIDT: Mr. DeMary, after surviving such a serious accident, is there any improvements that you can see that should be made in the overall field of cabin safety, airline cabin safety?

After, you know, maybe giving that some thought after the accident, can you see anything we should be doing?

THE WITNESS: Well, I have given it a lot of thought and nothing comes to mind at this time, thank you.

MR. HAMMERSCHMIDT: Okay, any other questions for this witness?

(No response.)

Thank you very much for participating in our public hearing, and you may step down.

THE WITNESS: Thank you.

(Witness excused.)

(Applause.)

MR. HAMMERSCHMIDT: Let's see, our final witness is Mr. Jeff Marcus. Mr. Marcus, would you please come forward?

(Witness complies.)

Mr. Marcus will also be questioned by Ms. Nora Marshall.

JEFF MARCUS, CHILD SAFETY SEATS, FAA - CAMI,
ATLANTIC CITY, NEW JERSEY

Whereupon,

JEFF MARCUS,

was called as a witness and, after having been duly sworn, was examined and testified on his oath as follows:

MR. SCHLEEDE: Mr. Marcus, would you please state your full name and business address for our record?

THE WITNESS: My name is Jeffrey H. Marcus. My business address is the Civil Aeromedical Institute at the Mike Maroney Aeronautical Center in Oklahoma City.

MR. SCHLEEDE: That is an FAA facility?

THE WITNESS: That is an FAA facility.

MR. SCHLEEDE: What position do you hold with the FAA?

THE WITNESS: I am the manager of the Protection and Survival Laboratory.

MR. SCHLEEDE: How long have you had -- how long have you held that position?

THE WITNESS: In January it will be three years.

MR. SCHLEEDE: Okay. Briefly describe your training and experience that qualifies you for this position.

THE WITNESS: In 1975 I received a Bachelors degree in Mechanical Engineering from the University of Maryland. In 1980 I received a Master of Science and Engineering from Michigan State University where I did my graduate work, looking at the ways of modeling the way that people move for computer simulations of things like pilots ejecting from high performance aircraft.

After that, I took a position with the

National Highway Traffic Safety Administration, the part of the Department of Transportation that looks at crash injuries in automobiles, where I was involved in research on human impact tolerance and response.

I held that position until 1991 when I left to take the current position that I have.

MR. SCHLEEDE: Thank you very much. Ms. Marshall will proceed.

MS. MARSHALL: Thank you. Mr. Marcus, do you have Exhibit 6(j)?

THE WITNESS: Yes, I do.

MS. MARSHALL: Thank you. Can you describe the current FAA policy regarding the use of child restraint systems on air carrier accident airplanes?

THE WITNESS: I am not a person to speak about policy; however, the FAA recommends that parents carrying young children use child restraints which are approved child restraints. However, they are not required.

The basis for what is an approved child restraint is if it was sold in the United States there is a standard put out by the National Highway Traffic Safety Administration known as FMVSS, Federal Motor

Vehicle Safety Standard 213 concerning child restraints.

If a child restraint was sold in a foreign country and it has complied with the requirements of that foreign county or with the U.N., then it is also approved for use on air carrier operations.

MS. MARSHALL: Can an airline, a U.S. airline, prohibit a passenger who has purchased a seat for a child prohibit them from using an approved child restraint device, according to the regulations?

THE WITNESS: It is my understanding that they cannot if it has been approved.

MS. MARSHALL: Can you describe the types of -- excuse me, let me rephrase that. How many different times has CAMI done testing of child restraint systems?

THE WITNESS: There was a series of tests that we did in 1993, most recently, and that was just released yesterday. In the report there were a series of tests that were done in 1989 that have not actually been published, I believe, and that was the first test that had been done for a good long period of time.

I know there was one other series of tests, but I am not sure of the dates.

MS. MARSHALL: Are you aware of any other testing of child restraint devices for aircraft use anywhere else in the world?

THE WITNESS: The British have had some interest in the use of child restraints in aircraft, and in 1993 they published the results of a series of tests at the Cranfield Institute looking at child seats in aircraft applications.

As part of that research, they had commissioned a library there to do a worldwide search for any references that anybody had published anywhere in the world on the use of child restraints in aircraft, and they came up with a total of three references over a period of 20 years, and CAMI was a leading contributor to that literature.

MS. MARSHALL: The tests that were conducted in 1989, why were those tests -- why did CAMI decide to run those tests?

THE WITNESS: The tests in 1989 were done in conjunction with the -- with Transport Canada that was at approximately the same time that the British Civil Aviation Authorities had allowed the use of a particular kind of device called the belly belt.

Transport Canada was considering allowing and recommending the use of the belly belt, and there was also interest within the FAA in terms of how well that responded -- how well that worked in simulated crashes.

So, that was the basis for doing the test, was to see, first off, how well belly belts have done, because of these changes by the British, and to look in, more general, at the issue of how well child restraints worked in aircraft.

MS. MARSHALL: Okay. Why did CAMI decide to run tests in 1993 on child restraints?

THE WITNESS: It was partly because of various comments that we had received. We tried to maintain close contact with people who are involved with the airlines who are dealing with the day to day operational problems in air carrier operations and cabin safety situations, to give us some guidance as to things that we should study.

A fairly consistent series of questions that we received and an issue of concern that was frequently expressed to us had to do with child restraints. Another contributing factor was that in 1988 the FAA substantially improved the crash-worthiness requirements for all categories of seats on aircraft.

We asked the question, then, of how well did the level of protection that would be offered by a newly -- a new type -- a newly designed type of seat that met the new requirements, how well would that compare to the protection offered by child restraints.

MS. MARSHALL: You mentioned earlier about the Federal Motor Vehicle Safety Standard 213 as the basis for approval for child restraints. Can you tell me the differences between the automotive environment and the airplane seat environment for child restraints?

THE WITNESS: Yeah. If you look in Exhibit 6(j), I believe -- let me just turn to it -- there is one page, page 12, that is a drawing from a scientific presentation made last November, and there you see superimposed a generic aircraft seat and the test fixture that is required in FMVSS 213.

The most salient point there is to compare the location of the seat belt anchors in the 213 fixture with the seat belt anchors that you find in an aircraft seat, and if you look at that, you will note that the anchors in the aircraft seat are considerably forward, as well as being above.

That results in an unfavorable angle on the belt in many child restraints, since the angle of the belt is what provides the tension in the belt that stops the child restraint. There appears to be significant differences between aircraft seats and the generic type of automobile seat that 213 tests with.

MS. MARSHALL: How about the other things that are different? Is there a difference between break-over?

THE WITNESS: Yeah, another significant difference between automobile seats and aircraft seats is that aircraft seats have a feature known as seat back break-over. Seat back break-over means that if you push on the top of the airline seat, it will come forward with approximately a 30-pound force.

It is important to understand that that is an operations and maintenance consideration that makes it easier to get the seats in and out of the aircraft for maintenance and a consideration in terms of storing the seats.

It is not at all in any shape, or form related to the crash protection that the seat offers.

However, with a child restraint, if you have an adult seated in the row behind where the child restraint is, that adult will probably come forward in a crash, will hit the seat back of the row in front of them which will cause that seat back to break over.

Then, if there is a child in the row in front of them, that seat back will come down on the child, which is not yet a dangerous situation, but the adult will continue forward and their crash forces will be -- will, if you will, squash the child between the seat back and the child restraint, unless there are features built into the child restraint to provide protection from that.

MS. MARSHALL: How about differences between automotive seat belts and airplane seat belts?

THE WITNESS: Automobile seat belts have the buckle in a much different location than aircraft seat belts. The significant difference of that is that in many of the child restraints that we tested, the location of the buckle interferes with the belt path through the child restraint.

If you do not have a good belt path, then you will compromise the performance of the child restraint.

That was one of the problems that we had. Another -- that we noted.

Another problem that we noted with the belts was they are difficult to thread through the child restraint, and then a final problem that we noted, a difference, automobile seats tend to be much wider than aircraft seats and some of the child restraints that we looked at were basically too wide to fit into the typical width of an aircraft seat.

MS. MARSHALL: Are there differences between automotive and aircraft in the distance from where the child restraint would be located and something in front of them that they would hit?

THE WITNESS: Yes, the requirement in Standard 213 is for a 32-inch head flail envelope. A head flail envelope is an area of open space in front of the child restraint which has to be free and clear so that when the child dummy comes forward the head will not strike anything.

In an aircraft seat, when you place a child restraint in there, you typically only have 22 inches of head strike envelope available. So, you not only have a situation where the disadvantageous seat belt locations require the child's seat to slide forward before you begin to see significant restraint, but you also have a problem because you have less head strike envelope available before the child's head will hit the row in front of them.

MS. MARSHALL: What types of devices did you test in the 1993 series?

THE WITNESS: I believe there is a table that shows what we tested. It is on page 7.

(Pause.)

We tested booster seats, which we coined as a somewhat generic term, referring to a device for an older child weighing in the range of 30 to 60 pounds. It does not have a back on it. It simply raises the child up. We tested some of those.

We tested aft facing carriers which are used for very young children. Those, the child rides backwards. The reason why those are used for very young children is that newborn children do not have sufficient strength in their necks to provide resistance from the crash forces. When they ride backwards, their neck musculature is not required to stop them.

There are also types of seats called convertibles, which can be used as both rear facing and then as the child grows can be turned around and used as forward facing. We tested many of those. That is, probably because of the wide range of applicability, some of the most popular designs that are out there.

In addition, we tested a harness which belts around the child. This is for larger children, and then the seat belt goes through the back of that and stops them, and we did tests with the belly belt where the child was held by an adult dummy, and we tested a three-year-old size child dummy just sitting in an aircraft seat restrained by the seat belt, no child restraint.

MS. MARSHALL: Did you mention belly belts? Did you test belly belts?

THE WITNESS: I -- yeah -- if I didn't, I meant to.

MS. MARSHALL: Okay. Can you describe the results of the tests of each of those types of -- let's start with booster seats.

THE WITNESS: The -- maybe let me start with the best and go to the worst.

MS. MARSHALL: Okay.

THE WITNESS: The -- all of the rear facing child restraints that we used performed very well, and we saw nothing that gave us any reason to be concerned about how well they would protect the child in an accident.

We observed that booster seats did not offer any increased protection over what the child would have in -- when they were restrained simply by the belt that is already available in the aircraft seat.

We did some experimental work looking at abdominal pressure. A general principal of restraint design is you do not want to load the abdomen. However, there are no accepted measurement technologies, meaning dummies, or ways to interpret readings that you get off of the abdominal pressure.

We did note, however, without being able to provide any understanding of the abdominal pressure, that the booster seats provided higher abdominal pressure than a child just restrained by a lap belt.

The forward facing carriers seem to be vexed by the problems with the seat belt anchors, and it is our belief that improved performance might be possible.

The harness systems that were tested are severely compromised by the problems with the seat belt anchor locations and did not offer what we would regard as acceptable restraint performance.

Given that I have spent about 14 years involved in human impact response, just the name belly belt cringes. It gives me the willies when I hear it, and our testing confirmed that the belly belt is in no way, shape, or form any type of an acceptable restraint system.

MS. MARSHALL: Okay. If you compare all of those devices to holding a child unrestrained on the lap, how do they look?

THE WITNESS: With the possible exception of the belly belt, any restraint -- there is no way that any human being could hold a child during the kind of crash forces that you would see during an accident. Schwartzenegger couldn't do it.

That being the case, that child is going to be thrown free from the parent's arms. In instances where the children have survived in these types of accidents, I would imagine it has just been -- my personal opinion is that it has just been by luck that they hit something soon after they were thrown out of their parent's arms.

In other cases, and there is no way that you can tell when and where that might occur, they get thrown all over the cabin, bounce all over the cabin and suffer fatal injuries.

There is no question that every restraint that we tested offers a much better situation than -- with the possible exception of the belly belt -- than the child just being held in the parent's arms. That is tantamount to no restraint.

MS. MARSHALL: In these tests, how were you evaluating the performance of the devices? What was your criteria for evaluating them?

THE WITNESS: We looked at primarily two items. I believe -- there is also a table on our performance criteria. But, in terms of the dynamic performance when we ran the test, we looked at whether or not the head of the child dummy would strike something in front of it. We regarded a head strike as unacceptable restraint.

We also considered abdominal pressure. As I said, abdominal pressure is an experimental system that we were playing with to get some insight into whether or not the restraint systems loaded the abdomen. There are no acceptance criteria provided with that.

If you look at page 3 in that exhibit you will see our performance criteria. I have been talking about the second one, dynamic -- I am sorry, the third one, "Occupant Protection During a Crash."

The first one, "Fit Adaptability and Adjustment in the Airplane Seat and the Lap Belts Provided on the Seat," refers to, basically, can you put the child seat in an aircraft seat and once you have it in there, is it possible to attach the lap belt correctly.

There were a number of child restraints that we examined in our study that either would not fit into an adult aircraft seat, or when they did it was very difficult, if not impossible to properly attach the lap belt.

Dynamic structural performance is simply a question of after you do the test, does the device hold together. If it flew apart, then it would be unacceptable.

MS. MARSHALL: We were talking about FMVS 213 earlier, and I just want to go back to that briefly. Can you describe the significance of the inversion test that is required, or is described in 213?

THE WITNESS: 213 was originally developed as an automobile standard and there was a desire to have certification standards for aircraft. In, I believe, 1985 the Department of Transportation decided to add what is known as an inversion test to the 213 standards.

If a child restraint passes the inversion test -- and I will describe it in a second, basically what that is -- then the child -- and it passes the other dynamic requirements of 213 -- then the child restraint may be labelled as suitable for use in automobiles and in aircraft.

On the other hand, if it does not pass the inversion test, but only passes the impact test, then it can only be labelled as suitable for use in automobiles.

The inversion test is you put a child dummy in the seat, you put the seat in a simulated aircraft seat and you turn the seat upside down, and the child dummy has to be retained. It cannot fall out of the seat.

That was put in, I believe, to take care of situations where an aircraft in a bad landing might roll, or start top break up, or something of that sort. In my personal opinion, it also benefits automobile designs, because it takes care of cars that roll over, and in Europe, European standards for automobiles include an inversion test.

MS. MARSHALL: The report that you mentioned earlier, does that describe the 1993 tests?

THE WITNESS: Is that the one that was released yesterday?

MS. MARSHALL: Released yesterday, yes.

THE WITNESS: Yes, it does.

MS. MARSHALL: Where can people get a copy of that report?

THE WITNESS: I actually believe there is going to be a Federal Register announcement shortly listing my name as a contact person, and if there is anybody here who would like to obtain a copy of the report, it was released yesterday, it has not yet come back from the publisher. If you give me your card, or your name and address I will mail a copy of it to you as soon as it is available.

MS. MARSHALL: Okay. One last question. There was a press release issued yesterday by the Department of Transportation that dealt with child restraint. Are you familiar with that press release?

THE WITNESS: Yes, I am.

MS. MARSHALL: Can you tell -- can you just summarize what the press release says that the FAA is going to be doing -- or, the Department of Transportation is going to be doing about child restraints?

THE WITNESS: Partly, it describes some of the testing that we had done. I believe it describes a coming ban on the use of harness type of restraints. It also noted, but did not describe any pending action on booster seats.

It talked about how the FAA and the National Highway Traffic Safety Administration would be reviewing the standards for child seats in aviation situations.

MS. MARSHALL: Okay, one final question. In 1990 the Safety Board issued recommendations to the FAA about child restraint, and one of those recommendations was for the FAA to test -- to conduct tests to determine at what age a child is adequately secured by the lap belt in an airplane seat.

Did your tests come up with any results that would answer that recommendation?

THE WITNESS: I believe so. We tested child dummies seated without a child restraint, just secured by the lap belt, and we tested both a three-year-old -- it is important to note that three-year-old refers to the size of the dummy, not how long it has been away from the manufacturer.

(Laughter.)

We tested a three-year-old dummy in that situation, and we also had a unique dummy that we developed at CAMI that had certain measurement capabilities not generally available on standard dummies for our purposes. That dummy is the size of a two-year-old.

We found that both the two-year-old and the three-year-old, in our opinion, gave -- were adequately restrained by the aircraft lap belt. A rough rule of thumb that I personally use is that if a child is old enough to be of a proper size to fit into a booster seat, other than using the booster seat they are old enough to just sit secured by the lap belt.

MS. MARSHALL: Okay. Although I promised that was my last question, I actually thought of one more. Are you aware of any airplane seats that have integrated child restraint systems? I know -- I have seen it advertised on TV that -- a U.S. car manufacturer advertises them as part of car --

THE WITNESS: I am not aware of any aircraft seats that have integrated child seats, like Chrysler Corporation has. I believe that Virgin/Atlantic Airlines, which is not a U.S. carrier, offers child seats to parents who bring children onto their aircraft. The airline supplies them.

Short of that, I don't know of anybody else who does that. I am not aware of any child restraint design specifically optimized for it, although I have heard occasionally from some manufacturers who have been looking into that.

MS. MARSHALL: Okay. Thank you very much.

MR. HAMMERSCHMIDT: Thank you, Ms. Marshall. Let's see, going to the parties, National Air Traffic Controllers Association?

MR. PARHAM: We have no questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Honeywell?

MR. THOMAS: No questions, thank you.

MR. HAMMERSCHMIDT: Airline Pilots Association?

CAPTAIN TULLY: No questions, thank you very much.

MR. HAMMERSCHMIDT: U.S. Air?

MR. SHARP: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Okay, Douglas Aircraft Company?

MR. LUND: No questions, thank you, sir.

MR. HAMMERSCHMIDT: Pratt & Whitney?

MR. YOUNG: No questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Okay, Association of Flight Attendants?

MS. GILMER: Thank you, Mr. Chairman. Mr. Marcus, is it correct that you -- the testing that you have done that you just mentioned where the two and the three-year-old dummies are secured just with the lap belt in the passenger's seat, have you not tested a dummy under the age of two in that way?

THE WITNESS: We tested a dummy the size of a six month old child; however, that dummy would not be adequately restrained just by the lap belt. A child at six months old should be in a rear facing carrier.

MS. GILMER: Okay, and until we do have a federal rule to protect children under the age of two in aircraft, and for whatever reason an adult is travelling with a child under the age of two, can you tell us, given the fact that a six month old would not be protected adequately simply seated in the seat with the lap belt, and we understand that that would also be the case in the adult's lap, what about a child a little bit older,
say -- say 12 to 15 months?

THE WITNESS: You are looking for the cut-off of when they can -- the minimum size?

MS. GILMER: We have heard and been told that if a child is large enough to sit up on its own that it would be safer in the lap belt in the passenger's seat, as opposed to the adult's lap. Would you concur with that?

THE WITNESS: If I were travelling with my son and we were getting ready to brace for impact and I had blown away part of my mind and not brought a child seat with me onto the plane, then I would certainly strap him in with the lap belt that was available, because some restraint is better than none, and me holding him is no restraint.

However, that is -- because of the small size of the child, that is significantly less restraint and exposes the child to significantly more risk than they would be exposed to in a properly designed child restraint.

MS. GILMER: Okay, thank you very much, Mr. Marcus.

MR. HAMMERSCHMIDT: Let's see, International Association of Machinists?

MR. GOGLIA: Yes, I have one question. Mr. Marcus, are current FAA regulations in agreement with the CAMI report?

THE WITNESS: Well, it depends on what you mean. I am not an expert on regulations, I do research, so I can always hide behind that. We -- the testing that we did was an experimental program and it was not the basis for any certification.

The FAA does not certify child restraints.

So, given that we didn't test to the 213 standards that the FAA does not have any regulations regarding child seats, I don't really -- I am not sure I can answer the question.

MR. GOGLIA: Okay. Well, just one other question. Is there any discussion, or is there a notice of proposed rule-making concerning the CAMI report?

THE WITNESS: I can tell you with confidence that the results of our research have been supplied both to NHTSA who has the responsibility for certification standards for aviation in child seats and also to the parts of the FAA concerned with their design and operation.

Those people have reviewed the report and in yesterday's press release I believe it said that they would be examining current regulations with regard to that.

MR. GOGLIA: Okay. Thank you, Mr. Marcus. No further questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you. Dispatchers Union?

MR. SCHUETZ: Mr. Chairman, no questions.

MR. HAMMERSCHMIDT: Let's see, National Weather Service?

MR. KUESSNER: No questions.

MR. HAMMERSCHMIDT: Federal Aviation Administration?

MR. DONNER: Just one quick question for Mr. Marcus. You mentioned the affect of a seat back break-over on forward facing child seats, and I wonder what the effect would be on an aft facing child seat if an adult pushed the seat back forward?

THE WITNESS: We did have that feature in our test. We did not note any problems. Most of the rear facing carriers have sides of the child restraint that come up and, as a result of that, the structure of the child seat takes most of the impact loads, and that is a padded surface in any case. So, we did not see that that would be a problem.

MR. DONNER: Thank you, that's all I have.

MR. HAMMERSCHMIDT: Thank you, Mr. Donner. Anymore questions from the Tech Panel? Mr. Feith?

MR. FEITH: Yes, sir, just a couple questions. You were talking, Mr. Marcus, about the 1989 results when Ms. Marshall asked you about the previous testing that you did, and you said they hadn't been published. Was there a reason why those results weren't published?

THE WITNESS: Researchers' zeal to do testing rather than writing it up.

MR. FEITH: Then, why did the testing that was performed in '93 get written up and published and presented yesterday?

THE WITNESS: Because there was a new manager of the people doing the testing that came in in the interim.

MR. FEITH: So, those results of 1989, were they incorporated in this 1993 study?

THE WITNESS: The study that was released yesterday is just of the 1993 results. I hope to go back and revisit the tests that were done several years ago and bring that information out.

MR. FEITH: Not to prolong the subject, but in this discussion about booster seats and harnesses, can you just give me the Reader's Digest version what the FAA's position is on the boost -- the use of a booster seat and a harness? Is it that it doesn't provide a level of adequate protection for a child?

THE WITNESS: That the child is restrained at least as well, if not better, with just the lap belt on the aircraft seat, that the parents provide no additional protection to their children by bring a booster seat onto the airplane.

MR. FEITH: Being that Ms. Marshall asked you about the press release of yesterday -- and I know that, for the benefit of the audience, they don't have a copy and which we will probably add as an exhibit to the report -- I just want to make sure I am clear on this, because one of the processes of our investigation is to write recommendations, and this press report talks to the fact that it says that the FAA said that booster seats may not provide enhanced protection for children beyond what a seat belt provides in an aircraft.

A later paragraph then says that the FAA in the meantime will consider initiating rule-making to address the use of booster seats and harnesses in aircraft. Which way are we going? I am a little confused.

THE WITNESS: I can talk about the results of our research. I am not sure what regulatory reforms with regard to booster seats will come along. I do know that a number of airlines do not allow the use of booster seats in their operations.

MR. FEITH: When the testing for 1993 -- or, in 1993 started on this current -- that is now published, what was the anticipated time table for release of that information?

THE WITNESS: We -- I think I have been making excuses going on a year of when the results would be out. In April of '93 when we did the testing, I was telling people that I thought the results would be out in September of '93. They are finally out in September of '94.

It turns out to be much more difficult to sit down and write a report and make it coherent, especially in such a broad, open field where so little has been published, as with child seats in aircraft. So, I am not at all a reliable guide to how long it should have taken to get those results out.

MR. FEITH: One final question, and you may not be able to answer this. Are you aware of any pressure from upper management for the release of the report yesterday?

THE WITNESS: I know that there are a number of senior officials within the FAA who are very interested in child restraints, and we have recently been encouraged to get the research results out.

I am not aware of any guidance in terms of why it was yesterday. I do know that we have been very busy this summer getting the results out and having them reviewed and getting the final report written up.

MR. FEITH: Very good, Mr. Marcus, thank you very much.

MR. FEITH: I have no more questions, Mr. Chairman.

MR. HAMMERSCHMIDT: Thank you, Mr. Feith. Mr. Schleede?

MR. SCHLEEDE: No questions.

MR. HAMMERSCHMIDT: Okay. Mr. Marcus, thank you very much for your participation in this public hearing and for sharing with us your accumulated expertise in this important safety area. You may step down.

(Witness excused.)

With the last witness having been heard, this concludes this phase of the Safety Board's investigation.

In closing, I want to emphasize that this investigation will remain open to receive at any time new and pertinent information concerning this accident. The Board may, at its discretion, reopen the hearing in order that such information be made a part of the public record.

The Board welcomes any information or recommendation from the parties or the public which may assist it in its efforts to ensure the safe operation of commercial aircraft.

Typically, any such recommendations should be sent to the National Transportation Safety Board, Washington, D.C., zip code 20594 within 30 days after the receipt of the transcript of this hearing. This deadline usually is -- could be affected by unforeseen follow up investigative activities that evolved during the hearing.

For this accident investigation, the Safety Board will notify you -- that is, "you" being the parties -- of the actual deadline which will be determined by the completion of aircraft performance work still ongoing at the Safety Board. So, we will notify you of this future deadline. If you have any questions concerning this subject, you may contact either Mr. Ron Schleede, or the Investigator In Charge, Mr. Gregory Feith.

All the evidence developed in this investigation and hearing and all recommendations received within the specified time will be presented and evaluated during the preparation of the final report of the accident in which the National Transportation Safety Board's determination of the probable cause will be stated.

On behalf of the National Transportation Safety Board, I want to again thank the parties for their cooperation, not only during this proceeding, but also throughout the entire investigation of this accident. I might editorialize, I thought that, from my perspective, having participated in a good many public hearings, that the deportment of the parties and this public hearing was what I would call exemplary.

Also, I want to express sincere appreciation to all those groups, persons, corporations and agencies who have provided their talents so willingly throughout the hearing, especially the witnesses.

I also wish to thank the NTSB Support Staff, in particular Ms. Eunice Ballenger, Ms. Rhonda Underwood and Ms. Jan DeLorge for all the behind the scenes work that has helped make this hearing a success.

The record of the investigation, including the transcript of the hearing and all exhibits entered into the record will become part of the Safety Board's public docket on this accident and will be available for inspection at the Board's Washington, D.C. Headquarters.

I want to put emphasis on this next sentence. Anyone wanting to purchase the transcript may contact the Court Reporter.

I now declare this hearing to be in recess indefinitely.

(Whereupon, at 2:40 p.m. the hearing was adjourned.)

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