NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

In the matter of:	:	
THE INVESTIGATION OF THE ACCIDENT INVOLVING DELTA AIR LINES, INC., FLIGHT 1288, MD-88, N927DA, PENSACOLA REGIONAL AIRPORT PENSACOLA, FLORIDA, JULY 6, 1996	:	Docket No. SA-515 **VOLUME III**

Atlanta Hilton & Towers Hotel
255 Courtland Street
Atlanta, Georgia 30303

Friday, March 28, 1997

The above-entitled matter came on for hearing pursuant to notice, at 8:30 a.m.

Board of Inquiry:

John Goglia, Member NTSB
Chairman

Dr. Bernard S. Loeb, Director
Office of Aviation Safety

Dr. Vernon Ellingstad, Director
Office of Research & Engineering

Thomas Haueter, Chief
Major Investigations Division

Technical Panel:

Thomas Conroy
Jean Bernstein
Dr. Evan Byrne
George Anderson
Frank Gattolin

Staff:

Kevin Peterson
Special Assistant to the Chairman

Linda Jones
Confidential Assistant to Chairman

Shelly Hazle
Government & Public Affairs

Carolyn Dargan
Administrator

National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

Parties to the Hearing:

Delta Air Lines, Inc.
Technical Operations
Ray Valeika, Senior Vice President
Department 217
Post Office Box 20706
Atlanta, Georgia 30320-6001

McDonnell Douglas Aircraft Company
Flight Operations
William C. Steelhammer, M.S.
Senior Accident Investigation Coordinator
3855 Lakewood Boulevard
Long Beach, California 90846

Pratt & Whitney
Commercial Engine Business
Mike Young, Accident Investigation Coordinator
Airworthiness
400 Main Street, M/S 162-24
East Hartford, Connecticut 06108

Parties to the Hearing: (continued)

Volvo Aero Corporation
Aero Engine Services Division
Lennart Thoren
S-461 81 Trollhattan, Sweden

Federal Aviation Administration
Department of Transportation
Harold Donner
800 Independence Avenue, S.W.
Washington, D.C. 20951

Air Line Pilots Association
Captain Paul McCarthy
3877 Nottingham Drive
Tarpon Springs, Florida 34689

Board of Accident Investigation
Henrick Eindler
Stockholm, Sweden

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C O N T E N T S

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P R O C E E D I N G S

(Time Noted: 8:30 a.m.)

CHAIRMAN JOHN GOGLIA: On the record. Good morning, everybody. We will convene day three of the public hearing into the accident involving Delta flight 1288. And for today, our first witness will be Dr. Broz.

(Witness testimony continues on the next page.)

DR. ALFRED BROZ, NATIONAL RESOURCE SPECIALIST FOR NON-DESTRUCTIVE INSPECTIONS, FEDERAL AVIATION ADMINISTRATION, BURLINGTON, MASSACHUSETTS

Whereupon,

DR. ALFRED BROZ,

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

MR. HAUETER: Dr. Broz, could you provide your full name and place of employment for the record, please?

THE WITNESS: Yes, sir. My name is Dr. Alfred L. Broz. And doctor is an honorary title. I work for the Federal Aviation Administration. My position is out of Washington, D.C. My office is located in the New England Region in Burlington, Massachusetts.

MR. HAUETER: And what's your title with the FAA?

THE WITNESS: My present position with the

FAA is that of Chief Scientific and Technical Advisor for Non-Destructive Evaluation.

MR. HAUETER: And could you, please, provide just a brief history of your experience in this field?

THE WITNESS: I will try to be concise. If you don't mind, I'll do that from some notes. I've been with the Federal Aviation Administration since July 1 of 1990. Within that position, I've given advice on a number of issues, including the aging aircraft programs, the engine titanium consortium, the new course we have in place for training our NDI, our aviation safety inspectors in NDI.

I've been professionally trained as a physicists. I have a BS degree, an MS degree, and a Ph.D. in physics. The Ph.D. from the University of Notre Dame.

Prior to working with the Federal Aviation Administration, I spent 15 years as an Army civilian. My last position with the Army was that of the Chief for Materials Testing and Evaluation Branch. That site was in Watertown, Massachusetts at the Army Materials Laboratory, where I managed approximately 50 people involved in technical areas.

I was one of the founders and participants in

the ad hoc group on NDT under the White House Committee on materials and technology. I served as the Contracting Officers Technical Representative for the Department of Defenses Non-Destructive Testing Information Analysis Center. I have consulted for the Office of Technology in reports prepared for Congress in the area of non-destructive evaluation for advanced materials.

The Army Program for Training and Certification of NDT personnel was also under my management and control while at the Army Materials Technology Laboratory.

I do have experiencealso in fluorescent penetrant experience in fluorescent penetrant. Most of that has been the area of management and the generation and providing guidance for specifications and standards for both the process itself and the personnel involved in the process.

I've done that in a number of ways. Part of that is being a member of the American Society for Testing and Materials. Participating in an ASE Committee K activities. And while at the Army, Materials Technology Laboratory, the DOD program. And specs and standards for NDT is actually managed by the

Army, including the Air Force's and Navy's efforts in updating and cleaning up and promulgating new material.

I've initiated the ongoing R&D program within the FAA in the area of florescent penetrant inspection, and I also provide technical guidance to that particular R&D effort. And that should do it.

MR. HAUETER: Thank you, sir. Mr. Gattolin.

MR. GATTOLIN: Good morning, Dr. Broz.

THE WITNESS: Good morning, Mr. Gattolin.

MR. GATTOLIN: Can you hear this?

THE WITNESS: Yes, I can, sir.

MR. GATTOLIN: Okay. Great. Thank you. Earlier this year, you and others were involved with two other engine manufacturers regarding FPI programs and inspections, et cetera. Could you share a little bit of -- a little of this with us? What were the reasons for getting together with these folks and what is the expected outcome of this, regarding the FPI inspection process and things of that nature?

THE WITNESS: There were meetings before initiating a series of reviews in response to a National Transportation Safety Board recommendation. And before initiating those reviews, we thought reasonable to spend time with the engine manufacturers

reviewing with them their guidance for FPI both during the manufacturing and during the customer support portions of their business.

So, we did, indeed, review that. That was done as, again, a reasonable way of making certain that we were aware of the guidance that was, indeed, there with the tech base for that -- for the commodity of the rotating engine components.

MR. GATTOLIN: Was this also intended to establish a consistent methodology for FPI steps by step?

THE WITNESS: One of the things that was discussed there and that has -- was discussed actually earlier in other activities, including my participation in the SAE Committee K activities is that we should be working together as an industry of having in place a single accepted FPI standard for critical rotating engine components.

There is an SAE document, which the engine manufacturers did, indeed, work on. It's SAE 2647. And, however, there are enough exceptions from that by the major engine manufacturers to let it serve as a guidance document, but not necessarily as the document that is utilized.

There are reasons for that. Part of my personal perspective here is that employees could transition from organizations. You would not necessarily have to have a Pratt line or a Rolls line or a GE line. You would an FPI process. You, indeed, would have to be doing things peculiar to the components you might be looking at, but insofar as the FPI process itself, that would be standardized.

MR. GATTOLIN: Okay. And is this -- how far along have you folks progressed on getting this -- if I might use the word "standardized process?"

THE WITNESS: There was a task group initiated last -- a week ago Monday at the SAE Committee K meeting, that included two chairman; one each from General Electric and from Pratt & Whitney, who would be forming the task -- the rest of the task group to develop that particular document.

I, based on other constraints, was not able to attend either that meeting or the American Side and Non-Destructive Testing meeting that followed it last week. But I'm aware of the fact that that did, indeed, take place there.

MR. GATTOLIN: Have they -- these representatives given you any sort of a time frame as

to when this may -- at least a draft of the document and procedures may come forth?

THE WITNESS: I think that within the community of generating specs and standards, that it's not necessarily an overnight process. And realizing that we have already in place a fairly decent document with the 2647 document, there has been no time line established yet for generation of that.

Usually documents of that nature will take in the order of a couple of years to get finalized to the process. The committee formerly only meets twice a year. There is a good deal of work that goes into generating, reviewing, getting consensus on the components that's there. I know in my past positions within the Army, the specs and standards that even though we had relatively heavy control, as far as the review and the time line, we were still talking two to three years for a final consensus, technically reviewed document to be in place.

It's not an easy thing to do. However, it is probably the best way of managing it, so it is, indeed, a consensus document where the technical capabilities within the tech base are accurately reflected in the document.

MR. GATTOLIN: Okay. Thank you. We heard testimony yesterday from another -- other groups, other individuals with quite a string of qualifications. Regarding the incorrect perceptions that industry has about FPI, the acquiesce cleaning in FPI. Just for my own refreshment, would you outline some of the major misconceptions that the people in the industry have from your perspective, please?

THE WITNESS: I think one thing that is often overlooked is that the cleaning that perceives FPI is, indeed, an important part of that process. I, personally, am not an expert on cleaning, but I'm aware of the fact that the cleaning is the necessary pre-cursor to doing a valid FPI. That's one item that's often, I think, missed.

The other one is a -- what I would call a management perception that since this is such a conceptually simple process, that one does not have to pay attention to it or to invest in it or to upgrade facilities in it in order to match what is good recommended practice.

So, I've -- again, basically from my perspective, a lot of management oversight and investment in the technique and the process. You have

to enable and empower your personnel to do as good a job as they can. It is, again, a very conceptionally simple appearing process, a lot of process variables that could impact, that do, indeed, need to be managed and managed well.

MR. GATTOLIN: Could you give all of us a few examples of these process variables? Some of those that are really outstanding, if you will?

THE WITNESS: Thank you for making it a smaller subset.

(General laughter.)

THE WITNESS: One of the fears I have here is not being concise and sometimes just talking for a very long period of time when asked an open-ended question.

MR. GATTOLIN: Don't worry about it.

THE WITNESS: The fact that it is clean is an important step. The fact that you have the penetrant on long enough for it to get into the cracks is an important step. The fact that you remove the excess penetrant, because any of the penetrant you don't remove from the surface when it gets to the inspection booth, the inspector sees that.

It closed just as well as any of the crack fill or the penetrant filled cracks. And, for example,

in that inspection booth, having to deal with 100 false indications, trying to find whether or not there's a real one in there is not the kind of task you should be presenting to an inspector.

The issue of emulsification, again, removing excess penetrant, one has to caution both on not doing enough, which means that you have too much background and doing too much, which means you could possibly remove some of the penetrant from the item that you would like to have it stay in.

Another important step here is actually the application of the developer. The developer itself has to be uniformly applied. It has to be applied at a reasonable thickness. You can't put on too much. Or you can put on too much, but you really shouldn't. And you, obviously, have to have some on in order to aid the process.

The other -- another issue is in the area of interpretation. One has to make certain that the inspector in using the tools uses those well. For example, the issue of bleed back. One of the things we did here is that -- and I did want to technically clarify. Is that it is, indeed, important to do the bleed back if, for example, you use an unacquiesce

developer to do that bleed back, you may, indeed, have removed all the penetrant.

So, doing that a number of times and then saying, ah ha, there's nothing left here, is not a very viable technical procedure.

And those, I think, are the highlights.

MR. GATTOLIN: Okay. You mentioned that -- and I'm going to paraphrase it or at least give you my interpretation of what you said a little bit ago. That the FPI line and management of these lines need to keep it up to date. That would -- modernizing it and things of this nature. Would it be a -- how do you feel about a procedure that was established, oh, 20 years ago that's being used -- still being used versus what's available presently? There's --

THE WITNESS: The --

MR. GATTOLIN: -- that much change?

THE WITNESS: The procedures realistically have kept in tune with the times, if you look at the guidance documents. They are, indeed, updated. Those within the professional societies, the main ones there, and not just the professional societies, but with the government, the guidance, the SAE guidance, the ASTM guidance, and the OEM guidance, is updated.

The comment, again, is that some things have popped up like black lights that didn't work very well. Gave out too much visible light, for example. Those have gotten into the system, and those, indeed, were removed from the system. But, I think, as far as updating on the guidance, the guidance has, indeed, been well managed within the tech base. And, again, in those major areas from the OEMs, the DOD, and even though the DOD has just recently gotten out of the business or part of it.

MR. GATTOLIN: How about the actual procedure itself, has there been much change? You have updated guidance. Say, an operation has been using the same process for the cleaning and the FPI inspection now or today as they did 20 years ago.

THE WITNESS: There has not, what I would call, been substantive changes.

MR. GATTOLIN: Okay.

THE WITNESS: One, again, as learned about black lights, about bleed back, et cetera, but nothing that I would call substantive. The process is basically what it was around 55 years ago.

MR. GATTOLIN: Okay. You alluded a little earlier that the management should be aware of the

processes, so it would work better. And I'm going to -- would you clarify that, please, i.e., would a shop manager of the FPI's side, the inspection side, how conversant should that individual be with the cleaning side of this process and how conversant should the cleaning individual, the supervisor or manager be with the inspection side? And then a third portion, C, is how conversant should the inspector be or how knowledgeable should he be about the cleaning of the object?

THE WITNESS: Let's start at the top from my memory of your question. And the issue that I was initially referring to is the fact that this is one that needs, indeed, to be managed as far as an investment within the organization. That doesn't necessarily mean people have to know very much about it, other than the fact that it is a necessary part of doing business that has to, indeed, be managed and resources have to be applied to it.

The next issue that I believe you asked was in the area of the immediate managers and/or supervisors for both cleaning and for the FPI process. I would like to believe that the manager for the FPI process is aware of the fact that the cleaning process

for the materials that come into a shop that isn't, indeed, an important and critical one and does have a very good working relationship with that other shop foreman.

I would also like to believe that the shop foreman for the cleaning organization has a very good working relationship with the foreman for the FPI shop and is aware of the fact that part of his product line does, indeed, go to FPI inspection.

If we go down to the level of the individual inspectors, I think the inspectors on the FPI side have to be aware of the fact -- and I think there's some very reasonable guidance out there of things that come into their shop that are too dirty to be inspected. And they should, indeed, return those, and it should be considered a normal way of doing business than an adversarial one.

On the cleaners side, I would like to see a good deal more sensitivity of the fact that their product or at least part of that product line is going to an FPI inspection. And that their caveat there is not to clean the part, as well as possible, but to clean it as well as possible for an FPI inspection. This means, for example, they do not take plastic media

blast all over the thing. They up the pressure to make it look good, but perhaps do some inadvertent damage. They may, indeed, for example take other tools and clean it up, but may, indeed, prohibit downstream a valid FPI.

I think the cleaners have to be aware of the fact that their job is not strictly just to clean the items so it looks good, but so that the subsequent step is one of FPI and the process controls that are in place in cleaning have to be also aware of that.

MR. GATTOLIN: Okay. Thank you. We had heard some comments yesterday about an inspector's daily performance checking that. I would like you to, if you would, please, give us your thoughts on that and provide any -- well, just go ahead and give us your thoughts on it, please?

THE WITNESS: I'm going to ask you to redo that one. I was doing a sip of water, I think when you hit the crucial point that I missed in the question.

MR. GATTOLIN: Okay. We talked yesterday about how to check an inspector's daily performance.

THE WITNESS: Oh, okay.

MR. GATTOLIN: And being in the position that you are and having worked on a number of programs, what

would you suggest as a viable method to check the inspector's daily performance on the line?

THE WITNESS: Well, we've heard a number of tools described here as far as the tam panels, LCF blocks, putting a part through, making certain that a number of other issues realistically and in a practical situation. It's important, I believe, for the foreman or supervisor to basically watch, work with his staff to assure himself that in their performance of their duties, they are doing them well. That is the -- again, the only reasonable way putting through bogus parts or -- and that's a bad term. I'm sorry. Putting through a flawed part. Putting through -- having them work on an LCF blocks every day. Those are not realistically good, practical, viable ways of assuring a daily performance.

I think you realistically -- you watch people and you look at people while they're working. It doesn't mean you spend all day looking over their should, but you do an assessment. The other things, I think, that were brought up are very good training aids and perhaps very good retesting aids. I, personally, concurred with the one from the pilots that we shouldn't put parts that you put back into an airplane

out there for a test. I like that suggestion very much. How's that?

I think those kinds of things are very appropriate for a testing exercise, a recertification exercise, a retraining exercise for inspectors. And that includes the flawed specimens that you find, the artificially produced ones, for example, say, the LCF blocks. A lot of other tools that are out there in order to basically judge inspector performance. But I wouldn't routinely throw those to the line.

I know of no good studies that say that does anything good.

MR. GATTOLIN: Okay. Thank you. In the area where the inspector is, how important is it that the individual have as little background white light and also the proper intensity of the black light that he's using, as well as a clean area? What are some of the problems that could take place with that?

THE WITNESS: I think there are two distinctions I'll make here. One of them is for the overall process itself. And that starts off, again, with the application of the penetrant and then you get into an inspection area where you're looking for the indications.

It's hard to -- unless you make that distinction of saying what's appropriate. It's obvious that during the handling and the application of penetrant and the emulsifier, et cetera, one should be able to see what you're looking -- what you're working on and not stumble, et cetera. So, there are reasonable guidelines for the fact that you should have a high white light level there for part of that.

Rinsing, usually people will use a fluorescent black light tubes to give you an idea of what kind of background you might be leaving on there. That's also, again, a very reasonable thing to have in the overall FPI processing inspection area.

To go to where you would be making the distinction of are the indications here flaws, that particular inspection then has a lot more requirements for it. Usually within the standards, it's not recommended to have more than 2 foot candles of white light within that inspection area. That's enough for the inspector to be able to see while he's performing.

I, personally, don't like it quite that high, but others than myself have said that's a reasonable upward bound. The inspector also should have available to him a spot type of black light that he can

manipulate, move around, along with himself being moved around, along with the part being moved around, so that he can put relatively high levels of black light intensity on the part in a localized area to do that inspection.

The usual criteria within the standards is a thousand microwatts per centimeter squared at a distance of 15 inches from the black light bulb. That measurement, again, varies from standards, but usually should be performed on a daily basis. What happens with the black lights is they -- as a function of time, start diminishing their output. It's a kind of thing that if you just look at them, you can't tell that unless you do the accurate measurement.

So, we've talked about the two light issues in there. There are other tools that the inspector should have in that arena. They include the handling, fixturing, the ability to mark indications, additional developer and/or not in order to do -- properly do the bleed back operation, application -- applicators for solvent and a number of other tools, to allow him to perform his job. But the light that you asked about, again, in that area are those two. The white light and the black light.

MR. GATTOLIN: If you would, just for me, I've read these things and I've said all right, what is 2 foot candle. And I thought that would be something we'd find at Christmas. So, what's that equivalent to in a light bulb in a lay term, a 10 watt light bulb, 5, 25 watt bulb?

THE WITNESS: I'm going to be very honest with you and tell you I can't do that conversion right now. I can tell you historically where that one came from. And it's very obvious from the definition, at the time before, there were electric light bulbs, you took a standard candle and a foot away, that was the light intensity. That one has stayed within the system.

There are other systems that are utilized for doing that. Lumens is one of them. And if you look at light bulbs in the order of, say, the 50 to 100 watt range, they are in the order of 1,000 to 2,000 lumens, the lumen -- and I forget conversion factors off the top of my head. There's a very simple one and I think it's a factor of ten, but I don't even remember which way it is.

MR. GATTOLIN: Okay. Just wondering. Thank you. On the subject of tam panels. You led a team at

Delta and found some problems with the tam panels. I don't care to discuss that at this point, because we have already gone through that. But I would like you to elaborate on, if you would, please, is what would be the best way and most practical way to clean tam panels and to store them?

THE WITNESS: You've asked two questions.

MR. GATTOLIN: Right.

THE WITNESS: Best and practical.

MR. GATTOLIN: Okay.

THE WITNESS: A very -- the thing you have to remember about tam panels is what they really are. And that is, basically, a piece of stainless steel with some chrome plating on them. That chrome plating is relatively thin. The actual cracks that are on there are in the plating. They're not in the stainless steel. They are relatively shallow. Hence, they are a very good indicator, actually, whether or not your system is working.

In order to clean them practically, you can just spray, for example, an unaquiese wet developer on them a couple of times. If you don't have any more indication, I would then, again, use basically what Sam Robinson said, he used the word "serficant" (sp), but

that's basically soap and water. You wash them off. Dry them. Make certain you're not taking the water or contaminating. They store them in a solvent.

It's an easy and very practical way of managing that. You just take the top off the container and put the panel in and close it up again.

A better way of cleaning to make certain that they are always clean, et cetera, is to do the ultrasonics that was commented on, that's basically an ultrasonic cleaner, with a solvent in it, and then to do the storage again and the solvent.

My own personal thing is for a practical thing, I'd try the non first. And if that cleans it up, I wouldn't worry about the rest, because you already know it's clean. And I would then just put it in the solvent. But that's a practical tradeoff.

MR. GATTOLIN: Okay. What type of quality of product areas can compromise parts cleaning?

THE WITNESS: The things that one worries about with parts cleaning is the fact that they aren't cleaned in the first place. That there's contamination. The contamination can be any of the things that the cleaners did not actually remove. The alkaline cleaners -- again, they're in place. They'll

not remove everything.

There couldn't be surface damage done by handling during the cleaning process and actually in the FPI process. I am not aware of the practical limits, for example, of some of the mechanical ways of cleaning. There are cautionary statements within the specs and standards to be careful when you do those things, but it doesn't mean that they are precluded then if you have adequate data that they cannot be performed.

The thing that would be of concern there, again, is that the FPI inspector in receiving those items cannot tell realistically what has been necessarily removed. He has a number of things that he can do to say that they're too dirty. For example, if when he puts the penetrant on and the penetrant breaks on him, he knows that there's something really wrong with the cleaning process that went before it.

MR. GATTOLIN: Okay. Going into the subject of flash drying, can you, please, tell us what the limitations of flash drying is, in your mind?

THE WITNESS: The flash drying is a technique that has been historically utilized within the tech base. It is a practical way of trying to bring a

component up to temperature relatively quickly.

The heat transfer from the water to the metal item is much faster than using just, for example, a convection heat within an oven. And the tradeoff there is getting the item relatively hot, relatively fast, so that it dries fast. In a production environment, if you can do that process, for example, within five or ten minutes versus it taking 30 minutes to an hour, one usually defaults to the one that's the most time effective and, hence, the most practical one.

It has, indeed, worked. Does indeed. Has demonstrated a capability. People find cracks all the time with utilizing that as the drying technique. And I can -- you know, I think I've shared with you some of the very practical reason for why you would do that. Again, as you've learned, one of the major engine manufacturers recommends an oven drying. The other two do not.

MR. GATTOLIN: As the part is drying -- and I believe you've answered this, but I'm still unclear. If we've got a deep crack in the large part -- let's say, such as a 219 hub, flash drying, in your mind, will consistently remove water from that type of a crack?

THE WITNESS: I would like to restate the question in the sense as how do you assure yourself that the part is dry and adequately dried? And the issues of being adequately dried would apply to both the flash drying process and to an oven process.

Whether it's brought up to heat using the water or brought up to a temperature using the oven and the for the period of time that it's at that elevated temperature are the important criteria, not the process.

So, what I'm trying to share with you is that the drying is, indeed, an important issue, and that that, indeed, has to be properly performed for the item. And, again, the contact times or the amount of drying times are perhaps different for the processees, but the issue here is one of adequate drying period, not a technique for drying.

MR. GATTOLIN: Okay. Thank you. On the subject of plastic medium blasting, are there any -- what are the potential anomalies that can take place with this process?

THE WITNESS: The concern that's here is that in the guidance and, in particular, within ASTM, they share with you the fact that one should, again, be

careful in utilization of any kind of mechanical cleaning. And they specifically state, titanium in there. That may, indeed, have been a technical oversight on the part of the people who did that one, but that is, indeed, in there.

There have been at least one study that's in the public domain, which was done by the Navy and around the '90s time frame. And if you need to, I can get that for you, but basically -- and it was not for titanium. It was for an aluminum product or aluminum material. That basically said there were two issues there. One was painting and the other one was in the area of filling up the crack with the product or with the plastic media.

It was more from my perspective an issue, these are things that one should be worried about to make certain they're under control.

MR. GATTOLIN: Okay. The last question that I have, and then George Anderson would like to talk with you for a short time, is how does an inspector or the processor check to see that a plastic media may not be embedded in part of the component that's going to be dipped into the dye?

THE WITNESS: The FPI inspector has no tools

in order to make a judgment call that there is plastic medium in the crack. He doesn't know where the crack is. He doesn't know where to look. He has no tools to look.

MR. GATTOLIN: Okay. How about the --

THE WITNESS: He cannot make that judgment call.

MR. GATTOLIN: How about the processor, the individual that's going to be dipping it into the dye and taking it from that point?

THE WITNESS: The processor is a peculiar thing to Delta Air Lines. Usually, that is an FPI inspector who does that and the same criteria holes. He has the same -- he has no different tools. He does not have the capability of making that technical judgment call. He does not know where the crack is, does not know where to look, and has no tools to look.

MR. GATTOLIN: This leads me to one other question. Sorry. What could be done to ensure that plastic medium would not be embedded into a crack?

THE WITNESS: I think the issue here is making certain that the process that is used for cleaning is in conformity with the guidance that is there and in this particular place, that the pressures,

the stand-off distances and the angles of application are in accordance with the guidance that's available.

Again, that's -- it's a quality control issue. It's not an issue that you can go in and look, because you don't know where the cracks are, if there are any, even. So, the only way to manage this one is the quality assurance tool issue.

MR. GATTOLIN: Okay. Well, thank you very much, Dr. Broz. Mr. Anderson.

MR. ANDERSON: Good morning, Dr. Broz.

THE WITNESS: Good morning, Mr. Anderson.

MR. ANDERSON: I would like to change the subject somewhat. In your capacity as the senior non-destructive inspection expert or technical expert, I would like you to share, if you would, with us some of the -- some of your prospective on the blue etch process that we've been talking about so frequently here?

THE WITNESS: I am aware, again, of the fact that blue etch is one of the inspection tools that is utilized for titanium looking for hard alpha, alpha case, and some machining anomalies. It is not a classical NDT technique. I'm not an expert in the technique, and I do not consult in the technique.

My own personal thing on this one is that this is an issue that you look at, you look at the data, you look at whether or not you have reference standards, and make a decision from that. I have not been asked to do that. But in my peripheral assessment of other techniques, I've seen that, looked at it, but I do not make the judgment calls nor do I consider myself a real expert.

I just haven't had the chance to look at the data or to make any decisions based -- or form any opinions based on data furnished. And that's part as a personal call on my part, not to learn a whole bunch more than the things I'm already even responsible for.

MR. ANDERSON: Is there -- are there other resources within the FAA that have done technical evaluation work on the blue etch or would you say that this is a relatively recent issue, technical issue?

THE WITNESS: The utilization of blue etch has actually been around for a while, as you're aware. And what the agency has been doing historically -- and I think probably doing very adequately is making some very good engineering decisions based upon the data presented to it and saying, based upon this data, this is a credible way of doing viable inspections.

Usually, in those kinds and that level of oversight, I would not have any role. There's no need to throw me at that kind of an issue.

MR. ANDERSON: Would it be reasonable to expect the FAA to establish some base line of test data or verification of this process, so that the public's confidence in its ability to detect the type of anomaly that we've seen in this accident investigation was well-founded?

THE WITNESS: Again, I have not reviewed the data that is already available and, perhaps, already applicable in this area. And I would not be in a position to give what I would consider a reasonable opinion in this area for lack of sufficient data on my part. For all I know, that material and information may already be available and probably is, as a matter of fact.

MR. ANDERSON: I understand. Are you familiar with the resources available to you in the engine directorate to conduct research in this area or have this done by the outside academic community?

THE WITNESS: The engine propeller directorate per se does not have research capabilities within the directorate. They have a role in defining

and establishing research objectives that are funded and managed by other parts of the Federal Aviation Administration.

MR. ANDERSON: Are you aware of any programs of funding for research in titanium, titanium fabrication, titanium manufacturing?

THE WITNESS: There is, indeed, a relatively significant and actually very successful program, called the engine titanium consortium, that was established as a result mainly of the Sioux City incident, of looking for and the issue of inspectability for hard alpha. There have been some very significant advances made in the detectability at the billet stage under that particular program, which is the base material that goes into the rest of the manufacturing process.

There have been a number of other activities in that particular program that took, again, a few years to get that in place and is one area, for example, where I do, indeed, give a good deal of technical advice.

So, it is, indeed, a resource. Again, the lead time for -- I think, as you're aware, of impacting the Congressional budget is a minimum of two years to

get anything of significance funded.

MR. ANDERSON: Can you tell us, generally, about the level of Federal funding or FAA funding that would go into the area of non-destructive inspection, not just titanium parts, but that would relate to rotating engine parts, which would be of a special concern to the engine directorate?

THE WITNESS: There are other activities besides the engine titanium consortium. There is another effort at Southwest Research Institute. Some of the manufacturing inspection issues that are there involve the propulgation of hard alpha. The types of material during the manufacturing process, looking for its distribution and its detectability.

Another effort that is, indeed, in place that I think is of interest to the engine propeller directorate is a joint effort from our Center for Aviation Systems Reliability at Iowa State and at San Dia National Labs in the area of doing florescent penetrant, R&D. That's one of the issues that I brought up earlier.

That one is presently funded under the aging aircraft program. But, again, the issues that are there are generic to the tech base of the adequacy of

performing fluorescent penetrant inspection.

MR. ANDERSON: So, is it correct to say that the larger part of the funding is going toward the air frame type of NDI problems?

THE WITNESS: The thing I've shared with you is that there are efforts at San Dia, at Iowa State under the larger caveat of airworthiness assurance, which is where the next contract will be at and may not, indeed, be with those particular contractors, and with an effort, again, facilitated by Iowa State that is called the engine titanium consortium.

There are other issues that are dealt with within those efforts that are not only inspection issues. And, for example, again, the Southwest issue, the Southwest Research Institute issue.

MR. ANDERSON: Yes.

THE WITNESS: Those are not mainly inspection issues. And I'll be honest with you, the only portion I usually track are the ones that are the inspection-related issues.

MR. ANDERSON: I understand. A related question is, does San Dia -- do San Dia Labs do any work with the penetrant side of the non-destructive inspection?

THE WITNESS: San Dia is one of the participants in the R&D program, looking at fluorescent penetrant inspection. That is correct.

MR. ANDERSON: Changing to a different area, could you share with us, Dr. Broz, how you inter-relate with the engine managers at the propeller directorate as far as they, as I understand, are the primary managers of the individual engine programs. And how do you relate to them in transferring and communicating technical issues?

THE WITNESS: It depends upon the area of interest. I work with the standards organization in the development and in the monitoring of the R&D activities. I will work with the certification office, the managers, perhaps in the area of new engines, looking at inspection issues related to them.

I will work with other parts of the organization when we're having troubles, for example, with things failing, where I will then consult on solutions that may involve inspection. I will also work with the manufacturing aviation and safety inspectors, again, giving them technical guidance when they go out and do some of their reviews if it's -- if they're running into activities that are primarily NDI.

That's the ways within the directorate itself. And that interaction involves people from Mr. Parde, obviously, down to individual people within the directorate.

I do the working relationship with whoever is appropriate for the consulting.

MR. ANDERSON: I understand. If you, as the senior technical person at the engine and propeller directorate --

THE WITNESS: Let me clarify that, sir. I am not the senior person at the engine propeller directorate. I do that for a much larger audience than the engine and propeller directorate, just as a resource for the agency.

MR. ANDERSON: And so, you technically -- your technical superior would be?

THE WITNESS: I'm sorry?

MR. ANDERSON: You would -- your technical superior would be who?

THE WITNESS: I have a manager in Washington, D.C., who is my -- part of the management chain. And, again, the position is out of Washington, D.C.

MR. ANDERSON: My question would be, in your capacity as a technical -- having technical oversight

of the non-destructive inspection process for the FAA, at least in the area of engines, which is our interest here, what would your prior -- next priority be if you receive funding for research that would enhance the issues that we've looked at here? That would include, of course, the fluorescent penetrant issues, as well as the blue etch. Where would your priority be, sir?

THE WITNESS: The priority would be in assuring the viability of the fluorescent penetrant inspection process. We have a technology that is now 55 years old. The concern here is that one of the very viable third parties for assuring the adequacy of that material has just retired from the Air Force. And the Department of Defense has, again, been getting all the specs and standards business.

The first portion of our research program is to the ability to -- and I'll use this word "duplicate" the capability of validating fluorescent penetrant inspection products, as well as the Air Force was able to do and having that as a tool from which then to do other engineering efforts.

One of the other things that we have done under that program is actually document the process that was utilized by the Air Force. Since this was

basically institutionalized in the form of one individual, we thought it reasonable to actually document that. So, that's been one of the efforts in that program.

I would actually think the return on investment was not only in that particular program, but in assuring that the good guidance that is available is, indeed, transmitted. One thing, for example, there will be a work shop at the next American Society of Non-Destructive Testing on penetrant materials. I think the return on investment here is getting the good guidance into the tech base.

We've done some of this at the ATA, NDT forum. Again, it will be an issue at the next ATA, NDT forum. But if I was looking at return on investment, I would want to be making certain that the good guidance that is available is implemented in the tech base. And that's not necessarily heavy research effort.

MR. ANDERSON: Yes, sir. The part that I hear loud and clear -- and let me make sure that I understood it correctly -- is that the -- some of the information now is in the form of military specifications and standards.

THE WITNESS: The guidance document, MIL-I-

6868 has actually been rescinded and has been replaced by an ASTM document, 1417. And actually, a 95-A version of that. The issue that, again, is the one of concern is a qualified products list that the Air Force did issue saying in our opinion, these penetrants perform adequately at this level. Hence, they're suitable for doing an FPI process. And that was done independently, again, by a third party.

It was not done by the manufacturer of the product who said, here, buy my stuff, it's good, trust me. I really like that independence, and I wanted to make certain that it was well-documented and potentially transferrable within the tech base to another custodian. If necessary, for example, for aviation things, I would have had no problems with the fact that once we were able to duplicate it, if it was necessary to serve as that third party, at least for aviation stuff, through the San Dia operation.

I was, again, concerned with the maintenance of the QPL list.

MR. ANDERSON: Yes, and I would like to ask one more question in that area. This document that you are transferring is, indeed, a dead document in the sense that --

THE WITNESS: The document we're transferring is not a dead document, sir. Excuse me for intruding.

MR. ANDERSON: Let me clarify what I mean by that. The military is no longer using personnel or resources to update it with more modern information. And my question to you, sir, is when it is transferred to an organization such as the ASTM or San Dia labs, what assurance do we have that resources will continue to be dedicated, to keep this document current and not allow it to become obsolete?

THE WITNESS: I think you have a very good question, sir, and I can give you no personal reassurances, since I don't have that kind of money myself in my pocket. I think it's an issue, again, that does, indeed, have to be worked with in the tech base.

I will assure you that I do my level best to make certain that there are resources, indeed, expended in that area. Again, those that I can influence have so far been within the FAA. I will share with you that the Air Force has continued and intends to continue maintenance of the QPL list.

They have rescinded -- they have not rescinded, but they will rescind the document that is

in place under which the QPL list is developed and that will become an SAE document. I believe they're going to adopt the 2644 document in place of the MIL spec. They still will maintain the QPL list, though. And that's their intention, and they have, again, personally reassured me, the management within the Air Force, that they intend to do that, as well as they can for the foreseeable future.

MR. ANDERSON: Now, just one more follow-on question there. Assuming, of course, at least for the present, that this information is the best information that the industry has to maintain the integrity of -- in this case, the inspection processes, we've already heard from various vendors and so on, that there are different specifications in use, different -- they are free to use whatever specification -- the engine manufacturer is somewhat free to use the specification they choose to in their manuals.

How does the FAA intend to impose or communicate or strongly recommend these standards that they believe are the best?

THE WITNESS: Again, I think you have to be clear that there are different kinds of standards. And let me go back again to the QPL list. The QPL list is

a document that controls the materials being utilized in the process. And that one says, an evaluation -- well, that one evaluates and says, these are suitable. This is a level 4 penetrant, for example, and when properly applied, it will perform within these minimum -- the minimum criteria, a one controlling the material.

The other documents that are in place are more of what I would call process documents. And, again, the effort for my personal part is to look for a coming together, at least for the critical rotating engine components, a more uniformed document.

I'll utilize Delta's example. They have relabeled -- and that was actually one of the issues that Mr. Gattolin stumbled over yesterday as a level 1 and level 2 penetrant. There a level 2 is the ultra high sensitivity. The level 1 is the high sensitivity one.

That's nomenclature adopted by Delta. I've picked on them, because Mr. Gattolin tripped on that one yesterday. What happens is because of the different guidance documents for the process, we have finally gotten in place, I think, the fact that people say this is the level, the sensitivity, the kind of

material, I would like to not see this relabeling within the user's -- for example.

And, again, you're going to see my own personal efforts of trying to get a process one in place that is more universally utilized and makes it much easier, again, I think for the people who use the process, to use it for different -- different vendors or I mean, different OEMs.

It also makes it much easier for personnel to move from organization to organization and not have to relearn what I would call useless information. That's how they do business there and how they call things.

MR. ANDERSON: Thank you very much, sir. Mr. Chairman, I have no more questions.

THE WITNESS: Thank you, Mr. Anderson.

CHAIRMAN GOGLIA: We will go to the Tech Panel. Mr. Conroy?

MR. CONROY: Yes, Mr. Chairman, I have three questions for clarification. Dr. Broz, I believe you mentioned that the FPI process itself is a 65 year old process.

THE WITNESS: The process is 55, sir.

MR. CONROY: Fifty-five. Do you feel there are any important new ways to complement or supplement

this process?

THE WITNESS: There are many non-destructive testing tools that are utilized. And FPI is only one of the many tools within the repertoire of the technology that's available. It is an extremely useful area inspection device that's relatively inexpensive and relatively easy to utilize.

There are other techniques. They are usually more point specific insofar as doing an inspection. And part of the technology is knowing which tools to use where and where the best return on investment -- what is the most practical one utilized.

There are, depending upon whose listing you look at, well over 100 tools in the arsenal of NTD technology for assessing materials and components.

MR. CONROY: I believe you were present yesterday when Mr. Maucere testified. Is that correct, sir?

THE WITNESS: I believe I was, indeed, here.

MR. CONROY: Yes, sir. And the record will show his testimony, but if I can characterize it, I believe you stated that he now has confidence in eddie current, especially, since the accident. I wonder if we could have your comments regarding this as a

supplement to FPI and whether FPI in itself can stand alone or whether it requires eddie current?

THE WITNESS: I think the comment that I would like to make here is that you have a number of tools. The fluorescent penetrant inspection has some relatively well-known reliability figures as far as flaw size that's detectable. It is, indeed, an area inspection device.

I would see the utilization of an eddie current device in this particular application, improperly done a rotating probe, et cetera, to be one that would complement the fluorescent penetrant inspection. What you accomplish then is by having two inspection methodologies utilized, if having the good results of one, enhancing the good results of the other, so you have a higher probability of finding flaws, but they are ones that complement, not necessarily one -- saying one is absolutely better than it is. One really has to look at the applications.

This one, again, is a bolt hole with one linear geometry. It is one where it's relatively easy to implement -- at least technically. Not necessarily practically -- to implement an eddie current inspection. Because the -- you're able to then do a

very thorough assessment of all the little points by doing a circular inspection, but, again, the issue here, I think, is one of complementing, not necessarily saying one is necessarily better than the other.

And I think the thing that has, indeed, been put on in this particular one is one we're looking for enhancement, so we have a complementary techniques that are utilized for the inspection process.

MR. CONROY: Is it fair to characterize what you just said that FPI can stand alone as a reliable process for rotating titanium parts, such as this?

THE WITNESS: I think FPI is a viable, stand-alone process, based upon proper application and, again, will adequately do jobs with -- or perform as long as you know the limitations of what you're trying to accomplish. If you operate within that -- those parameters, it is, indeed, a very viable inspection methodology.

MR. CONROY: Thank you very much. One last question in regards -- your comment that at Delta Air Line, the processor and his work is separate from the FPI inspection or the FPI. Is that true, sir?

THE WITNESS: My perception, while I was at Delta, is that what I would have normally considered

the FPI process, which is from the application of the penetrant to doing the inspection, is what I would normally consider the FPI process and I would normally consider the people doing that FPI inspectors.

What Delta has set up is that processors perform all the functions except for in the booth doing the reading of the part for indications.

MR. CONROY: You found that a variation from the normal industry practices?

THE WITNESS: Yes, I did.

MR. CONROY: Do you feel that's an important variation?

THE WITNESS: I think the suggestions that were made in the report is that if that process is continued, that there should be some enhancement of the training that's provided those people. Quite often, the people who do that, for example, in other situations would be a level 1 or some other kind of person or even a -- well, not necessarily a specialist, depending upon the call, but they would not necessarily be the same level of person doing the inspections and the calls for criticality of the indications.

So, again, the suggestion in what we did make as a team was that they should consider, perhaps,

upgrading the training and the documentation the training provided those personnel.

MR. CONROY: Thank you very much. Thank you, Mr. Chairman.

THE WITNESS: Thank you, Mr. Conroy.

CHAIRMAN GOGLIA: Any other questions from the Tech Panel?

MR. EINDLER: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: We'll go to the parties. ALPA?

MR. MCCARTHY: No questions.

CHAIRMAN GOGLIA: Pratt?

MR. YOUNG: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Volvo?

MR. THOREN: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Delta?

MR. VALEIKA: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: McDonnell Douglas?

MR. STEELHAMMER: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Dr. Ellingstad? Oh, the FAA. I'm sorry.

MR. DONNER: Thank you, sir. We have no questions.

DR. ELLINGSTAD: Thank you. You indicated,

Dr. Broz, your desirability of a single FPI process standard instead of different standards dictated by different of the OEMs. How variable are the OEM recommendations or requirements?

THE WITNESS: The issue here is the fact that realistically, a carrier will take that guidance, then establish its own process to say that it's in conformity. It will try its level best to find one that they can utilize for both -- or for either two or three of the engine manufacturers. And what they ended up doing is doing the technical judgment of what is the best blend of those.

We have a regulatory problem in the fact that when we put out an airworthiness directive, that it should be done in accordance with the particular OEM's guidance. That's not necessarily what's in place at the carriers and/or the repair stations that would, indeed, see that item. It would be much easier to manage and much easier to implement guidance if that was, indeed, the same process. The variability is not necessarily always very great, but there is different sensitivities within the OEMs as to what things they considered a little bit more important.

So, one player may say you need to do this a

little bit better. Another one will say, you have to do something else a little bit better, and it's an issue of -- well, let's see what the best process is, so that when we put it out, we don't have to have people interpreting it and reinterpreting it for their particular application and for their particular organization. You lose things, a personal call in translation.

DR. ELLINGSTAD: Is there a gap in the oversight here that creates difficulties for the repair station, for example, in terms of -- they're responsibility, as I understand it, to the OEM for compliance with that practice and they're trying to come up with a single procedure that will satisfy their treatment of parts from different OEMs. Does the FAA have a sufficient role there in terms of examining whatever that procedure is?

THE WITNESS: There were, for me, too many variables in your question to manage an easy response. And I'm going to ask you to, please --

DR. ELLINGSTAD: Okay. I apologize for that. We have a situation where the repair facility has to accommodate to requirements or recommendations from multiple OEMs. And that -- and basically, satisfy

them. And what I'm asking is, does that create a difficult situation for them in terms of establishing when they, in fact, have developed a procedure that will comply with these multiple requirements?

THE WITNESS: I think they, indeed, have to put an effort into developing that. And that, from my perspective, is not necessarily time well spent by them. I don't -- I think it's wasted time, if we would have a more single document that provided the process guidance. Admittedly for particular components, ones should be looking at different places, there should be things highlighted. But insofar as the process itself, I would like to see it being uniform.

And I'm convinced by looking at you, that I didn't answer what you wanted.

DR. ELLINGSTAD: No, I think you got most of it. Thank you.

THE WITNESS: Thank you, sir.

CHAIRMAN GOGLIA: Dr. Loeb?

DR. LOEB: Good morning, Dr. Broz. I would like to just follow up on that. You've repeatedly addressed the issue of efficiency, time -- savings and time, easier to transfer and so forth as being one of the major benefits of developing a single process

standard or standards for a single process. My question is, the lack of a single standard, having a variety of ways in which these processees are now performed and done, is that -- does that have a direct bearing on the effectiveness of the inspection, the safety aspects?

THE WITNESS: I would like to believe the issue is here of one of efficiency and the ease of doing oversight on the part of the regulator, also one of ease in compliance with the ADs, and those are the issues that I'm worried about. I am not so concerned with the process itself.

DR. LOEB: So, I would like to believe that it would be one of efficiency, as well. I'm not sure I do believe that. I'm wondering whether these differences, these variabilities may, in fact, go to the heart of why cracks may not be detected on occasions. Do you believe that consolidating and these variances in trying to develop a single or a couple of processees that are used would help to reduce the possibilities of cracks being -- not being detected?

THE WITNESS: I have the opinion that having a single guidance for the process would be a better way of doing business. That is, indeed, correct, sir.

DR. LOEB: The approval of the maintenance and inspection processees that are done and performed by an air carrier or by a 145 station -- repair station, is the providence of the FAA. Is that correct?

THE WITNESS: I'm going to share with you that that is easily outside of my area of technical competence.

DR. LOEB: Okay. That's fair enough. We have someone who I can direct that to. Let me ask a couple of questions just for clarification for myself. I don't know whether it's been -- these things have been addressed earlier or not.

How does a processor or an inspector determine that a part has been adequately dried, either through flash drying or through oven?

THE WITNESS: The issue of adequate drying independent of the process, the only thing that the inspector or processor can do is look at the surface and make a determination whether or not that is, indeed, wet. He cannot make a judgment call, whether or not there is any moisture or anything else in the cracks that he doesn't even know exist or potentially exist. He cannot make that judgment call.

DR. LOEB: Yes, that seems fairly obvious to me. And I would assume if that crack happened to be in a deep bore, 2 or 3 inches -- a hole that's 2 or 3 inches deep, it would be virtually impossible?

THE WITNESS: I think the criteria that I've already mentioned says that he doesn't have the tools period. The location is actually independent of that, if he doesn't have any method of doing it in the first place.

DR. LOEB: I would agree. I think my observation is that if it's extremely difficult on the surface, it would be virtually impossible if it was in a hole, in a deep hole.

THE WITNESS: I think the testimony I've already given is in concurrence with your comment.

DR. LOEB: Is FPI, in fact, an adequate inspection for detecting cracks that exists in a deep hole that's of small diameter?

THE WITNESS: I would probably preface this one asking what do you mean by adequate? I have, for example --

DR. LOEB: I'll be glad to deal with that. Do you think that if a reasonably sizeable crack existed deep in a bore of a hole that was, say, 3

inches deep and about a half inch in diameter, that it would be detected in a high -- with a high probability? In other words, 90 -- with 90 percent probability and some reasonable confidence band on that? Is that likely?

THE WITNESS: You're asking me for an estimate of what would be a reasonable detectable flaw size within that setting. It probably is not as small as that, which you would see if it was surface breaking at the end of the hole or on the face of the item. And I don't have any reliability data for that, which is deep in there.

I have, personally, demonstrated to any number of players that you can do relatively small cracks in holes that are relatively narrow and relatively deep, as long as you know what you're doing.

DR. LOEB: Let me ask it a differently then. Are you aware of any crack of any size that has been detected in a deep hole by an air carrier or repair station in routine maintenance and inspection using FPI alone? Not in fir tree areas, not in blade areas, but deep in the hole, are you aware of any?

THE WITNESS: I am not aware of any data.

DR. LOEB: Are you aware of any that have not

been detected until there has been an accident?

THE WITNESS: I'm aware of the recent incident in Pensacola, sir.

DR. LOEB: All right. Well, we have -- we can go back to Sioux City. We can go to the ValuJet DC-9, and we can, of course, come to this accident, as well. And, I guess, it concerns me that we -- we may be using an inspection technique that simply is inadequate to the task, and that's why I'm asking you these questions.

THE WITNESS: Can I clarify for you, sir, the Sioux City one was not in a deep hole.

DR. LOEB: No, I understand that. And, in fact, neither was this -- I mean, this one started in a hole. It came to the AF face. We had a sizeable crack at the AF face.

THE WITNESS: That's correct.

DR. LOEB: That even worries me more. What I am concerned about, though, is the early detection where you -- where it begins in a hole, you have the opportunity then and the inspection technique may not be adequate. I'm going to repeat the question I had started with this series. And that is, is it really an FPI inspection adequate for this -- for detecting

cracks in deep bore holes?

THE WITNESS: Again, it is an adequate technique if you are aware of the reduced or the increased flaw size that's reliably detectable.

DR. LOEB: How do you adequately get the developer into uniformly -- I mean, you earlier testified of the importance of trying to get a relatively even layer, not too thick, not too thin of the developer to get the FPI drawn out of the crack to the surface. How do you do that in a hole that's 3 inches deep and a half inch diameter?

THE WITNESS: If I was doing that, I would probably use a bulb for the application.

DR. LOEB: I've seen that technique. And I'll ask the question again. I don't know how you can do that evenly that deep in a hole with a bulb. I mean, I'm -- the reason that I'm asking these questions is obvious. Are we going to be doing this a year or two years from now, the same thing asking the same questions, because we did do this in Sioux City, although, I grant you we weren't talking about a hole at the time.

We were talking about a hard alpha. And we made recommendations at the time that consideration be

given to the damaged tolerance concept that is used in air frames. That you assume you have a crack, you develop an inspection program that is up to the job and perhaps an eddie current probe would be an appropriate thing. But we're years down the road from that now, and, in fact, six years down the road, and we were still talking about the same issue.

THE WITNESS: I think that if you are interested in looking at the inside of a long hole and you were to ask the question what is the best technique for finding small flaws in that hole, you would get the response that in rotating eddie current probe with the proper probe and a probe orientations and proper frequency, it's probably the best way of doing that particularly focused inspection.

The issue here, again, though, is Sioux City was not that particular kind of a flaw nor was this particular one, and in -- the comment, again, is that there is not a whole lot of data that says those kinds of flaws were, indeed, missed with the FPI process that were, indeed, in the middle of the hole.

If there is reasonable concern for doing that, one should, indeed, do a focused FPI in those regions. They should probably also do an eddie current

inspection in those regions. And they should be using the best tools available in order to be able to find those kinds of indications.

DR. LOEB: Okay. I have another question that I would like to ask you. Again, this for clarification as well. And it has to do with the plastic medium blasting. Do you believe that plastic medium blasting properly done would result in either pinning or smearing of titanium as opposed to aluminum?

THE WITNESS: I have not see any data whatsoever for titanium. And what I'm relying upon is the testing I would believe has been done by the OEMs in this area, to indicate that that is not a serious issue.

DR. LOEB: Is there any indication that it's an issue at all?

THE WITNESS: Again, the only --

DR. LOEB: The titanium?

THE WITNESS: The thing that I was trying to be very clear about, sir, is that within the public domain, we do have an ASTM document that says that we also have a Navy study that says for some relatively hard rod aluminum materials that was an issue. And I think to not be aware of those concerns is to not be

credible. The thing that is, indeed, there is that those are issues one should deal with them and manage those. I have seen no data, for example, that says that, indeed, properly applied, you're penning over or filling up. No, I haven't seen any of that.

DR. LOEB: Should there be some testing to determine whether that's the case?

THE WITNESS: I'm not convinced it hasn't already taken place and that it's not proprietary.

DR. LOEB: And what, that the FAA would not know about it?

THE WITNESS: One of the difficulties, for example, that I have individually is trying to, perhaps, look at all the material and all the things that are done historically. One of the things I did in my past life was make certain that I had a very active role in the Department of Defense Non-Destructive Testing Information Analysis Center.

There are over 50,000 documents in that database, sir. I realize I couldn't read them all a long time ago nor could I manage that. The issue there, again, was to say and look at how could we at least keep on top of these kinds of issues. For me to go back and try to resurrect all the things that have

been done within the last 20 or 30 years, is a relatively forbidable task.

So, I don't know whether or not the FAA itself may have had that. I do know a lot of proprietary information that's usually, by the way, though, from my Army experience, not from my experience within the FAA.

DR. LOEB: Why do you think we've had three accidents in the last six years in which cracks of reasonable size have been -- have not been detected by FPI and have been allowed to have progressed until failure?

THE WITNESS: My personal assessment is that what we need to do is make certain that the good guidance for the process is in need on the shop floor. And that's probably the reason why.

DR. LOEB: The processees are not being -- are not appropriate or not being implemented properly?

THE WITNESS: The guidance that is, indeed, in place is probably not being implemented as well as it could be or should be. The ones that I've looked at, there's been two of those, and a personal opinion is that the failure was in implementation of the guidance. It's not in the guidance itself.

DR. LOEB: Is there anything that is different, that has been improved in the system today that would provide us -- provide the traveling public with any assurance that this isn't going to happen again in the reasonable future? Is there anything that's been done to improve the situation?

THE WITNESS: There have been a number of activities that have been put in place and that are continuing. Again, I've shared with you, that we have an R&D program, an FPI. There will be a work shop that the guidance documents are, indeed, maintained within the tech base. And in addition to those of the OEMs, I think that the technical area is being managed reasonably well, insofar as the guidance and potential research requirements within that tech base area.

DR. LOEB: I realize that there has been a research and you've testified to it, but my question, again, went to the issue of what has actually been implemented? What changes are there that have taken place? What assurances are to the traveling public that we -- that the next crack that may be out there right now is, in fact, going to be detected prior to failure of a heavy rotating part?

THE WITNESS: I believe I can assure you,

sir, that the people I know who do inspection are extremely motivated to do a good job. I know, for example, that the people I've talked to who do this are very personally concerned.

They are aware of the incidence that do, indeed, take place. That the feeling of responsibility is very persuasive, not only within the individual, within the organization, but within the tech base that develops those things, and that the concern that is there is one that is felt not only individually, but by the entire tech base.

And so far as trying to do a much more credible job, both in the maintenance of the guidance and in the implementation of it. The people that -- and part of the reason I actually enjoy this technical area is I enjoy working with people that I believe have a very good technical credibility and very much of an understanding of the impact and of the responsibility of the work that they do.

I have seen a significant enhancement in the implementation of the guidance, since I have joined the agency. To measure that in terms that might be quantitative for you, it would be very difficult for me to do, but I have seen the concern, the -- I think the

enhancement of implementation, and I don't know what else to do to reassure you, sir, and the public. I think the people who do this for a living worry about doing a good job. I'm serious.

DR. LOEB: No, I believe you. I've met a lot of them. I believe you. I think they all intend to do a good job. My concern goes to the -- probably the heart and concept of this program. And that is, whether the entire concept is appropriate for doing what we need to do. I don't think it is that the people don't care. I think they care very much.

I would totally agree with you. Is it -- are we doing the right thing by a life-limiting, heavy rotating parts and not requiring mandating periodic inspections that have a reasonable likelihood of detecting cracks and maybe we can't do it twice, but maybe three times during the life of the crack propulgation prior to critical length? Do we -- should we not be re-examining this philosophy, this concept?

THE WITNESS: I think, again, that I, personally, cannot address those issues. I'm certain that the engine propeller directorate and the rest of the FAA will, indeed, take your words to heart and will do their level best to incorporate those. Again, I,

personally cannot.

DR. LOEB: That's fair enough. I appreciate that. Thank you, Dr. Broz.

CHAIRMAN GOGLIA: Mr. Haueter?

MR. HAUETER: Just two questions. You mentioned in your testimony about having an inspector look at 100 reflective targets as being a difficult task. And, obviously, the perfection would be only none or maybe just one where the crack is. What's a reasonable number of targets for somebody to see on a field like of this disc?

THE WITNESS: I don't have a good number for you, sir. I looked at one that I considered an extreme. You, again, don't want the inspector in the booth, who is supposed to be looking for indications, having to reclean the part. Okay. And that's not his job. His job is to say, okay, we've got a couple of things here. That's, obviously, a piece of dust. This, obviously, is a false indication. He looks at it and says, oh, this is a little bit of a smudge in the material. And for him to make five, ten, 15 judgment calls like that in looking at a piece, it's probably in the reasonable ballpark.

For him to have to make a couple hundred of

those on an item, I think we're probably testing the system. We probably haven't cleaned the part well enough for him to do a good job. We probably have not processed the part well enough. Something else is wrong. And, again, if I was the inspector in that booth, I would say, yoo-hoo, we need to reprocess this one. Okay. This is not my job to clean it for you.

MR. HAUETER: Okay. And the last one, in your job, do PMIs regularly contact you for guidance and --

THE WITNESS: One would have to define the term "regularly." Realistically, the entire agency is my customer base. So, I'm afraid that I would use the word "routinely." I am accessed by good portions of the agency that include the flight standards organization, the aircraft certification organization, and the R&D portion of the business. And I also get access by people within the industry and within the academic community and within the other facets of the government.

So, they are a part of those people who have accessed me or accessed me regularly with have to say, you know, gees, they do this every week and everyone does this every week. No, that doesn't happen. People

come to me when they believe they have a serious effort that they cannot handle within their own engineering expertise or within their own technical expertise. And it happens broad based throughout the agency and throughout the rest of the community.

MR. HAUETER: Did the PMI for Delta ever contact you regarding the process of Delta?

THE WITNESS: The response to that is, no, we did not.

MR. HAUETER: Thank you.

CHAIRMAN GOGLIA: Okay. The Chairman has no questions. One last pass. The Tech Panel. ALPA?

MR. MCCARTHY: Thank you, Mr. Chairman. Doctor, I get the uncomfortable feeling sitting back here that we haven't really used the magic words. And the words in our context is pilots that we're most familiar with, is pilot error. My profession is highly subject to human error. It is highly processed dependent.

And clearly, you have indicated in the chain of this cleaning processing and inspecting technique any number of human error possibilities. In fact, this is a highly human error intolerant process. Is that a fair statement?

THE WITNESS: I would concur with you up to the last word, that was the word "intolerant." I will concur with you that it is, indeed, a process sensitive one, that human factors issues are, indeed, involved here. Actually, the one word that was utilized in some of the earlier testimony, it is still robust.

It will survive a number of these issues. That's part of the reason it was chosen as the one for doing critical rotating components. But your assessment, I believe, is, indeed, correct that it is, indeed, very subject to human factors influences. For example, the inspector may not look in the area. Okay. And he could miss something that way.

A whole bunch of other issues like that are, indeed, part of the process. And I will more than concur with you, that those are, indeed, significant issues in the process. Okay.

MR. MCCARTHY: If then --

THE WITNESS: And that's --

MR. MCCARTHY: I'm sorry. Go ahead.

THE WITNESS: That's part of the reason, again, that the tech base is aware of that and does, indeed, utilize things like reliability of inspection, probability of detection as ways of assessing those

factors within the inspection protocol.

MR. MCCARTHY: I suppose, Doctor, what I'm asking is not whether or not you can try an engine err out the possibility of human error, but whether or not you are satisfied that the process that is in place is, in fact, error tolerant. And I would much rather use the term "error tolerant" than robust.

THE WITNESS: The process that is in place is reasonably tolerant. There are, indeed, enhancements that you can make. For example, the inspection booths area, they could be well ventilated, rather than full all the solvent material, residue. They could be cleaned. They could have a lot easier, for example, handling apparatus in them. They could have a lot better tools available for the inspector. A lot of issues like that are, indeed, in place within the profession.

MR. MCCARTHY: So, I guess, my next question, Doctor, would be what influence does costs have upon the error tolerance of this system?

THE WITNESS: I would have a very difficult time quantifying a response. I think the first -- one of the first things I did comment on is that the -- I would like to see an enhanced management investment.

And that would include the things that would help the inspector do a better job, such as inspection areas, handling equipment, et cetera.

So, I -- but as far as costing that out, I can't do that in any quantitative manner. I think it was one of the first things -- or one of the early things I had commented on. But I think that investment does, indeed, need to be made.

THE WITNESS: Thank you, Doctor.

CHAIRMAN GOGLIA: McDonnell Douglas? Oh, just Delta? Anyone?

MR. DONNER: I just have one question for you, Dr. Broz, and that's sort of a follow-up to Dr. Loeb's question about the things we are doing in response to this accident. We have said that we've been to Delta's shop. Can you tell me if the FAA is conducting evaluations at other FPI facilities?

THE WITNESS: In response to an NTSB recommendation, we plan to visit a total of six organizations. We have to date completed three of those. The reports for those three are still in what I would call a draft status. I can give you a relatively cursory opinion, prospective, but I think that would be probably premature to do at this time. I would rather

have us finish the six and formally look at the data that we have, indeed, gathered and present that as a collection. Okay. Thank you.

MR. DONNER: Thank you. That's all I have.

CHAIRMAN GOGLIA: Dr. Broz, you mentioned that you have chosen six or someone has chosen six. What is the population? Six out of how many?

THE WITNESS: I will share with you, sir, that I was not a part of the selection of either the six or the number 6. What my role here is to make certain that what we do do when we go in is as technically adequate and as credible as I know how to make it. Choosing this -- I cannot go out, for example, and tell you this is the best cross section or anything else. I just can't do that. As to how many again, I have to defer to my colleagues within the agency. I have no earthly idea.

CHAIRMAN GOGLIA: Okay. Any from the Technical Panel? Dr. Broz, thank you very much for your testimony. And you and I have had a working relationship for a number of years.

THE WITNESS: That is correct, MrChairman.

CHAIRMAN GOGLIA: And there's no doubt in my mind that you will do the best that you can do.

THE WITNESS: Thank you, sir.

CHAIRMAN GOGLIA: You're released.

THE WITNESS: Thank you, sir.

(Witness excused.)

CHAIRMAN GOGLIA: Our next witness is going to be Dr. Drury, but before we bring the good doctor up, we'll take a 15 minute break.

(Whereupon, a short recess was taken.)

CHAIRMAN GOGLIA: We will go back on the record. And we will proceed to our next witness. It's Dr. Drury. Mr. Haueter.

(Witness testimony continues on the next page.)

DR. COLIN DRURY, PROFESSOR, INDUSTRIAL ENGINEERING

STATE UNIVERSITY OF NEW YORK AT BUFFALO,
BUFFALO, NEW YORK

Whereupon,

DR. COLIN DRURY,

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

MR. HAUETER: Dr. Drury, could you provide your full name and place of employment for the record?

THE WITNESS: I'm Colin Drury. I am a Professor of Industrial Engineering at the State University of New York at Buffalo.

MR. HAUETER: And could you provide a brief summation of your history and experience?

THE WITNESS: I have a Bachelor's of Science in Physics. Then a Ph.D. in Production Engineering, specializing in Human Factors. Following that, I was manager of Ergonomics at Pilkington Glass in the U.K. Following that, I've been at the State University of New York at Buffalo.

I'm a fellow of the Human Factors Ergonomics Society and of the Institute of Industrial Engineers. Most of my work has been human factors in industrial

environments until I got involved with the aviation communication after the Lar (sp) incident. And my main work has been on human factors in inspection of all sorts, both manufacturing inspections and more recently, of aircraft inspection -- specifically, air frames.

MR. HAUETER: Thank you, sir. Dr. Byrne.

MR. BYRNE: Good morning, Dr. Drury.

MR. HAUETER: Good morning.

MR. BYRNE: Do you also hold an airman's certificate?

THE WITNESS: I'm a private pilot.

MR. BYRNE: Thank you. In your experience in the aviation inspection environment, what types of non-destructive testing have you observed?

THE WITNESS: I've observed -- when we started the initial work after the Lar incident, a number of different techniques, visual and NDI, eddie current, ultra sound, FPI, a little magnetic particle, and some x-ray.

MR. BYRNE: We've been talking a lot today and in the previous days about human error. And as a discipline, human factors to -- was designed to understand the causes for human error. I found it

interesting that Dr. Broz mentioned that FPI had been around for about 55 years, and that's about how long human factors as a form of discipline has been around. Would you describe for me or for us, what human factors of inspection covers in terms of the scope?

THE WITNESS: A human factor inspection really looks at how a person does an inspection job. How an inspector works. Breaks it down into component processees that we know something about from psychology, experimental psychology. And looks at the failure modes of these processees within the human, so that to complement, if you like, the analysis of the failure modes of the whole process. From a technical point of view, we can look at the failure modes of the human and see where their capabilities are exceeded momentarily or in long term.

MR. BYRNE: Thank you. And would you briefly describe the history of human factors research in aviation inspection?

THE WITNESS: In aviation inspection, much of the -- there was a little going on before the Lar incident. Much of the work has been since then. And it's been aimed at applying what we know on human factors inspection from largely manufacturing

environments, into the aviation field and primarily in the area of air frame inspection, because that was the issue there.

We, the community, have looked at issues, such as training and looked at fairly detailed task analyses of a lot of different inspection jobs to see what are the common factors and how common these factors are between aviation inspection and inspection of the fields. And then looked at many other factors, which potentially affect inspection performance, all the way down to, you know, things like lighting and flashlights and so on and visual inspection and eddie current inspection, looking at some of the display factors, time on tasks, and issues such as this.

MR. BYRNE: I would like to get into the issues in just a moment. Who is the primary sponsor for this research?

THE WITNESS: This has been FAA sponsored work, both through the Office of Aviation Medicine and also through the FAA Tech Center in conjunction with San Dia National Labs.

MR. BYRNE: And are you aware of any human factors research into non-destructive inspection for critical rotating parts?

THE WITNESS: I know of the work that's been done on measuring probability of detection in this case, which is -- is essentially, an outcome measure for the human factors. But more detailed analyses of the human factors involved, I don't know of anything published.

MR. BYRNE: Okay. We'll get to probability detection a little bit later. You mentioned task characteristics common to all forms of inspection that you've observed or studied. Would you describe for us what characteristics these are?

THE WITNESS: Well, within any human factors study, you look at the task, you look at the operator inspector in this case, the machinery equipment they use, and the environment that they're in. And all four of these would, obviously, play a part in inspection.

The characteristics are that when you break an inspection job down, there are a number of tasks within there -- perhaps, the two most critical ones are the search aspects of the tasks where you're trying to locate an indication. And then the decision aspects, which is why you're trying to make a decision about the validity of this indication.

MR. BYRNE: And where can this visual search

or the decision making or any other of these factors break down and allow an otherwise motivated and good intentioned inspector, who is aware of the consequences of the failure to detect an indication or a flaw in a part to, in fact, miss a flaw or a part?

THE WITNESS: In the pre -- before you get to the search process, where you get the inspector briefed on what they're supposed to be doing, this is not an -- this can change the way they do the inspection task, change their allocation of time to different parts of the task, their relative effort on different parts of the task.

During the search function, such things as the area around the line of sight, which you can see a defect, are very important, known as a visual lobe. And also the pattern of searching, how do you move your eyes across it or if it's an eddie current ultra sonic, how do you move the probe.

So, those are the aspects within search. Within decision, the aspects are how well can a person come to a decision about an indication, where there are clearly present false indications or potentials for false indications, and also where true indications are fairly rare. This makes it quite difficult.

MR. BYRNE: What task characteristics are unique to the aviation environment?

THE WITNESS: On the air frame side, the fact that you have to go to the point on the plane to do the inspection, which differentiates it from a lot of staffing and industry -- manufacturing industry where the part comes to you.

In the particular case we're talking about here, which is inside a shop, this is much more similar to manufacturing inspection than the place where the inspector has to climb around the plane and gain access in fairly difficult areas.

MR. BYRNE: And based on your observations of the FPI process, the inspection process, particularly, what's unique about that?

THE WITNESS: It's a form of visual inspection, even though, obviously, it's NDI. It gets down in the end to human vision, as does x-ray inspection, for example. So, within that, I think one of the unique characteristics of it is that all of the indications will have the same, for example, color characteristics. When the dye penetrates, anything whether it's a true or a false indication, it will fluoresce the same way.

So, you're looking for one color all the time, which is different from many other inspections where you have a long list of different appearing faults that you're looking for. And so, that's -- that makes this inspection less error prone, if anything, because you don't have a long list of different visual characteristics to keep in mind. There is only one way that thing can glow, one color it can glow.

MR. BYRNE: Deep holes aside, with this particular hub, when inspecting the surface of the hub, how would an inspector fail to detect an indication on the AF face of that hub?

THE WITNESS: Obviously, I can't tell you what happened on this particular occasion, because there could have been multiple reasons it happened. I can tell you generally some of the reasons why the detection probability may be lower than you would like.

MR. BYRNE: I guess, fi I could clarify. If you could focus on the visual search aspect of an FPI inspection.

THE WITNESS: Okay. With the visual search, as I said before, the area around the line of sight that you can see is very important, because if the inspector knows what they can see around their line of

sight, then they can choose a search pattern. They can choose to move their line of sight to the next fixation in steps of a reasonable size, so that they will pick up the small indication they're looking for, which would take, you know, clearly training experience to know that.

With the particular FPI on large surfaces, large areas, ways in which that system can break down, if there are a lot of background clutter, visual noise, that this can affect the size of the visual load. If you have other competing distractors within that area and those competing distractors would be indications from things, such as dirt and surface features, which should not get indications.

So, if the perforation was not done very well, you would end up, as we heard earlier, with relatively large numbers of areas which appear to be indications. That would then force you to deal with each of those, in turn, which is an interruption to your search pattern, and, obviously, takes time. It gives you longer within the booth inspecting, if there are more of these indications.

So, it's not just that it hurts the visual lobe and reduces the size of that, because of the

visual clutter. You have to get rid of the -- you have to come to a decision about each of these glowing areas and that can physically take time to do.

MR. BYRNE: How can you ensure that your visual search strategy before you get to the diagnostic process is an efficient one or is one that doesn't allow -- I don't move from one spot to another and have a big hole or gap in my coverage?

THE WITNESS: The usual prescription of that is that you should get people to be more systematic in their search. If you look at how people do do a search task, they tend to be reasonably systematic. They follow a particular scan pattern, which is quite often individual to the individual person.

It tends to be not very well controlled by things like processed documents, it's generally not written down what the scan patters should be. But within that scan pattern, the idea of having something which is systematic means that you don't -- the point where you're looking now defines for you what you've already searched.

So, you don't have to remember have I been there before or where do I start again, because you know because you're running a systematic pattern where

you're at now. And so the more systematic you can make it, the better.

Any of the interruptions that occurs can, you know, interrupt this flow of search. And so because of that, getting rid of any false indications can be a way that can be interrupting the search path and you could start off again not on the right point. And if you have a systematic pattern, if you always follow this, then that should not be an issue, because you know where you just were, you know where you need to go next.

So, the more systematic you can make it, the better.

MR. BYRNE: Is this an innate process or one that can be modified or enhanced through training?

THE WITNESS: It can be changed through training. People tend to have their own preferences for how they search. People are generally not very good at verbally describing these when you put eye movement monitors onto people and ask them to describe what they've just done, the two don't always tie up very well. But people do tend to be fairly systematic. You can train them into other search scanning strategies. It's not very easy to train them, but it

can be done.

MR. BYRNE: As we're searching around a part, what catches our eye?

THE WITNESS: Well, when you visual lobe the area around your line of sight where you can see a put together defect, when that contains a defect or an indication, then you -- that comes above, if you like, a threshold on what you do then as you move your eyes directly to that point and consider it further in more detail, in more depth and so on.

So, you first of all, pick it up away from the center of vision, unless you happen to center your fixation by chance right on it. You'll pick it up and it's technically a peripheral vision, but it's not out here. It's around the line of sight. And then you will move your fixation point to be straight on that. So, you pick it up on full of your vision. And where you can make better decisions, you can get better detail.

MR. BYRNE: Are there any eye tests to evaluate how good an individual is with this peripheral vision?

THE WITNESS: Yes, you can do it. It's usually not done when you give a person an eye test.

It's usually phoevial (sp) vision, the central vision that you're measuring. You ask a person to, you know, read letters, for example, and that measures the central vision.

Peripheral vision testing, as I say, we're not talking about the size of the visual field, which you can measure fairly easily. We're talking about how far off access you can measure and it can be done. It's more difficult, more time-consuming. It's typically not got outside of -- but it can be done.

MR. BYRNE: Would it be fair to characterize your previous statements in summary as indicating the visual search is a key facet for the effectiveness of the inspector's performance in the tent?

THE WITNESS: Well, unless you pick up an indication by search, you can't go through the decision procedures that tell you whether it is true or not. If you miss it in the search, then it just never reaches your consciousness. You can't do anything about it. And so in that way, it really is key. And you need to ensure that the whole area is covered, which means a systematic search strategy.

And you need to ensure that you have visual access to some of the visually difficult parts of the

task. It's all right doing some on a flat sheet, but a complex part, then you have to look at it from different angles, physically move the item around, so that you can gain visual access at different angles.

MR. BYRNE: What method is available for -- could be available to remove the dependency of FPI inspection on visual search?

THE WITNESS: Certainly, I don't know with a part as complicated as this, but there has been work done on ultimating the search portion of it. And our own work is looked fair extensively at what's called human machine function allocation, which bits of a job should you give to people and which to machines.

And out of that work comes the general suggestion that if you can allocate the search parts of the task to a machine and have the human do the decision parts of the task, you can probably get better overall system performance, but that is not on titanium hubs. We have not done it on there at all. But if you're going to ultimate anything, then one would suggest probably the search part of the task would do it, but remember, that any ultimation system is going to produce a lot of false indications, which will then have to be processed at the decision stage.

MR. BYRNE: Is there anything unique about the decision stage of the FPI inspection?

THE WITNESS: From a visual point of view, yes, because it requires sort of hand work and post-processing by swabbing the area and so on and reapplying developer as a check on what the -- on whether the indication is actually a crack or not.

In visual inspection, generally, hand work is used to rub something, scratch something, to see if it goes away. For example, looking for cracks or corrosion visually. In FPI, this is really no different, apart from the fact that you have a technique with a solvent and a developer to do that.

MR. BYRNE: How can you improve visual search and inspection or not visual search, decision making and inspection?

THE WITNESS: The usual prescription for this is standards of the work point. I have a standard there that shows you what is an acceptable and rejectable level of a flaw. In this case, there is no acceptable level of a crack. Any crack is -- should by definition be rejected at the FPI stage and taken on for visual inspection for confirmation and so on.

So, that is probably -- it is not a question

of judgment of length of a crack here at all, which there is in some other inspections. It could perhaps help to have examples under the same sort of visual conditions at the inspection point of what a crack looks like to provide reminders for the inspector. However, the inspectors are performing this type of task for much of each day on a very high -- a very wide variety of parts.

It may be difficult to get a catalog of things, which are really helpful to the person for that particular part.

MR. BYRNE: How important are individual differences, such as experience or training in the inspection task?

THE WITNESS: There are individual differences in inspection. A regular finding of any inspection research. The individual differences don't tend to collate across tasks, when you look at inspectors doing different tasks, even on some of the work done, for example, on visual inspection where we have different tasks on an aircraft. The same inspectors are not the best on all the tasks. And there is not a great deal of correlation between performance on one task and another task.

So, that the individual differences do tend to be rather task specific. In search ability, it depends, I say, on the peripheral visual acuity and how systematic your searching is. In the decision area, there are pretests that people have done, embedded figures tests, and so on that do correlate, somewhat with inspection performance.

The problem is that any of these don't correlate very highly with inspection performance, and they might correlate differently with different inspection tasks. You have difficulty explaining a large fraction of the variance in any consistent way by looking for selection procedures. You can explain perhaps 30 percent of the variance.

MR. BYRNE: Are there individual differences in how long inspectors take to inspect or cover the same part?

THE WITNESS: Yes, for a number of reasons. One, for example, if one person has a larger visual lobe than another person, then to move that visual lobe across a given surface area is going to take them longer. There are individual differences in fixation time, in dwell time, and so on. They tend not to predict performance very well. It's how many fixations

you take, which predicts performance rather than how long you take on each one.

In a task such as this where a reasonable proportion of your time may be physically post-processing the decision stage to eliminate false positive and there could be differences in the manual dexterity and how quickly you can do this task, what the delays are in that task.

So, that you could get quite large individual differences in here. You expect individual differences in time for doing a task anyway. Another individual difference is how long a person thinks is reasonable to spend on that. You know, typically, people inspect it until it's done, but how do they know until it's done.

MR. BYRNE: I guess, what factors will contribute to that? My understanding of what is reasonable, a reasonable amount of time to inspect a part?

THE WITNESS: Well, fairly obviously. The criticality of the defective one is there. And the more critical it is, the longer people spend on it. The larger the costs. I use that in sort of a general manner to the individual, of missing a defect or missing one, if there's one present, the longer it

would take them.

One of the other factors is what's the prior probability of there being a defect there? If the inspector knows that there is a defect there and is merely looking for where it is, then perhaps they will spend longer on it than if they don't know if there's a defect there and they will inspect the thing carefully once and not know that there was a defect there and go back again to look at it.

Typically, inspectors will have a way of knowing when they have gone completely over the whole part and that will be the criterion people use for stopping.

MR. BYRNE: How does an inspector develop his probability of -- that a crack is going to be there?

THE WITNESS: You develop that by whatever information environment you're in. If you have no information, you can't do that estimate. Your information will generally come from what you have found in the past and from any knowledge you get of what other people have found.

The inspectors in FPI are continuously finding defects on the different parts that come through, but there may be particular parts, such as the

one we're talking about here where nobody had seen a defect in one of these parts. And so the inspector's best estimate is that it is zero. Now, obviously, inspectors don't behave like that, because that's -- you can't behave as if there's no defect on it.

You have got to work as if there was a defect on there, and you're trying to find it, and that's what people do. But when the expectancy is very low, this would -- in other inspection tasks when the expectancy gets low, the probability of missing increases.

MR. BYRNE: How important is it to get feedback on the defects that you identify during FPI, whether they -- how they've been resolved or what the indication -- how the indication has been evaluated? Whether or not it was a false positive or a true defect?

THE WITNESS: That is a very powerful determinant of inspection performance. If you can give people feedback that is correct feedback and timely feedback, it will improve their performance. Giving them feedback which is long delayed doesn't really help them, because they can't relate what they did at that time. You know, say, it's delayed by a few hours or a few days, you can't remember what it is you did that

either found that or missed it or whatever.

So, the more rapid the feedback, the better. But, of course, feedback, if you knew what the true fault was, you wouldn't be having the inspection in the first place. It's, obviously, difficult to give.

Where there are more faults, then the people down the line who do a final confirmation this, which is typically visual inspection, they do feedback to departments about what went on, what the outcomes were. I don't think it's done in a very formal manner, but it's usually done. Whether it gets back to the specific inspector is another thing. And in air frame inspection, it tends not to.

It may well be a different inspector, for example, who does the buy back of the repair from the one who did the initial inspection. So, it very often does not get tied back to that individual inspector. I do not know how it went on in this particular case, where that inspector did get regular feedback, but it can be done, it helps.

MR. BYRNE: You've been talking about feedback that is on what the -- or is about what the inspector found. How important is feedback on the other side that is feedback about errors that the

inspector made insofar as missed detections?

THE WITNESS: Again, that's extremely important, because it helps calibrate the inspector of the fact that they are missing or what it is they are missing. They may be missing, for example, whole classes of defects. That is probably not as true in this case where the defects are at least similar colored and similar looking.

But in other cases, it is very important, except that you typically don't have access to that data, unless there's another independent inspection done or, for example, the next scheduled inspection, a crack is found, for example, in air frames where the -- it would have been visible the last inspection and somebody missed it and you can give that as feedback, but, again, it's usually a long way removed in time from the time the person did the actual inspection and how useful it is to them to technically build up their repertorial skills, I would doubt.

MR. BYRNE: How effective is evaluating an inspector's performance in the tent through a written exam?

THE WITNESS: Well, there's two aspects of the inspection. One is a knowledge base and the other

is a skills base. And written exam will test the knowledge base, knowledge of the underlying processes, knowledge of the rules, knowledge of the physics underlying the system and so on. It doesn't get at the skill base. How a person, for example, structures their search pattern, how well they physically handle parts and so on, because it's not designed to do that.

MR. BYRNE: What's the most effective means to evaluate the skill base?

THE WITNESS: There are really a couple of ways. One is that you give the person a test batch of things to inspect and look at both what the outcomes are, which items are detected and where there are false alarms. And also give them feedback on how they did the task, what their search patterns were and so on.

And the other one is to put known defects in production. I have not seen that used in this industry. It can be done as an evaluation measure. It's a -- it is not always very productive, because inspectors are intelligent people. They can recognize these old friends as they come down the line. They know that one. They've seen it before. And so I think what you can do is you can test how well people can do the job by giving them something, saying this is a

test.

It's much more difficult to detect in a sort of a blind manner -- you know, of experimental designers, how well a person is actually doing. And so typically the measurements are what people can do rather than what they actually do in practice.

MR. BYRNE: Mr. Stevens yesterday testified that if you would send a test piece through to evaluate an inspector's performance, that you would want to make sure that that test piece has a crack that is small or one towards the threshold of the detection side versus a large gaping crack.

Does it -- how important is crack length or defect length or size when evaluating an inspector's performance through the use of test pieces?

THE WITNESS: I think I would extend that observation rather than just have one size of crack, to have a range of crack sizes, and items which don't have cracks on them. If you are running an evaluation study, you would have things in there which did not have cracks. You would have things which had small cracks and large cracks and so on.

For this type of inspection, crack length is a predictor of a fair amount of the variance of whether

a thing will be detected or not. And so you need a range of these to be put in there.

MR. BYRNE: And would you be able to generate a probability of detection curve for a particular inspector based on these data?

THE WITNESS: You can do, yes. You've -- there are some good techniques out there in the literature. World Rumble have done work on this as a hovian (sp) barons and so on on taking yes/no data. Yes, they found this. No, they didn't find that. And developing a mathematical curve based on that data, which describes their probability -- their expected probability of detection.

MR. BYRNE: Would you elaborate on the type of information that a probability of detection curve would provide?

THE WITNESS: The usual curve, which is the graph you see of a single curve, tells you what is the long run expected -- value expected probability of detecting a defect of a given size. Very often you're also given a pair of curves around this, which give you the 95 percent confidence interval on that. And that the upper one of these tells you what you can detect on a few -- on how good your performance could be. And

the bottom one gives you sort of a reasonable lower bound on how bad your performance could be or would be expected to be.

So that you can tell from this, given a particular crack size, what is the probability of being detected and what is the distribution around that probability. So, for example, it's typically used in saying what is the largest crack that's likely to remain in that structure after you've done the inspection.

MR. BYRNE: Likely to be missed or --

THE WITNESS: It's likely to be missed. It's likely to remain in there undetected.

MR. BYRNE: Okay.

THE WITNESS: Which is what is used again in the air frame side as a basis for repeat intervals for inspection.

MR. BYRNE: How generalizable across different part geometries are probability of detection curves?

THE WITNESS: The data that I've seen, the published data, I've not measured it myself. The published data shows that there are differences between individuals, differences, obviously, between

techniques. You know, eddie current is different from FPI. But also the actual type of crack determines the location of the probability of detection curve where it is on the access waters, the -- say, the 9 to 95 value. The value of 95 -- the probability detection of .9 with 95 percent confidence.

So, part geometry and where the crack is on that part are clearly important in this.

MR. BYRNE: I would like to transition into ways to mitigate human error in the inspection process. What changes have you seen in industry attempts to minimize human error in inspection over the years, insofar as aviation inspection?

THE WITNESS: Typically, the interventions have been, as we said, task machine environment and operator and so on. On the inspector side, training is obviously an issue there. Selection or placement procedures keeps coming up, but my own view is that it doesn't -- we can't do a good enough job of explaining enough of the variance to make it -- to get a robust inspection selection device, but training is extremely important to you and you can train people very well.

I think one of the things that we find is a very heavy reliance on classroom training for the

knowledge base and then on-the-job instruction, OJI, for the skill base. And some of the difficulties there are that they -- with OJI, you are passing on the wisdom of previous people in an actual production environment. That wisdom can be right or wrong and you can transmit poor practices along with good practices, unless you're careful. I think the other problem with it is that you have no control over the input to the inspector on that day.

You are not controlling the sequence of things that come to them in training. Now, when you're transitioning from training to the real environment, it's important to give the person a wide variety of experiences, which is what OJI is for. But it, again, is difficult, because you can't say, today, we're going to look for cracks in this, because that might not exist, or you might like, if you are training somebody in the most efficient and effective manner possible, to start with larger cracks and move down to smaller cracks. Clearly, you can't do that when you have no control over what's going in to the inspector on that particular day.

So that -- you know, OJI is, obviously, needed, but it has some inherent limitations, as on the

training side.

In the other areas, I would see on the search side whatever you can do to reduce the amount of visual clutter, improve the visual lobe performance. An example there that has come up already is the amount of white light in the inspection booth.

Two candles is an overall level. You would get this by putting a light meter down at the point. If that registered the same as two candles one foot away, then that would be two foot candles. It's how you get that light, which is at least as important as how much light there is around.

If that light gets there by a bright light shining in your eyes -- there are some in my eyes and there's a glare sources around, then that can reduce performance much more than you would expect from that level. So, it's a question of trying to keep out extraneous glare sources. So, this could also improve things.

MR. BYRNE: Can changes be made in the type of guidance provided to an inspector, either written guidance or verbal guidance before inspection of a part?

THE WITNESS: That's extremely important,

because it does determine how the inspector strategizes their inspection. If you can provide them with knowledge which tells them where other people have found difficulties, where cracks ought to be expected from fracture mechanic's considerations and so on, the inspectors know this. They've had a considerable amount of training in this.

This is the knowledge base that goes into the training. But if you can re-emphasize it for different parts with different life histories and so on, then the more information you can give them, the better they will be able to do the sort of job that you would like them to do by concentrating on certain areas.

MR. BYRNE: And after the inspection, the type of information provided to an inspector, you've mentioned using the test piece and feedback on the evaluation of an indication. Are there any other changes that could be made to provide greater feedback to an inspector?

THE WITNESS: One of the useful things -- and this one come up in OJI as well -- is to give an inspector feedback of the method they're using. And in process control, you're not always -- you're concerned with the outcome measures, but the outcome measures are

probably very gross feedbacks of performance, because either you find something or you miss something, and defects are pretty rare anyway.

So, if you can give people information on how they're doing it -- if you can help the process control of the task look at how they're inspecting something, look at how they're moving something, look at how they're using their information within the booths, look at how they're using the light and so on, if you can give them feedback on that, that can help them to do a good job, provided you are giving them feedback, which is, in fact, correct.

MR. BYRNE: And you spoke about the concept of selection or that inspectors in your air frame example for different types of inspection, the good ones were not consistent across different types of inspection. Could you, however, describe common characteristics or what characteristics a good inspector should have?

THE WITNESS: This has been done where you get a consensus of people -- for example, supervisors, other inspectors, and so on, to write down what is a good inspector. The only trouble is, it comes out looking like what is a good fireman, policeman manager,

whatever. The sort of characteristics you want are the sort of characteristics that you want in a good employee.

The problem with that is that those sort of characteristics don't seem to be related to success in terms of success on a test of what fraction of defective items in a test that they pick up. You know, everyone agrees that they're common characteristics an inspector should have. But they tend not to be validated again, you know, hard performance data, where that performance data is available.

MR. BYRNE: Yesterday, the concept of doing redundant inspections as a means to improve overall inspection performance was discussed. Are there any human factors principles that need to be considered when developing a redundant inspection program?

THE WITNESS: Well, with the redundant inspection, what you would like is two independent looks of inspections. If these are clearly not redundant, if these are clearly not independent, you may not be getting what you think you are getting. For example, if one was FPI and another one was another technique, eddie current or x-ray or whatever, then they clearly have different strengths and weaknesses.

They would be very complementary.

If you had two people doing the same inspection, then if the reason a person did not find a fault was that, for example, they merely missed that particular area or went too quickly over a particular area and so on, then if you can combine those two in an independent manner, that would help. But if it was a common mode failure, if neither of them were looking particularly at one particular area, they're both missing the same area, or that, for example, the surface preparation wasn't very good or there was some things that was the same in both cases. And then you may not be gaining a lot form of redundant inspection at the same type.

And also combining them, inspection, there is an old quote from the literature on this, which says, inspection is always even if implicitly of people. And if you reinspect after somebody else, then you're reinspecting that person. And that is likely to affect how you do it. It may even affect the first person of the line knowing that the second person is going to inspect it. Whereas, if there are two independent people who inspect it separately then compare results, then that is much more likely of an independent

inspection.

Although, that's typically not the way these things are done.

MR. BYRNE: So you're saying if I'm doing the inspection the second of a redundant inspection series and I am looking at the JPC or the job card and already see the previous inspection results or inspector sign off, that will affect or may affect my --

THE WITNESS: I don't have any data. I don't know of any experiments that have been run to look at this. My own view knowing what I know about human performance, is that it may well have an effect. I could not rule out an effect of non-independence between the inspectors if the second one knew what the first one had found.

MR. BYRNE: And today we spoke about eddie current of deep holes as a method of inspection. What you know about eddie current of deep holes -- or based on what you know about eddie current performed on a hub, such as this, what human factors does it alleviate in the inspection process and what still remains?

THE WITNESS: First of all, my experience with eddie current has been almost entirely on -- it has been entirely on air frame. And typically, on

things like rivet cracks on fuselage lap joints. Eddie current changes a visual search into a procedural search. So, instead of visually moving your eyes from here to here, you move a probe from here to here.

And so what it does, it has a different set of physical characteristics. So, unless you get the probe moving correctly, then that can cause errors. If you look at the data on errors in eddie current inspection, some of them are due to just faulty probe movement. And some of them are due to the difficulty of making the probe movements under visual control while simultaneously visually monitoring a screen.

Now, you can get around, because we have alarms that you can put on screens. Eddie currents -- eddie current inspection does have false alarms associated with it. Then you go back to that place and you try again. And typically, when you find an indication, you repeat the inspection on that.

So, that eddie current inspection is still subject to human error. I think it's subject to somewhat different human errors. Both of them tend to bid on in practice for fairly long periods on very similar structures. And as such, if there is any visualence problem potential in here, it would come up

in both of them, because of the length of time you're doing it.

MR. BYRNE: So, if you were to automate an eddie current inspection procedure in terms of the movement of a probe, are you saying that there would remain human performance issues insofar as monitoring in visualence?

THE WITNESS: If the ultimation was done so that it essentially completely eliminated any probe movement errors, you are removing one part of the task, you are getting the person to concentrate on another part of the task. But now it's paced by the speed that the movement can go at. And so you are much closer to a classical visualence situation where you have a series of events and some of these events are important and should be responded to and some of them are not important and should not be responded to.

Typically, a search which involves visual work, such as FPI or x-ray, even though they're NDI techniques, you tend not to -- or shall I say, I have seen very few documented visual decrements in the industrial inspection literature where this has taken place. I've only seen, I think, a couple. And many places that have measured it have not found a visual's

decrement in industrial task. But I think if you're looking for one, something like a repetitive eddie current task may be the sort of place you would look for it.

MR. BYRNE: Thank you. And one final question. How effective is providing an incentive for detection of a defect to improve or make inspection performance more consistent?

THE WITNESS: My own view is that it would be fairly ineffective. I think that an incentive could perhaps help where people are not motivated inherently to do a good job. I've worked with very large numbers of inspectors, both in industry and in aviation, and I've never found one for whom that was a problem.

Now, there may be people out there who are not motivated to do a good job. I've just not met them. I've been extremely impressed with the inspectors that I've dealt with. So, I honestly don't think that was the thing I would ever pursue.

MR. BYRNE: Thank you, Dr. Drury. Mr. Chairman, I have no further questions.

CHAIRMAN GOGLIA: Are there any other questions from the Technical Panel?

MR. EINDLER: Yes. What's your experience

regarding inspector fatigue? I mean, for a long time, can an inspector be 100 percent concentrated in inspecting identical parts? Like in this case, for example, we are talking about 48 identical holes. I mean, there's a human factor problem.

THE WITNESS: They -- as I said, the visualence literature says that people's performance decreases with time on the task. Certainly, inspectors subjectively feel what they report as fatigue and boredom. It is there. I have not seen published evidence that it is a big factor in actual inspection tasks.

Actually documenting in real inspection task, the performance gets worse as you spend more time on the job. But the typical advice that's given is don't spend too long on the job. And I thoroughly agree with that advice. I don't see why you should force people to spend long amounts of time on the job, which could have a visualence decrement associated with it, which could have a fatigue decrement associated with it.

So, I would seesome limited amount of time spent doing the inspection task and have that broken up with other things. They, indeed, not be rest periods in the sense of, you know, going to sit down and having

a cup of coffee. They could be other tasks that you have to do. And most inspectors do typically break their day up. They know this. They like to get what they call a good round of inspection tasks, but they do like to break at fairly regular intervals. Left to their own devices, they may go longer than the literature seems to recommend on visualence decrements.

MR. EINDLER: How critical is the time of the day?

THE WITNESS: The inspection data we have doesn't say a lot about time of day and performance. What we know from other studies, not of inspection, is that time of day could have a large effect on some performances. Truck driving errors and so on and errors in manufacturing industry -- not inspection errors, but other errors, accidents and so on, do tend to be more prevalent during the long times, you know, the middle of the night and so on. Midnight to 5 a.m. But you would expect that something like this would have an effect on people doing this, this sort of task.

I know that some work has been done at UKAA at Resilee in England looking at different shifts and time of day on shifts. The data were fairly inconclusive. They got a fairly large number of errors

on one particular shift, and most of these seem to be the person not lining up a straight edge correctly for doing an eddie current task. Whether that is a time of day fatigue effect, I don't know.

In shop inspections, such as this, it does not seem to be a thing which is a 24 hour task. In air frame inspection, much of the inspection does occur after a plane first arrives -- overnight typically. And so that, I think, can be more of an issue in air frame inspection than in engine inspection.

MR. EINDLER: That means that you have never considered to put the most critical inspection sequences in a period where you can expect the inspector to be the most fresh condition for the inspector work?

THE WITNESS: I've not -- I have never had to schedule inspectors doing a job myself. So, I've never put them into that position. My advice would be don't have too long in the hours of work and don't do critical inspection periods at times when they view circadian rhythms at the point you would expect problems, which is the in the middle of the night. You know, midnight to 5 a.m. or so. Don't do it at those times. But, again, if you ask me for evidence, say,

how much does it decrease performance, I don't have that, because it's not been done.

MR. EINDLER: Thank you. No more questions, Mr. Chairman.

CHAIRMAN GOGLIA: We'll go to the parties. FAA?

MR. DONNER: No questions. Thank you, Mr. Chairman.

CHAIRMAN GOGLIA: Pratt & Whitney?

MR. YOUNG: No questions, sir.

CHAIRMAN GOGLIA: ALPA?

MR. MCCARTHY: Yes, sir, Mr. Chairman. Doctor, in your discussion of your attempts at quantifying probability of detection, I got the sense that you proceeded with the assumption that the part is delivered to the inspector, in all respects, properly prepared with otherwise detectable cracks and that your probability of detection is, therefore, predicated upon missing a crack that should have been detected. Is that correct?

THE WITNESS: That's how it's typically measured. You give a person a test piece or you give a number of people a number of test pieces. And there are defects on certain number of them. Defects are

different sizes. You measure which ones were detected and which ones were not.

Typically, the experiments have been done to look at the ultimate ability of these tasks. In which case, I don't have -- I wasn't there when those experiments were run, but I would strongly suspect that they were very well cleaned, but I don't know that.

MR. MCCARTHY: Well, in the discussions that we've heard during the course of this hearing, it seems clear that there are certain -- certainly several opportunities for human error in the cleaning and preparation process. Would you agree with that?

THE WITNESS: Yes.

MR. MCCARTHY: And isn't it then true that if you were to get a true metric of probability of detection, it would have to include not only the probability of detecting a detectable crack, but it would also have to include the probability that a crack would be rendered undetectable by human error in the cleaning and preparation process.

THE WITNESS: Yes. I think that you would need to look at the failure modes of the preprocessing and see how a defect could have arrived at that point, so that it is not detectable. Not just that it

wouldn't, it's not being detected, but it is not detectable or its detectability is reduced and that could certainly happen. I know a number of places there if the process is not properly controlled, it could happen. But there are re-interim points to this process.

If there is too much dirt on the part and that dirt is visible, it very often goes back through the cleaning. If the part arrives at the FPI line and the penetrant won't stick to it, then it may well get recycled. So, there are a number of places of error in here. But there are also a number of places where the system can correct itself on the way to get there.

And ultimately, it can get to the inspector and the inspector can refuse to inspect it and say that there is -- there is just too much on this. But given that it was cleaned properly and looked visually good, then I don't have a good way of saying whether it still could have a crack that is being concealed by some of these other processes. I don't have that data to hand.

MR. MCCARTHY: You don't have the data, and I appreciate that, Doctor. My question, however, is whether or not you would agree with the thought that the quantification of probability of detection that has

been arrived at experimentally is going to be somewhat higher than the probability of detection in actual field experience, because of the human error inherent in the preparation process? It would be somewhat lower than that laboratory condition figure that has been used.

THE WITNESS: Yes. If you put it in another way, I doubt if it could enhance the system. I think that if it's going to have an effect, it would make the probability lower, but I did not run the laboratory -- I don't even know whether laboratory test -- I suspect they were done with real inspectors under laboratory type conditions, but you would have to go back to the original papers to get those. But I don't know how well the parts were cleaned and so on for that.

I would suspect they were done very well, but I don't have data on that.

MR. MCCARTHY: Thank you, Doctor. No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Volvo?

MR. THOREN: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Delta?

MR. VALEIKA: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: McDonnell Douglas?

MR. STEELHAMMER: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Dr. Ellingstad?

DR. ELLINGSTAD: Thank you. You indicated that one of the variables that will influence detection performances, the visual noise that's present. In your observations, how noisy is the visual field for a typical FPI inspections of parts, particular, say, for hubs?

THE WITNESS: They -- it varies across the hub itself. If there are places where, for example, after it's come through the FPI process and is being dried, if it was not dried completely, if there is any water there, that will have developer adhering to it and may leach out some other stuff. You may get particular places where it is poor. On the general large surface areas, it can be quite variable. I mean, you know, some parts can be cleaned well, some parts can be cleaned badly.

I do not know enough about this particular process of titanium hubs to know how variable those surfaces are between one hub and the next. I've seen a number of them, but I haven't seen a very large number.

DR. ELLINGSTAD: Okay. You had also indicated that the scan patterns to the performance of

the visual search were important. In terms of your observations of these processees, do you believe that the inspection process, particularly with respect to how that scanning is accomplished, are sufficient well prescribed in the process standards?

THE WITNESS: No. I think the -- within the process standards, it says that you should inspect the whole area and give particular attention to particular places. But typically and again on the air frame side, very little is said about how you should do the scanning, because that's a fairly difficult thing to write down. It's a thing that inspectors, when you talk to them, don't know how they do it or have to stop and think about how they do it.

They treat it more as a skill level than a verbal level. And so it tends to -- it tends to get missed in writing down how to do a job.

DR. ELLINGSTAD: Do you think it would be possible to improve that process with a more structured -- if the technique sheets, for example, prescribed a scan methodology, would that be something that you would expect to improve that part of the process?

THE WITNESS: Yes, I can't -- it reduces their ability, which is what process control is all

about. And if you can reduce the probability that somebody just never looks at an area or skips across an area too quickly or whatever, then you have improved it. You can't make it any worse.

DR. ELLINGSTAD: Okay. Another area that it seems to increase variability here is the mixture of parts that the inspector is presented with. And I think we've heard an ample description of the fact that on the line at any particular time, there is a very large variety of parts that are presented to the inspector, both in terms of sizes, types, manufacturer, that are done in order.

What do you expect the consequences of that variability in terms of the specific task that is presented to the inspector to be? Is it good or bad to have this variety of parts?

THE WITNESS: It actually cuts both ways. It can be detrimental in that people may have to sort of remember, reinvent a new scan pattern for each item. And they may not get the best guidance on how to do it or what's the critical point and have -- and so on. You can get around that by better tech sheets for the inspection.

It could make things better, because it's

giving the person the variety which will help to alleviate a visualence decrement. If there's a visualence decrement going to occur, then task variety is one of the things that helps alleviate this.

Also, in this particular case with a task where nobody is -- nobody seems to be able to remember ever rejecting one of these hubs, it at least gives other things coming through, which have got defects in them, which reward the inspector for having found the defect. It's very rewarding to an inspector to find the defect. Yeah, that's what they live for. It's a very large part of their life.

DR. ELLINGSTAD: In that respect, are you suggesting that that mix of parts, some of which have a higher probability of a defect is going to somehow raise that overall expectancy --

THE WITNESS: I would think it would.

DR. ELLINGSTAD: -- from a single detection perspective?

THE WITNESS: It also keeps the person -- I mean, inspection is something where there are not that many defects. I mean, not that many things that come through are rejected. And so with defects being rare, whatever you can do to give a person more recent

exposure to defects is likely to be better.

In particular, where you're trying to inspect a part which literally has no defect history records to the inspector, this could be useful. Now, whether that actually transfers to this other part, I don't have a technical answer to it. I would suspect it did.

DR. ELLINGSTAD: Okay. In a sort of a related area that would, I guess, fall under either training or evaluation of performance, you talked a little bit about the -- I believe I understood you to indicate that you favored the performance of test inspections of some sort on some kind of a recurring basis?

THE WITNESS: I would think you would do two things. One, it would give the inspector feedback on how well they're doing. And, secondly, it would be a process control measure that the management would like to see of this process -- the process on a regular basis. So, I think that would be a useful thing.

DR. ELLINGSTAD: From either of those perspectives, how frequently do you think it would be appropriate to expose an inspector to some kind of a systematic test of inspection performance using both the null samples with no defects and samples with

various kinds of defects?

THE WITNESS: That is a really difficult question to answer. I don't have -- I keep saying, I don't have the technical data where it says it should be daily or monthly or three months or whatever, because nobody has run an experiment to try it out, those sort of intervals. It would seem to me doing it versus not doing it is very important. Knowing when to do it within that, it's a balance between a person learning and memorizing all these defects, because they see them every day. And getting rapid information on how well they're doing.

So, I cannot give you a time span on that. I'm sorry.

DR. ELLINGSTAD: What's your impression of industry practice? Is it in your knowledge very frequently done?

THE WITNESS: It depends. Most of my experience in this is air frame. Typically, it is not done very often there, but it ranges all the way through. For another aviation example, if you look at the people who inspect your unchecked baggage when you go onto a concourse, they get tested essentially every day. So, there are different levels in different

places.

DR. ELLINGSTAD: I think I've detected an absence of enthusiasm for putting real parts with known defects through the line. Is it possible to do some combination of a regular daily or, at least, more often than quarterly or whatever testing on the line with some kind of standard materials? Can you use test blocks in sort of the way that tam panels are used to check out the line when it fires up in the morning?

THE WITNESS: I think the test blocks ought to be fairly carefully constructed. They ought to challenge the searchability, as well as the decision making ability. And the trouble with many test blocks is that there is one hole and there is a crack somewhere on that hole or there may not be. There usually is. And so, you know you go straight to the point and you know exactly where to look.

Whereas, I think what you need to do is put in parts which are realistic enough to have a fairly complex search procedure associated with them. So, that you can challenge that part of it.

But, again, getting back to salting the line with none defects, which the inspector doesn't know test items, I would have to think very, very carefully

before recommending anything like that, because I'm not sure it's practical for reasons that we've heard.

DR. ELLINGSTAD: Thank you.

CHAIRMAN GOGLIA: Dr. Loeb?

DR. LOEB: Thank you. Dr. Drury, I would like to go back just for a minute to this issue of the time on task. How important do you think time on task is to the ability to detect a crack, if it were there? Is it very important, not very important or --

THE WITNESS: I think it's reasonably important in the sense that there is a very good control measure. You can just stop people spending too long on the task, but so it's fairly easy to control. But how it effects probability of detection, as I said, the data that we have from NDI doesn't say that it's a large effect. The data we have from the laboratory visualence tasks say that it could be a very large effect.

The data on the laboratory visualence tasks also is somewhat depressing, in that it doesn't say you're okay for a certain length of time and then it drops off. It says you start getting worse as soon as you get in there, which is not a pleasant thing to know.

I would think because we control it easily, it would be fairly simple to set some standards, like not more than half an hour, three quarters of an hour, whatever. But with this particular task where you have to go a certain amount of dark allotation before you start, clearly you couldn't have it done in a very short times, because the dark allotation takes time, as well. And so there may be an initial sort of warm-up phase in FPI, just because of dark allotation, so you don't want to do it too frequently.

DR. LOEB: Do we know at this point what time on tasks would be appropriate for FPI?

THE WITNESS: There is no data on that.

DR. LOEB: Would it be useful to get data on that and then make it available to the industry?

THE WITNESS: I think if you were running any studies on FPI, then you ought to use time on task as a variable within all the other things you want to look at in that, and pull it out as a variable in the analysis, and see what its effect is and use them for the basis of recommendations. I'm not sure that I would run the study just using time on task. I mean, you take a lot of resources to measure something, which you may not find much out about. But I think if you

were measuring -- if you were running an experiment anyway, you would treat that as a variable very seriously, put it in there at different levels and then make the appropriate recommendations.

DR. LOEB: You spent a bit of time looking at FPI inspections being done and, in particular, on the hub in question. And you're aware that there have been a number of accidents in which cracks have initiated in heavy rotating titanium parts have been progressed to failure, resulting in at least three accidents in the last six years.

Do you have any -- do you have a feel for what is going wrong, for what might be happening with the FPI and the failure to detect these cracks?

THE WITNESS: I have a feeling. I cannot say specifically on these particular instances. My view is that they -- if you look at probability of detection, which is what this is all about, are you going to detect it or not, then a certain amount of this is driven by crack length. The longer the crack, the more likely you are to find it. But I suspect that there are some errors people make, particularly misses, which are unrelated to crack length.

And so that you can and do miss things which

are quite large, horrifyingly large, for other reasons than it didn't appear above threshold in that particular glimpse you were taking, perhaps because you didn't look there, perhaps because it was difficult to access and get at and you didn't spend long enough in the access or fatigue factors or other things.

I suspect that these -- that there are some factors within here that are driven by crack length and some factors which are not.

DR. LOEB: Having looked at this process and especially as it applies to deep holes, narrow deep holes, do you think that this is a very effective inspection technique for cracks in a deep hole?

THE WITNESS: The difficulties wh deep holes is difficult getting the illumination and your eye into there at the same time, your vision into there at the same time. What you see down the deep hole is for shortened. Getting the hole itself well cleaned before you start, getting the developer to be even in the hole, as you said before. These are all things where you would suspect that that would be more difficult than on a large flat area or a rear face or something of this sort.

You would suspect it would be more -- one of

the more difficult areas to do well on.

DR. LOEB: Do you believe that this inspection technique should be relied upon as essentially the sole inspection technique to detect a crack in a -- especially in a heavy rotating part in which liberation of a heavy part can create an accident? In other words, in a critical situation like that, do you believe that it is appropriate that this be the only inspection process to be used to try to prevent that from happening?

THE WITNESS: You would need someone to answer that honestly, who evaluated all of the processes and knows them technically well to see what alternatives are out there. My view is that this technique is a very powerful technique. It will find quite small floors. And it may not find them, as well, under certain places. And those places may be the very ones that are causing the trouble.

In that case, you would have to look at other techniques, as well.

DR. LOEB: Given though what you have heard, that I'm not aware that anyone has brought to our attention a case in which a crack has been identified in this manner in a hole. And in addition, that in at

least two of the three cases, we have had cracks that were on the face and of size. Do you believe that this inspection process really provides adequate protection, if it is the only process used?

THE WITNESS: Yeah, I don't know the other side. I know that these three were missed. And they clearly shouldn't be missed. You don't want this to happen. If changing the technique will do it for you, then, obviously, you should recommend changing the technique. If it won't, then I'm not sure you've gained anything.

DR. LOEB: I guess, that was my next question. That you can provide redundancy, I guess, in two ways. And that is to have two different people doing the same -- using -- applying the same methodology, the same technique, or you can have two different people doing two different techniques or one person doing two different techniques. Having looked at the FPI, having some knowledge also of eddie current, not so much as it applies to engine parts, but to air frames, do you think that it would be appropriate to have some redundancy in this process?

THE WITNESS: Again, I can speak to this as a human factors engineer, not a complete process

designer.

DR. LOEB: Exactly.

THE WITNESS: I can't do that. But as a human factors person, it would seem to me if the other technique was open to different modes of failure, then the chance of the two techniques failing on the same part would be much reduced.

If both the techniques were open to the same common mode of failure, like two people doing the same task, who were either not independent or were having difficulty at the same point, then that would be much -- that would be less effective -- I don't know how much less effective.

DR. LOEB: Thank you.

CHAIRMAN GOGLIA: Mr. Haueter?

MR. HAUETER: No questions. Thank you.

CHAIRMAN GOGLIA: Dr. Drury, I have one question. Earlier -- and I know you weren't present -- we had some numbers given out indicating a very high probability of detection for certain visual inspections that were enhanced by either etching or FPI. In any of your work, have you come up with some numbers or have any numbers been developed on the -- you know, in a percentage form of the likelihood of an inspector

detecting flaws in materials?

THE WITNESS: Yes, it's a function of crack size. I am typically not opposed to this measure. I've worked with people who have measured this. I've only done this for visual inspection, but I know the work in other areas.

When you look at the probability of detection curve, it's saying that some samples are found more than others. And when you look at it and look at say a 90 percent probability of detection and it comes out to .13 inches, .2 inches, .1 inch or somewhere around there, then you look at the raw data. You find that there was one sample, perhaps, of .3, .4 inches that was missed.

And if you regard it as a probablistic process -- and this is just one sample of that -- then even though 90 percent of those get detected, occasionally, they get missed. I think the difficulty is moving from there to reasons why that one was missed on that particular occasion. And if you treat it purely as a probability, that's one thing you say you would expect a certain number to be missed.

If you were trying to get down to reasons, it's probably more difficult. Does that answer it or -

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CHAIRMAN GOGLIA: Somewhat. The work that's been done in San Dia in visual inspections, has it been published?

THE WITNESS: Yes, that -- the report on the visual inspection research project came out last year.

CHAIRMAN GOGLIA: Okay. Thank you. Back to the parties, any additional questions? All right. To the Tech Panel? Well, Dr. Drury, before I send you on your way here, I just want to make one comment. Again, you and I have worked together in the past. And as someone who has been both a test subject and someone who has helped you in the collection of data, I just want to let you know that your work is greatly appreciated.

THE WITNESS: Thank you.

(Witness excused.)

CHAIRMAN GOGLIA: We will call our next witness, Mr. Ray Valeika.

(Witness testimony continues on the next page.)

RAYMOND VALEIKA, SENIOR VICE PRESIDENT, TECHNICAL OPERATIONS, DELTA AIR LINES, INC., ATLANTA GEORGIA

Whereupon,

RAYMOND VALEIKA,

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

MR. HAUETER: Mr. Valeika, would you provide your full name and place of employment for the record?

THE WITNESS: My name is Raymond Valeika. I work for Delta Air Lines here in Atlanta at Hartsfield International Airport.

MR. HAUETER: And what's your position with

Delta?

THE WITNESS: I'm Senior Vice President of Technical Operations.

MR. HAUETER: And would you provide your employment history and experience in aviation for the board?

THE WITNESS: Okay. I'm a graduate in aeronautical engineering engineer type. I worked at the McDonnell Aircraft early in my career in wind tunnel testing and a few other jobs. Most of my career has been spent with the airline starting in 1965. I spent 21 years at PanAm. Nearly seven years at Continental. And two and a half now here at Delta Air Lines.

In the airlines, I started out as an engineer. I was a structures engineer. I was a powerplants engineer for a while, and worked my way into the quality control side, and into quality and engineering, and into being Vice President of Maintenance and Engineering at PanAm and then similar positions at the other companies.

During my career, I've chaired quite a few committees and I'm a member of quite a few committees. Particularly, I would like to mention, I did chair the

committee that developed the MSG-3 process, which uses damaged tolerance in the development of maintenance programs. And I also chaired the original Aging Aircraft Committee when much -- quite a few years before this current aging aircraft when we developed the damaged tolerance requirements for the fail safe aircraft.

I've been pretty well in maintenance for about 30 years.

MR. HAUETER: Do you hold any FAA ratings or certificates?

THE WITNESS: No, I don't.

MR. HAUETER: Thank you.

MR. GATTOLIN: Good afternoon, MrValeika.

THE WITNESS: Good afternoon.

MR. GATTOLIN: I would like to start out with some things. Could you tell us what departments report to you at Delta?

THE WITNESS: The technical operations function has -- is divided into production and support. The production consists of basically line maintenance, engine maintenance, component maintenance, and aircraft maintenance, and then we have quality control, which Mr. Maucere heads up. We have an engineering function,

a planning function, and a support material function. And, of course, the administrative function, because we're a large department.

MR. GATTOLIN: Right, okay. Where does your department fit into the corporate chain of command? You have these others that are basically your responsibility. Where do you -- who do you report to?

THE WITNESS: I report -- let me go down, rather than up for a minute. We have the chairman and then we have three executive officers, one of whom runs operations and I report directly to him with the technical operations.

MR. GATTOLIN: Okay. Very good.Thank you. During a one-year period the accident, how often did you have the opportunity or how often did you visit the FPI and cleaning shops, if I may ask?

THE WITNESS: It's really hard to say how often. I'm one of those wander around type people. So, I've probably been there -- oh, the engine shop is right below me. And as a matter of fact my window in the office opens up on the engine shop.

So, other than having a picture in there, so they think I'm there occasionally, I do go down there. I'm probably in the engine shop certainly once every

two weeks. And as you walk through the engine shop, the cleaning shop is on the left and the FPI shops is adjacent to it. So, you know, probably once a month or so, I wander through there.

MR. GATTOLIN: Have you had an opportunity to watch or observe the cleaning and the FPI process itself, the inspection process?

THE WITNESS: Yes, I have.

MR. GATTOLIN: You have. All right. And during this one-year period before this accident event, what type of formal meetings did you have with Mr. Maucere and individuals that report to him, regarding the operation of the inspection shop, cleaning shops?

THE WITNESS: With Mr. Maucere, I have weekly meetings on my staff. And also ad hoc meetings with some of the people that report to him. Somewhere -- let me kind of describe some of the meeting schedules -

MR. GATTOLIN: Sure.

THE WITNESS: -- and maybe it will help you a little bit. Whenever you have a fairly large organization like we have, there is some formal meetings, which I think are essential, so, you have

some continuity. And, of course, the informal meetings. But, generally, at 10:30 every morning, we have a get together. It just looks at yesterday very quickly. And so we have a daily discussion. And if Mr. Maucere's not there, then his people are there.

In addition to that, then I have my staff meetings once a week. And these are scheduled type meetings. Over and above that, we have ongoing meetings where I meet with the quality folks or the engineering folks or the TOEC committee, which is technical ops where we review maintenance programs, various groups like that. We don't have a specific time set for the FPI people to meet with me, but I have had employee meetings and meetings with the quality people, oh, probably on an annual basis two or three times with a variety of employees.

Again, we have a monthly managers meeting. So, Mr. Clements would attend my monthly managers meeting and a variety of others. So, it would be hard for me to really give you a specific number of meetings --

MR. GATTOLIN: Okay. I understand.

THE WITNESS: -- but I know them personally by name and that kind of thing.

MR. GATTOLIN: Do you -- when you have these meeting with these folks, do you have any type of agenda or is it just basically let's talk about what's going on? Would you tell us a little bit about what goes on?

THE WITNESS: The morning meeting has a very specific agenda. That is, that we talk about basically, okay, what has happened. How many airplanes are available and how many engines are available, what's tomorrow going to look like? My staff meeting also has a specific agenda, where we cover topics and then we continue discussing those topics if they're not cleaned up.

Most of the meetings really do have an agenda. It's very hard just to sit down and BS kind of thing, because that process then just takes up too much of your time. So, you have to focus. And it's fun to talk, but you really have to focus. So, agendas are much more common than maybe people think.

MR. GATTOLIN: And during the formal meetings, discussions, I'm sure, come out about operations and, as you're saying, what's available, what's not available. Now, if we can focus, let's say, in a particular shop, if Mr. Maucere or Mr. Clements

were to have some concerns about the operation or equipment, what is the process of handling these concerns? How do you resolve the concerns that may be brought up? Now, just specifically to equipment or whatever, but --

THE WITNESS: Sure.

MR. GATTOLIN: -- just to concerns, generally speaking?

THE WITNESS: Generally what happens is that either the -- we have a variety of indices that we track, so that at least gives you an indication of either problem areas or areas that we need to review. For instance, we would talk about engine production. You know, where are we with the 219 engine? How many engines are we going to produce and what are the issues keeping us from producing it? Is it a parts issue? Is it a technical issue? Is there a backup in one of the shops? Where's the critical flow.

Those kind of discussions occur very often. And generally, they lead into things like you're referring to. Maybe the backup is that there's too many parts or we don't have enough people or the equipment is not working or one of the tanks is out. Those kind of things actually come to my attention

quite frequently.

MR. GATTOLIN: And you just assign -- you assign the task for resolution to the department heads and have them report back to you?

THE WITNESS: Generally, we do. In some cases, they assign it to me, because it has to go up and we either have to fund something or do something with manpower or maybe redesign some of the processes, things of that nature.

MR. GATTOLIN: I see. Okay. Do you keep a record of the resolution of any problems that may -- do you have records that are kept in a department file or anything of that nature?

THE WITNESS: There are some that are kept on a record, where they were specific issues, particularly, the audit type issues. But certainly an issue, such as there was a backlog in production, we would not keep a record as to what we did to break that backlog --

MR. GATTOLIN: I understand. Okay. Before the accident took place, were you content on how the FPI and cleaning shops were operating?

THE WITNESS: Yes, I was content. However, at that -- prior to the accident and subsequent to the

accident, we had been looking at the -- the FPI process had been a bottleneck. And one of the things we wanted to do quite early on is to create more focus shops in our engine area, whereby individual shops are more self-contained, where they may have different functions. And, in particular, with the FPI area, we had several pieces of the production area that had difficulty in the cases -- the particular case is a very complicated part, as you know. And the cases were going through the FPI lines.

So, early on, we wanted to move an FPI requirement to the case shop and send the landing gear pieces out of there, and the wheel and brake pieces out of there. So that the FPI shop that we're referring to becomes more of a rotating part. You know, of the kind of things that are in there right now.

And so those were some of the issues that we had addressed prior to and subsequent to the incident.

MR. GATTOLIN: Okay. Would you say that these shops were operating within the parameters of the OEM requirements?

THE WITNESS: Yes, they were.

MR. GATTOLIN: They were. Okay. What thoughts did you have concerning the FPI and cleaning

shops after you became aware of the facts -- at least, the initial facts of this accident? What went through your mind from the standpoint of there's things to do, shall I say?

THE WITNESS: The same things that would go through your mind. I mean, we had a tragic accident. So, first of all, you intersect and see what is there? Are we doing something? Do we need to review, change things? Is the staffing proper? Are the people working too hard and too many hours, or whatever? All those kind of issues, obviously, come up, because an accident is a very personal thing. These aren't just statistics. These are things that really involve you and especially in the maintenance kind of function.

Particularly what we looked at was the fact is the workload has gone down, because we took pieces out of there. So, we didn't feel that it was a work issue. And we did ask -- the FAA came in and we had several other audits where we brought people in, and the whole cleaning process, FPI process. It's the same kind of things you've heard today.

We basically reviewed the very same things. I mean, it's not a mystery that if you don't clean the part, you can find a problem with it. So, we spend a

great deal of effort focusing on that. And particularly, focusing on these complicated parts and questioning whether the procedures we're using are sufficient.

As a matter of fact, as far as the shop goes, we developed the eddie current technique, and then Pratt came in and bought off -- shortly after the accident, because we felt that eddie current, if there was a known problem, is an appropriate method to refine the inspection process. But we went through both the cleaning and the FPI shop in detail throughout that period of time.

MR. GATTOLIN: You mentioned you began to develop the eddie current program with Pratt & Whitney. What other immediate changes, if you want to use that phrase, did Delta undertake as a result of the accident?

THE WITNESS: Let me just begin with the accident as it happened and the events we took shortly thereafter. I think it's -- sometimes when you have meetings like this, you're looking at time lapse photography, so you have one event, and then maybe six months after, another one, but they all look continuous and flowing and sometimes you don't get the flavor.

And sometimes the activity may seem inadequate or we may seem very quick at it and start to tell.

The instant the accident happened, we -- Harold McDonald, who runs the engine shop, we had phone calls. And the first thing we did -- before knowing what it was, we had suspicion it could be fan blades, because there have been some problems with fan blades locking up. So, we did an immediate fan blade inspection on the whole fleet to make sure that none of them were -- that we had any fan blade problems. And this is as I was going to Pensacola.

Shortly after arrival in Pensacola, I did see that it was the hub failure. And the action we took was two-fold. One is we issued a flight ops bulletin to start using reduced thrust. There was no reason for us technically to do that, but we thought it was good judgment to use some reduced thrust takeoffs.

And the second thing we did then is we initiated as the investigation was going, we did look at the serial numbers and start looking at the -- we didn't know. We didn't know whether it was a -- what kind of problem it was. You know, the hard alpha business that you already heard about.

So, we then took on our own, determine what

the serial numbers were on this particular hub at the production time were, and we pulled those engines off one of the aircraft, what we determined as it was actually taxing out and we made a decision to stop it. There was nothing found wrong with it, but that was the action we took.

Shortly thereafter, then we began working with everybody on the inspections. We then kicked off the inspection to -- on the wing to do the eddie current. We started on a wing, where we pulled the disc off. We found that worked reasonably well, but because of the fan blade issue, we also felt that maybe we were better off swapping disc by disc completely with fan blades, because that took care of two issues.

So, we went through that. And those were the immediate actions that we took in order to get the -- to assure ourselves that we didn't have any kind of a lingering problem out there, whether it be related to a batch or whether it be related to some other things.

The shop procedures that we took action on, I'll be glad to expand on them, but it's the same things as Maucere said --

MR. GATTOLIN: Please.

THE WITNESS: -- with the -- where we went

through the shop and we got into the training of the cleaners. We put an inspector in the cleaning shop, so that the parts come out there. We got the process sheet, did the -- I don't recall exactly when we did the -- putting the wheels and the donut and those various other things that we felt we needed to do in a shop to enhance our procedure, but all of those came shortly thereafter.

I don't recall how many of the exact number of recommendations that we had when the FAA came in, but I think we've now taken action on every single one of those in August or September when they did the audit. So, there's been a good deal of effort on our part to get some of these recommendations in place.

MR. GATTOLIN: Could some of this have taken place before the event took place? Could some of these changes have been made before the event, do you feel?

THE WITNESS: I could win every single baseball game on Monday.

MR. GATTOLIN: Oh, okay.

THE WITNESS: So, you're absolutely right. I mean, we could do lots of things. There's no way you can -- you know, I think everything could be done before when you know something that came later have

consequences that didn't work out.

MR. GATTOLIN: Well, this was a result of looking at the problems. Is that what I'm hearing you saying? This is -- the changes that were made were a result of the accident? And these changes were possibilities of areas that could be improved? Am I --

THE WITNESS: Some of these were.

MR. GATTOLIN: -- incorrect in understanding that?

THE WITNESS: Not all of them. Let me just talk about the one thing that seems to have been coming up is the staffing level. The issue that we have looked early on prior to the accident and took us ironically enough -- you know, the FAA is not the only organization we have to deal with. There are other organizations.

But, for instance, in the case of FPI, for us just to physically move a booth within our building -- not to increase the number of particles going in the air, but just move it, it took us ten months to get approval to put an FPI booth in the K shop. We had some real -- we had the concerns, you know, on how in trying to create -- we feel that focus shops are really a good way to go, where you have the whole

responsibility for the thing.

MR. GATTOLIN: Right.

THE WITNESS: And so those kind of things were done earlier. Some of them, unfortunately, because of some of the processes took a long time to implement. But they were not as a result of the accident. Some of the actions were in place.

MR. GATTOLIN: Okay. So the ten month period for approval, did you say that was from the FAA to get an approval to make this change?

THE WITNESS: The EPA.

MR. GATTOLIN: From who?

THE WITNESS: The EPA.

MR. GATTOLIN: Oh, the EPA. Okay. Thank you. All right. Delta had this continuous analysis surveillance system. Was it ever used during, let's say, the previous two years on the FPI and cleaning shops?

THE WITNESS: Yes. And we had -- I don't have it right in front of me the actual dates, but there was, I believe, a 1994 report. And at that time, to the best of my knowledge, the kind of things we found were not procedural problems that referred to cleaning or that, but procedural problems in terms of

the manuals, procedural problems in terms of P-met and various things of that nature, but they were not specifically in highlighting any shortcomings in the process itself.

MR. GATTOLIN: Again, that was the -- are you talking of the NASIP from the FAA?

THE WITNESS: No, this was our own.

MR. GATTOLIN: That was your own audit. Okay.

THE WITNESS: NASIP was in a '94. The subsequent NASIP in '95, I don't think looked at the FPI shop.

MR. GATTOLIN: Okay. In '94, according to the FAA's FPI technical review, the 1994 NASIP identified items that impacted the effectiveness of the FPI process. Can you share with us what these items were that would impact the -- impact the effectiveness of the FPI process that they found?

THE WITNESS: I really can't, only -- I mean, I could if I reviewed the records right now. I joined Delta in September. NASIP was prior to my coming there. And I was involved with -- all I can tell you is that all of the actions that NASIP highlighted, all of the actions that have come subsequently that I've

been involved in, we implemented or we had good reasons not to implement them.

MR. GATTOLIN: All right. Were there other changes to the FPI and the cleaning shops after the accident that we haven't talked about yet that you folks have made? For personnel staffing, have you added some more? I can't recall.

THE WITNESS: Well, the numbers that we -- we have increased the staffing, but I don't think that was subsequent. I'm looking at Mr. Maucere. I don't think the -- we increased staffing in the FPI area, the two people. I don't think it was after that. I think that staffing was in place that we put in. Perhaps it was the cleaning shop -- but the main things we did, the cleaning shop was, again -- the points that were raised earlier are very valid. The cleaning shop is a critical piece and you've really got to bring it closer to the consequences of their actions.

So, the training and the focus on the cleaning shop and there have been some management changes around it, we've done things of that nature there.

MR. GATTOLIN: Okay. Well, in the FAA's FPI inspection back in August of '96, had identified a

number of areas that they had some concern with and they referred to these as observations and they had recommendations and Delta responded to these recommendations in a positive manner, from what I can recall from reading both of the documents. Would you say the observations of the FAA were valid?

THE WITNESS: I think they were valid at the time they were made.

MR. GATTOLIN: Okay.

THE WITNESS: Because I think, you know, as a sincere effort and whether there is indications, systemic issues or not, the observations were a snapshot in time, and we took them to be valid and took action.

MR. GATTOLIN: Well, if that's the case, then I'm kind of confused about how the CAS or how CAS or other internal audits would have missed some things that were observed by -- most of the things that were observed by the FAA? Can you give me any explanation for that?

THE WITNESS: I think I can? The CAS system -- first of all, this is -- we deal with the whole subject of this investigation, but is it a focused inspection or is it a general inspection. The FAA

inspection is very, very focused in very specific areas. Our audit procedures tend to be -- in some cases, they may be focused at a specific job function, which we feel is not working. We may put an extra inspector on it or do something.

But generally, the audits are taking more of a -- just taking a pulse of the area. And the kind of things that we have seen in our audit, some of the same issues have come up. And we thought we fixed them and they've come up again. That's why we continue having audit problems. But, certainly, not in the detail that the FAA inspection has found them.

MR. GATTOLIN: Why do you feel these -- some of these situations that you're alluding to keep reoccurring? What's the reason for them and could you give us a couple of these situations from your recall?

THE WITNESS: Well, some of the situations that they were highlighting things, such as training records, et cetera. Some things like using the FPI brushes for our own process spec. I think one of the interesting things that was said by Dr. Drury is that some of the habits that are in place -- you know, experience is good, but experience also can in some cases create those good and bad habits kind of thing.

And some of the things, you know, when you are really changing a process, when you're changing an organization, sometimes old habits are hard to break. And sometimes, you know, you just have to keep doing and doing. It's got to be relentless.

The fact that something is found on a surface, I don't take that -- I don't put a value judgment. Obviously, I put a tremendous value judgment if we can't over a reasonable period of time eliminate those kind of problems. And I think in the cleaning area, in particular, I think the training aspects, the inspection aspects, I think those are very important. Some of the equipment pieces that we have to put in the timing, et cetera, I think those are things we have to do.

MR. GATTOLIN: Okay. In the Exhibit 8E, page 21, there is a comment here. And I wanted to talk with you a little bit about that, if you could go through it with us. It's observation, I would assume, O or Oscar 2, where it talks about -- you indicated a continuous analysis surveillance system and reliability program had generated actions as a result of the Pensacola accident, but the team could not verify that any internal Delta Air Line audits of either the engine

cleaning department or the non-destructive inspection shop had been performed, subsequent to the incident in Pensacola, Florida accident.

Can you -- would you tell us, do you folks keep records of your CAS and your reliability reports, inspections? How does this work?

THE WITNESS: Yes, we keep records of the CAS findings.

MR. GATTOLIN: And how is this situation -- what happened here, if I may ask?

THE WITNESS: I think what we're using here is -- when we did the audit of the shop, there's an audit, CAS audit, but subsequent to the incident, it wasn't a CAS system audit, it was -- you know, let's put some resource on this and let's look at it real quickly. So, it was a -- it didn't fall within the CAS system as such. It may sound like I'm double talking, but --

MR. GATTOLIN: No, go ahead.

THE WITNESS: -- you know, something happened. We said, let's look at it. The CAS system is the routine ongoing kind of process. So, we did look though the shop. We had a lot of detail looks. And like I said, subsequently, we had FAA come in and

we went through procedures. We went through the records. We went through training to make sure that everybody's qualified. You know, the normal thing you would do when an incident occurs.

MR. GATTOLIN: Okay. So, basically what you had done after the accident, there was nothing that was in a formal type of report. That's what this is saying here?

THE WITNESS: That's what it's saying, yes.

MR. GATTOLIN: But someone had called it a CAS and it really wasn't. It was just something, let's get this -- let's take a look at this right now? A reaction?

THE WITNESS: Right.

MR. GATTOLIN: Okay. How do you ensure a follow up on items that you find during these audits? What do you specifically do -- and just kind of go down the ladder, if you will?

THE WITNESS: What I do specifically, one is there's different levels of findings. The first thing with findings is somebody's got to take action on it. Anything that's out over 60 days without action taken comes to me. And then I do get the significant findings. A significant finding would be a mistake

denoted and things of that nature. I get those.

I don't get them routinely. My primary focus is to deal with the exceptions. And also to make sure that the repeat ones, if there is no action taken in 60 days or if it repeats, then they do come to me and we have a formal process for that.

MR. GATTOLIN: Okay. If you would take a look at Exhibit 8R, please, and turn to page 2. What I would like to do is read a portion of the second paragraph into the record, so that we're clear. And this would begin with -- the paragraph begins with the metallurgical examination.

What I would like to read in, the number of striations and the appearance of the fracture surface suggests that the crack was present on the AF face of the hub for a distance of 0.46 of an inch at the time of the last FPI. The length of the crack along the wall of the hole is about 0.9 of an inch at the time of the FPI.

This crack was almost, I would say, it was about a half inch outside. It was on the back face around the corner on that?

THE WITNESS: Well, about .46. And not going into the radius.

MR. GATTOLIN: Right. Okay. How would a crack of that size have been missed by the shop that had been basically meeting the OEM parameters?

THE WITNESS: Well, I think that's really why we're here. I really wish we would know that.

MR. GATTOLIN: What are some of your thoughts on that, please?

THE WITNESS: First of all, I think we have to -- let's focus on one thing. The important thing that we have to focus is the whole fail safe issue here or safe life issue, excuse me. If we have a safe life part, it is assumed from the beginning that the part is defect free. And if it's defect free, then we establish certain inspection requirements that are intended to find normal wear and tear and abuse and various things of that nature.

And so you have an area level type inspection program to protect that. If the part has a defect, then the principles in developing the inspection program don't fall into the area level. You then really got to get into crack propulgation rates and damage tolerance, et cetera, et cetera, et cetera.

So, I think the first point that has to be made is, yes, there was a defect in the part, and if

there is a defect in the part, you now must focus your inspections towards that defect, not use a general area level to determine, you know, what the problem is.

The second thing is, I think the same issues have been raised, what has been bothering me throughout the hearings is, as we listen to the hearings, there is an issue in water in the crack. We can follow the procedures either we bake it or we don't bake it. We air dry it or we don't air dry it. Both are perfectly good procedures. All are OEM approved procedures. An issue, does the dust get in the crack or doesn't get in the dust? There's some thoughts that the pinning knots can cover the surface. There's some thoughts it doesn't cover the surface.

So, I think I can list just as many variables and make the same kind of assumptions that all of those variables existed. What I'm really concerned about is hypothetically, can we do everything right and not find a crack? We don't know what we did wrong. We don't know what the condition of crack surface was at the last inspection.

We know that there was a crack. We counted striations, but we don't know that dirt was in or wasn't in. That the dirt could be cleaned out, the

outcome had to be cleaned out. We just -- we don't know the condition of that surface.

We do know that there was no dye in the surface, which the indications were that there weren't -- wasn't any. So, you know, if I really could tell you that, I think -- I wish I could, but I think all these other variables -- and I think that's both as an industry and as a result of this finding. I think we've got to focus on several issues. One is we got to focus on FPI as a general area inspection, and an FPI as a focused inspection, and does it have to be enhanced?

But the number two thing, I really think we do have to discuss, is the up front product is being delivered. Are the inspection processes in place to assure a totally defect free product? If those are in place and we can assure that, then I think FPI is an appropriate procedure. If we can't assure that, I think we've got to look at damage tolerance.

MR. GATTOLIN: Okay. For the purpose of clarification, I would just like to read something from the metallurgist factual report in 15A, I believe it is. It said, no unique chemical identification related to the dye penetrant was found in the fracture surface

of the hub. I just want to make sure that you understand what that was saying there, okay? That was the last paragraph of the report number 97-25.

DR. LOEB: What's the page number?

MR. GATTOLIN: It's page 2, I'm sorry.

DR. LOEB: Of what Exhibit?

MR. GATTOLIN: I believe it was 15A, yes.

DR. LOEB: Oh, 15A.

MR. GATTOLIN: It's the metallurgist report dated November 25. The factual report dated November 25, 1996.

THE WITNESS: I don't have that, but that's all right.

DR. LOEB: Fifteen-A?

THE WITNESS: Yes.

CHAIRMAN GOGLIA: So, I just want to bring that out as clarification for you. But the point is the system, you're saying that you question the system of inspection. Did I hear you say that or am I --

THE WITNESS: No, not question -- I did not at all question the system of inspection. I'm questioning the appropriateness of inspection techniques to detect certain cracks for certain conditions. What I am questioning is that if there is

a pre-existing condition in a part, do we use random events, shop visits, opportunistic events, to try to use randomness to find a specific crack that is growing at a specific rate?

Secondly, I question, if there is a pre-existing condition inside a bore of a hole, is the FPI technique specifically to focus on that when there is no reason for you to focus on that? You know, is that the right technique? I think FPI technique is very appropriate, but I think if we are going to focus on pre-existing conditions, are we going to focus on certain crack propulgation rate issues, we must then develop techniques that will assure us that we have opportunities to find that crack. Whether we use FPI, whether we use eddie current, whatever we use, but we've got to use the technique to make sure that within that crack growth interval, we've got to find the crack.

MR. GATTOLIN: I see. Okay. Now, MrConroy would like to continue with a few questions. I'm finished.

THE WITNESS: But just -- excuse me. I did -- I think I said the very same thing you did. There was no indication of the -- in the crack of the dye.

DR. LOEB: Well, I think we need to clarify that for the record. The statement, as Frank read it, was no unique chemical identification related to the dye penetrant was found. I think it's also fair to say that it may not be foundable. We may not have been able to find it even if it was there. So, I think we just need to make that clear for the record. That we may not be able to take that as an indication that there was no dye in the crack.

THE WITNESS: Okay.

MR. CONROY: Thank you, Mr. Chairman. Mr. Valeika, I have a few questions. And I was away for a few minutes, so if your testimony got into these areas, I apologize, but I'll bring them up. First of all, to follow up on a question that Mr. Gattolin just asked and I believe you stated words to the effect of, FPI is not an appropriate process. We must look at damaged tolerance. Could you elaborate on that, sir?

THE WITNESS: Let me make sure that we don't get ourselves wrapped around an axel and get confused. I think FPI is a very appropriate process for general area level type inspections and it's a very good process. I mean, we have findings -- specific findings. We do find problems and we protected the

industry very, very well.

What I am saying, however, is that if we have a safe life part that has pre-existing damage in it, then we have to evaluate how do we detect pre-existing damage. An FPI may not be the appropriate technique to use to evaluate that pre-existing damage. We may have to use eddie current, ultra-sonic, whatever else is out there that will give you an enhanced opportunity, because the conditions for safe life, as you know, is that this part will operate throughout its life, even without an inspection.

If the engine runs successfully without a removal, that part doesn't have to come off for any inspection. If there is a pre-existing flaw in there, you have to evaluate that completely differently than you're doing currently.

MR. CONROY: I believe you were here yesterday for Mr. Maucere's testimony.

THE WITNESS: Yes, I was.

MR. CONROY: I'll ask you the same question that I asked Dr. Broz. Mr. Maucere seemed to indicate a greater confidence in eddie current, which has been added after the accident to examine this part and titanium rotating parts in general. Do you have an

opinion or comments regarding his statement and whether eddie current is -- for lack of a better word -- a favorite means of inspection now?

THE WITNESS: Let me state it this way. I think eddie current in that hole or eddie current in tide radiuses areas where it may be difficult for FPI to penetrant and to see, I do think it's -- at least as we know right now -- it is the inspection of choice. And I do have more confidence for that kind of an inspection.

On the other hand, there are applications in this very same hub that I don't think eddie current would be very good. You certainly wouldn't want to probe the whole surface of that thing, because you wouldn't be sure that you've got 100 percent coverage. So, you know, I think in the hole, the radius, certain specific focused areas, I think eddie current is the choice.

MR. CONROY: Thank you. Regarding your chain of command, how are problems brought from the shop floor, such as the FPI shop up to your level?

THE WITNESS: Most of the time, they're brought by Mr. Maucere. A good number of problems, Delta is a company that has a culture of people telling

you what they think, which is very good. I probably get as much input from the folks directly what they think pro or con of me or the shop or whatever else, as most places. So, I have quite a bit of input directly from the employees. I certainly have input from the CIT teams and I have a 1-800 number that we do. We have sort of a call ratio where they don't have to tell me who they are. They can call me. We do that.

And I would say that 90 percent of the issues and problems come through the chain of command. Mr. Maucere, Mr. McDonnell, they tell me these things. But I would say another 10 percent come from a variety of places directly from the employees.

MR. CONROY: And you said that you had a 1-800 number in which persons could call and choose to identify themselves or not?

THE WITNESS: Right. We have -- the first Friday of the month, they can call me. I'm on the phone, and they don't have to identify themselves. They can tell me whatever they want to tell me and they do.

MR. CONROY: I see. You mentioned originally your chain of command is at the vice presidential level. Are there any other vice presidents at your

level -- and I think you described it as three divisions -- in which maintenance or technical areas would report to a different vice president?

THE WITNESS: No, all of maintenance, whether in Atlanta or the system, reports to me. There are no maintenance -- unlike some airlines, marketing folks, they'll run line maintenance. I know some airlines the line maintenance folks report to the marketing. Anybody that turns a wrench works in tech ops.

MR. CONROY: I see. Thank you. Regarding question prior to that and the reporting problems or suggestions to your level, is there a system of reward in your chain of command in which someone at the shop floor can make a suggestion or find a problem and get it up the chain of command?

THE WITNESS: If you're thinking of programs, you know, where you incentivize by paying people for doing things, we don't have a specific program like that. I really found those to be very ineffective, quite frankly. I haven't had them here at Delta, but in my past life.

Those kind of programs tend not to work, because you can -- the fairness issue is very difficult. In an engine shop, people can save money or

do things a little bit easier, because they're in a confined area. Whereas, a line maintenance mechanic who is working at night changing a CSD, he may not have those opportunities.

So, what we try to encourage at Delta, which I think is very successful, is the CIT process. This continuous improvement process. And we do reward them with recognition, plaques, pizza, you know, some Disney tickets. That kind of stuff. But not -- we don't pay for suggestions.

MR. CONROY: Okay. I'm interested in discussing follow up to suggestions or problems that reach your level. Is there a system for recording and ensuring follow up to suggestions or problems that come up from the shop floor?

THE WITNESS: The CIT has a formal process in place. The audits have a formal process in place. And what I do in my own staff is that any item that's still open on my agenda, we continue keeping open items forever, ever and ever, until they're closed.

So, I do have that process, yes.

MR. CONROY: Are they recorded on a database or some official place?

THE WITNESS: The CIT and the audit findings,

yes. The others, no.

MR. CONROY: The others are just on paper and your managers ensure that they're addressed?

THE WITNESS: If it's done and we can close it, then it's closed, yes. But we don't keep a data -- I don't keep a data file. And perhaps my staff does if I ask them, but I don't.

MR. CONROY: I see. Do you -- and I believe you addressed this with Mr. Gattolin. You do visit the shop floor and you mentioned the FPI shops. Thank you. Regarding the FAA, do you communicate with the FAA from your position?

THE WITNESS: Yes. First of all, we have -- well, let me start with official FAA correspondence. Let's begin with that. All the letters that come through me. If there is any letters, they all come through me in or out. So, I do see that form of communication.

We have a monthly meeting with the PMI. We call it a fire side chat at 4:00 in the afternoon once a month. The PMI brings some of his staff and I bring some of my staff. And we go over -- we prepare an agenda in advance. Usually, just communication issues. You know, what are we doing wrong.

I know you talked about some of the calls sometimes we review, if there is a call, you know, not the DOT, but the FAA or whatever it may be, whatever issues. We have that. That is a standard. Once a month, we talk to each other routinely. But on a going basis, both with the current PMI and the previous PMI, we probably talk maybe as much as once a week, once every two weeks about various issues.

We really -- on a personal basis, I have a great deal of interface with the PMI.

MR. CONROY: And you say you have basically a sit down meeting with the PMI and his staff once a month and your staff?

THE WITNESS: Once a month.

MR. CONROY: How long has that been going on, sir?

THE WITNESS: It's been going on since I've been there. So, I can't speak before that.

MR. CONROY: Okay. Do you interface with the FAA on a higher level than the PMI?

THE WITNESS: When we used to know who was there, yes. A little humor. With the Washington gang, you know, I knew all the FAA people and interfaced with all of them for quite a few years.

MR. CONROY: All right.

THE WITNESS: I'm not -- I really can't say that right now, because there's big changes there and I haven't met too many of the new players yet.

MR. CONROY: Do they ask you for suggestions regarding changes or suggestions regarding FAA approved procedures?

THE WITNESS: At the Washington level?

MR. CONROY: Or at the PMI level.

THE WITNESS: Let me begin with the Washington level. The Washington level, I think we've had a pretty good relationship. And whether they asked it or not, we gave them our ideas and changes. Some they agreed with. Some we didn't disagree. You know, certainly with the former airworthiness folks that were in there, we knew those, because we had worked together for quite a while.

At the PMI level, yes, but PMI actually probably is more asking us for changes than the other way. At the Washington level, it's us asking them for changes. I think that's kind of normal. At the Washington level, we feel that certain policies need to be changed, certain procedures. You know, questions of certain AD notes.

At the local level, I think what's happening more is that the PMI feels that things that Delta should change and they come to me.

MR. CONROY: They encourage --

THE WITNESS: Although, we do talk back and forth.

MR. CONROY: They encourage suggestions or changes from you?

THE WITNESS: I have found the FAA to be very good about that.

MR. CONROY: And you mentioned that in getting, improving at the PMI level or more so now than in the past, is that fair?

THE WITNESS: Would you repeat that?

MR. CONROY: You mentioned that you've -- for one of a better word, that it is improving or increasing at the PMI level, where they're asking you for suggestions or changes to FAA approved procedures. Is that fair?

THE WITNESS: I don't think it's better or worse. I think it's been pretty good.

MR. CONROY: Okay.

THE WITNESS: We have a new PMI, so we haven't established the same relationship. Although,

in a short time, we've had three or four meetings already. And then he's asked for changes that we should do and some are absolutely appropriate and some we're going to have some more discussions about.

MR. CONROY: Are you satisfied with their encouraging suggestions regarding FAA approved procedures and your ability to make them?

THE WITNESS: We have to encourage that, because if we don't -- the one thing, there's often a misperseption or a misconception, I should say, that we're in an adversarial situation. I think that the issue here is that, you know, we really got to finish the mission safely together. And if -- it is so much easier for us to work with the FAA if we can, you know, merge and come up with systems and procedures that work together, rather than be diverse and oppose.

So, you know, everywhere where it's reasonable, we try to do that. There are issues that we truly disagree. And I think -- I mean, that's just normal. But, you know, if there are procedures and if you've got AD notes and all that, it's just a lot of easier to be -- that's why the issue of the various procedures or some discussion on FPI are kind of interesting.

We follow the OEM's procedures, because if there isn't an AD notice, it's so much easier than to be in compliance than have to get exceptions and doing all that. So, the same thing applies throughout just the normal relationship.

MR. CONROY: Okay. And I believe you were here for Mr. Hilerio's testimony.

THE WITNESS: Yes, I was.

MR. CONROY: The record will show exactly what he said, but I believe you stated that he spends 75 percent of his time on inspections. Do you feel that that's a fair amount of time?

THE WITNESS: It's really not my call. I wouldn't know what a fair amount of time or an unfair amount of time would be. And it would be tremendously presumptuous of me who's never done that to try to determine what it takes to inspect the hub or anything else. If he says it's fair, I think it's fair.

MR. CONROY: One last question. Regarding Dr. Drury's testimony regarding human factors. Do you have an opinion regarding how much time an inspector should spend on parts, such as this, in his day?

THE WITNESS: The only opinion I have is that I want to be sure that the inspector feels he can do

the job. I certainly don't want to hender and create artificial, either you must work this time or you shouldn't work this time. I think if he feels that it's within his capability and it's -- you know, within the reasonableness of the people managing it, then I think that's the amount of time he should spend.

And I think -- I really agree with what Dr. Drury said. I don't think there's a real fixed standard on that. This isn't, you know, widgets coming off the production line where we've got to crank out five. We just have to do what's right. And if the inspector feels he's comfortable, that's fine. If he doesn't, he ought to walk away from the job. You know, get a rest, get a break, do whatever.

MR. CONROY: I see. Thank you. Mr. Chairman, I believe Mr. Anderson has a question.

CHAIRMAN GOGLIA: Mr. Anderson.

MR. ANDERSON: (no microphone) -- your background in engineering, I have a feeling that you'll be comfortable talking a little bit about the --

CHAIRMAN GOGLIA: Pull the microphone closer to you.

MR. ANDERSON: Oh, excuse me. Mr. Valeika, can you hear me now?

THE WITNESS: Not real well yet. Try it.

MR. ANDERSON: I'll try it again.

THE WITNESS: Maybe that way, I can mumble back.

MR. ANDERSON: I've heard your testimony on your background as an engineer. I feel it would be okay to ask you some questions concerning some of the statistical issues that have been discussed previously here. And specifically in relation to the process, if we were somehow to pull some of that information together and come up with an accurate and perhaps repeatable statistic that showed that the FPI process when practiced properly had a 99.5 or a 999.5 percent probability of catching a crack, would that lead you to assure the traveling public that there would never be a crack missed?

THE WITNESS: Let me answer your question this way. I think we have to first of all look at consequences of failure. I think just purely saying crack or no crack and all that, we've got to deal with consequences of failure. I think if you can assure me 100 percent that the consequences of failure would not be catastrophic, then whatever techniques you do, I think just pure numbers of catching cracks or not

catching cracks is not a sufficient criteria. But the consequence of failure -- so if the consequence of failure is catastrophic, then we have to either through design, certification inspection, put together something that will give us ample opportunities -- maybe that 99.5 two or three times, whatever that number is, to make sure that doesn't happen.

So, that's the way I would answer that. I can't just answer you -- if I know the consequences of failures are catastrophic, I cannot accept 99.5 as is being the condition.

MR. ANDERSON: But everything we've heard so far would indicate that whatever that number is, it is certainly not 100 percent. Is that correct?

THE WITNESS: Obviously, there's nothing that's 100 percent. But if we know -- if we know that a condition exists, that we cannot certify to be safe, 10 to minus 6 is it, whatever? Ninth. I'm forgetting. But if it's not 10 to the minus 9, if we're not in that, then we got to redundancy do whatever. We can't just depend on the inspection technique as being --

MR. ANDERSON: I understand and I respect what you're saying. But the point I'm making is simply one of interpreting the statistic. And I will even

give you 10 to the minus 9 probability. Does that mean I can never have a failure, even though the probability is to be 10 to the minus 9?

THE WITNESS: Again, this sounds like I'm running for election and we're going to -- I think that if the certificating criteria is 10 to the minus 9 and that is the criteria by which we have to live and I can assure you of that, then that's fine. But we can't do anything less than that.

MR. ANDERSON: Okay. And so we -- I think we're coming to some communication here that the statistics alone do not assure that an event will not happen. It lowers the probability that the event will happen, but there is nothing in the probability that prevents. And so I would like to take that point and move to another question. And that is, you had mentioned earlier about the manufacturer perhaps having defects in their product.

I think you're familiar with other defects, such as inclusions that are very difficult. And a lot of effort has been made in the industry to reduce the incidents of these things. But would you accept or agree that the same probablistic type of situation agrees for the manufacturer, as well as the operator?

THE WITNESS: Absolutely.

MR. ANDERSON: So, who would have the greater obligation?

THE WITNESS: We both would have the obligation. I think the first thing we have to do is assure that whatever crack propulgation rates -- you know, whatever technical conditions for designing the part are such and whatever production inspection conditions are such that there is a very, very high probability whatever that number is again. When I sign, I mean, that part comes out correctly.

I think the second thing that has to be, we then have to be given an opportunity to find the flaw. I think if we have such a critical part, then I think we've got to design a part that has very slow crack propulgation rates, and then we have to establish reasonable intervals. And if you're forced to look at them, you're forced to look at them.

I think you're obligated to do that for those kind of parts. I think you do have to take the crack interval and the crack growth conditions into account.

MR. ANDERSON: So, there really is a team effort?

THE WITNESS: Oh, clearly.

MR. ANDERSON: That's all I have.

CHAIRMAN GOGLIA: Any other questions from the Technical Panel?

MR. EINDLER: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: To the parties. The Federal Aviation Administration?

MR. DONNER: No questions, sir.

CHAIRMAN GOGLIA: Pratt & Whitney?

MR. YOUNG: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: ALPA?

MR. MCCARTHY: No questions, thanks.

CHAIRMAN GOGLIA: Volvo?

MR. THOREN: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: McDonnell Douglas?

MR. STEELHAMMER: No questions, sir.

CHAIRMAN GOGLIA: Delta?

MR. MCDONALD: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Dr. Ellingstad?

DR. ELLINGSTAD: Just one quick question. With respect to the development of the process standard for the FPI process and for any exceptions to OEM requirements or recommendations, where is that signed off within the organization?

THE WITNESS: In the engineering

organization.

DR. ELLINGSTAD: Who at these -- at which level would approve that?

THE WITNESS: At the director level. The person -- we have people in charge of engineering.

DR. ELLINGSTAD: Okay.

THE WITNESS: It would be either at level reporting to me or one below that.

DR. ELLINGSTAD: Thank you.

CHAIRMAN GOGLIA: Dr. Loeb?

DR. LOEB: Mr. Valeika, I would like to mumble with you a little bit about damaged tolerance, if we could. And I appreciate some of the things you've already stated. I would like to ask a question or two, though, before we get into that. Are you aware of a crack in a heavy rotating part being detected at Delta? A crack that would have liberated a heavy part, not a crack in a fir tree or in a blade root or that sort of thing, but a crack that had been allowed to propulgate, could have deliberated a heavy part? Are you aware of such a crack ever being detected in the routine operations of maintenance and inspection?

THE WITNESS: Yes, I am. I think you have -- I want to qualify fir tree. I think fir tree could --

you know, if the blade is big enough, I think --

DR. LOEB: But I specifically don't want to get into that.

THE WITNESS: You don't want to get into that.

DR. LOEB: Yes. We will in a second. I'll ask you that. But I'm talking about where you deliberate a piece of a hub or a disc?

THE WITNESS: No, I'm not aware of that.

DR. LOEB: So, you don't know that -- to the best of your knowledge, a crack of that type has not been?

THE WITNESS: No, we have found at least one of this disc that we had sent to Pratt & Whitney or one of the hubs --

DR. LOEB: You're talking about 2037?

THE WITNESS: No, I'm talking about the 219. We did find the surface flaw with eddie current. But I don't think that falls in your category.

DR. LOEB: Yeah, in fact, I need to, I guess, clarify more particularly. Through the FPI process, is what I was talking about.

THE WITNESS: I am not -- as a matter of fact, I don't know of any that I've seen in my career.

DR. LOEB: You have detected cracks at Delta in other areas of discs. For example, in the fir tree or blade root --

THE WITNESS: Yes.

DR. LOEB: -- is that correct?

THE WITNESS: Yes, we have.

DR. LŒB: Do you have a feel for why that's -- you've been able to do that and we know of at least one case in which -- obviously, there was a crack in this disc and it wasn't detected.

THE WITNESS: I think that just some of Professor Drury's observations, you know, where it's the focus again. I think the fir tree is an area that every inspector will focus a lot more than they would focus further down in the hub, because you just don't find things. And the fir tree, it just has a lot more attention to it. Will you -- should you or shouldn't you further down? I think the tie bolt holes are the next place. But people just don't find cracks in tie bolt holes. So, it's not the same -- I think the intensity goes down as you go down the hub.

DR. LOEB: Cracks are -- have been found, though, in blade root areas. And that is not terribly uncommon. Is that correct?

THE WITNESS: That's right.

DR. LOEB: So, that it's possible that expectation plays a maybe fairly significant role?

THE WITNESS: You know, I really -- I can't speculate on that. I'll ask Dr. Lauber (sp) from the human factor's side as opposed to my technical side.

DR. LOEB: Well, I'll withdraw the question. Let me redirect it a little bit. Given the history of the three accidents in the last -- certainly in the '90s, are you comfortable right now that the safe life concept for heavy rotating parts is, in fact, a viable concept?

THE WITNESS: I am comfortable that the safe life concept is a viable concept, provided that as an example in the 219, that we've now enhanced it. We had some interval with an eddie current inspection or something like that. And in some other discs that there may be some critical areas in certain crack growth that we may want to do an eddie current inspection or some other inspection.

I don't think -- I think the safe life concept, I don't think we need to completely describe the concept. I think what we probably will have to do is consider some inspections on those parts that we

deem need to have some inspections.

DR. LOEB: Well, how do we do that though? The safe life concept says you don't -- this product, this component is simply not going to develop a crack in its -- during its safe life that will propulgate the failure.

I mean, it just -- it is not going to happen. That's the notion now. We've got three -- at least three discs that we are aware of. That for a variety of reasons, corrosion pits in one case, hard alpha in another case. And in this particular case, the possibility of some initial manufacturing process, flaws developed from which cracks initiated and eventually propulgated to failure. That's three times in this decade. One of which was catastrophic and another which resulted in the fatality -- in fatalities.

Doesn't that say to us that we've got to re-exam this concept, this philosophy?

THE WITNESS: I think what it says is we should re-exam how we control it. Now, maybe I'm saying the same thing you are, but let me just say something on that. I think what we have is that -- I guess, there are three issues here. One is just the

whole FPI issue. There's different methodologies and I truly agree with Dr. Broz. We ought to have one system. That would make the FPI process better.

I think the second thing and maybe that's the area we're in. I don't think we're quite yet to discard safe life. I think the piece that we're in right now is there's billions and billions and billions and billions of hours or millions of hours being accumulated. I think it's time that we stood back and said, okay, FPI is absolutely appropriate for this or that, but even within the safe life constraints that we now do an eddie current inspection or we develop a database and then start expanding that inspection.

And then the third thing is if we do know there's a flaw and we do know that something can go there, then you have to impose some kind of damage tolerance. I'm not sure we're ready to leave from an enhanced inspection technique within the existing safe lie criteria to damaged tolerance all in one leap. I think we're very close to it on some of these parts.

DR. LOEB: I guess my concern is that in all three of these, we shouldn't have had a flaw that initiated a crack, but we did. None of them would have required even an FPI inspection at any fixed -- at any

fixed time. The only time that even an FPI is required is if it is piece parted. I mean, there's certainly no requirement for an eddie current on these parts at all during their life.

Are you comfortable with that, having seen --

THE WITNESS: No, I'm not comfortable. You know, if I was comfortable with that, I wouldn't be talking about doing eddie current on this particular hub. So, I do think we're at a point where maybe we need to see which hubs. You know, maybe the fan hubs, certainly, big, lots of energy. Maybe we ought to do something there. And maybe hold -- try to get a database on the other hubs.

DR. LOEB: So, perhaps, what we would be looking at is those rotating parts in which a deliberation of a part could result in a catastrophic accident? Maybe those are the ones that should be concentrated on?

THE WITNESS: I think so. I think so in terms of an analysis, of a better inspection technique. The only thing we keep saying everything on our end of the process, our end being the airline process. We need to also -- we spent, I think, 11 witnesses have talked about subsequent inspection and five talked

about inspection before the part's released.

And what I really think we've got to start thinking a little bit is put the same rigor -- maybe the rigor is there or maybe I just feel the heat being on this side. But I think one of the things that I would like to see is in the analysis of the basic concept. Is the rigor to put inspectability at that end also as rigorous as we're discussing putting the rigor on our end of it? I think -- and maybe it is. I don't know enough about production processes and all that. But I want to -- first of all, if we're going to -- you know, the initial defect is a very important concept here.

So, I do think we've got to balance our approach. Do we have the inspection rigor applied on this end, as well as the stuff we're talking about on the airline end?

DR. LOEB: Well, I would agree with you. Of course, that's the other thing that gives me pause for concern, because we -- we missed a hard alpha inclusion a number of years ago, and now some sort of manufacturing flaw that existed was missed with the blue etch. And I haven't heard any testimony here that suggests that we have better ways of doing it yet. And

so that's why I'm raising this. Where there's a potential for a catastrophic accident, it seems to me that we may need to reassess this entire process.

And, again, if we're not going to catch the flaw at manufacturing and there is no required inspection for a crack at a fixed point, how do we provide confidence to the public that this isn't going to happen again and we aren't going to be here doing this at another future?

THE WITNESS: You know, clearly, this is leading to a damaged tolerance approach on some of the parts.

DR. LOEB: That's a price -- there's a price that ought to be paid for that, and we recognize that. However, do you think under certain circumstances, that price may be worth it? For example, instead of some fixed interval, would it be more appropriate to say anytime an engine is brought into the shop, would that be -- I mean, do you have some thoughts along those lines that you may want to share with us?

THE WITNESS: I think sometimes we spend too much time worrying about how -- if the engine comes in the shop and you're going to send it through an inspection process, yes, there is an incremental cost

to do an eddie current inspection. But, again, when you're dealing with the consequences of failure and the benefit derived, what we're talking about is possibly in the life of a 219 engine, we build engines right now -- you know, probably some of the best engines in the industry. Our average time on wing is really very, very good. We're pushing on average across the board on scheduled removal rate, somewhere around 10,000 hours. So, it's a very good, reliable engine.

So, saying that with eddie current's 40 holes once or twice in an engine's life, I don't think in some control fashion is a totally unreasonable thing that I wouldn't be willing to do, because we're doing it anyway.

DR. LOEB: I think that's a valid point. I thank you. I don't have any additional questions.

CHAIRMAN GOGLIA: Mr. Haueter?

MR. HAUETER: I have no questions.

CHAIRMAN GOGLIA: Any additional questions from any of the parties, the Tech Panel? Okay. Ray, you are released. You're off the hard seat.

THE WITNESS: Thank you, sir.

(Witness excused.)

CHAIRMAN GOGLIA: And why don't we take a ten

minute break and reload with Mr. Guyotte. We're going to go through without lunch, if you haven't noticed.

(Whereupon, a short recess was taken.)

CHAIRMAN GOGLIA: We'll go back on the record with our last witness, and that's Mr. Robert Guyotte. And while he's coming up, I believe all the parties have received a copy of one additional exhibit that we would like to put into evidence. Does anybody have a problem with that? Hearing none, we would offer Exhibit 15H, spoken as a true New Englander, H.

(Witness testimony continues on the next page.)

ROBERT GUYOTTE, BRANCH MANAGER, ANE-142, ENGINE CERTIFICATION OFFICE, FEDERAL AVIATION ADMINISTRATION, BURLINGTON, MASSACHUSETTS

Whereupon,

ROBERT GUYOTTE,

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

MR. HAUETER: Mr. Guyotte, would you provide your full name and place of employment for the record?

THE WITNESS: My name is Robert E. Guyotte. I work for the Federal Aviation Administration in Burlington, Massachusetts.

MR. HAUETER: And what's your position with the FAA?

THE WITNESS: I'm a Manager, Engine Certification Branch, in the Engine Certification Office, Aircraft Certification Service.

MR. HAUETER: And could you provide a brief description of your professional history?

THE WITNESS: I started my aviation career in 1968 at Pratt & Whitney Aircraft as a Technician in their Structures Engineering Test Facility. I was assigned to Engineering in 1974. I received my Bachelor's in Mechanical Engineering degree in 1974 and was elevated to an engineering status.

I was promoted to Senior Engineer in 1979. I joined the Federal Aviation Administration in 1981 as a Project Engineer. Was promoted in 1982 to my present

position as Manager of an Engine Certification Branch. And I received my Master's of Science in Engineering Management degree in 1983.

MR. HAUETER: And what FAA ratings or certificates do you hold?

THE WITNESS: None.

MR. HAUETER: Thank you. Mr. Anderson.

MR. ANDERSON: Good afternoon.

THE WITNESS: Good afternoon.

MR. ANDERSON: Would you tell us briefly your experience with the JT-8 engine D?

THE WITNESS: Yes, I can.

MR. ANDERSON: Letme try it again to get the reading on the microphone. The question was, could you just share with us your experience with the JT-8D engine series?

THE WITNESS: Yes, I can. I've been Manager of the JT-8D program for the FAA since 1985. My previous history with the JT-8D goes back to my engineering assignment at Pratt & Whitney in the powerplants systems group, which is a design and support group.

I've worked JT-8D performance improvement packages. I've worked on JT-8D-22, which is a Swedish

engine doing heat transfer and other design type work.

MR. ANDERSON: Has your recent experience as a supervisor been involved with this engine?

THE WITNESS: It's been involved with not only JT-8-D, but I also cover quite a range of gas turbine engines, JT-8-D, all the CF-6 products out of Evendale, G-90, CFM-56 engines, Pratt & Whitney Canada, and some foreign turbine engines, as well.

MR. ANDERSON: Thank you. With specific reference to JT-8-D series, could you perhaps share with us some of the highlights of uncontained events that you can remember from this past perhaps calendar year '96 up to the present?

THE WITNESS: Well, we've worked on several airworthiness issues, low pressure turbine hub failures, release of blade uncontained. We've worked on corrosion, failures on compressor discs, and, of course, the fan hub.

MR. ANDERSON: And were there any failures of rotating parts due to product defects, such as inclusions?

THE WITNESS: Yes, there were.

MR. ANDERSON: Could you describe the highlights of some of that?

THE WITNESS: Well, we have, as you know, the fan hub on a 219 engine, due to abusive machining. We have a melt defect on low pressure turbine for stage hub.

MR. ANDERSON: Okay. And could you give us a brief idea of what your process was in dealing with those and seeing if they were not major events compared to an accident, but was what we would term an uncontained event?

THE WITNESS: We go through our corrective action process in developing a fleet management program to ensure that a similar type of failure would not occur.

MR. ANDERSON: And what would that process be? Could you give me a specific example?

THE WITNESS: Our typical process of corrective action for these kinds of events begins at trying to identify the root cause of the failure, to identify what the threat is in terms of safety. In other words, what size population that we need to contend with. To identify the corrective action, fleet management program to contain the issue. And to issue an airworthiness directive, if necessary.

MR. ANDERSON: And is this a team effort? Is

this something that is done in consultation with the operators, as well as the manufacturer? How does that take place?

THE WITNESS: It's a combination of team effort between ourselves and aircraft certification, as well as our flight standards organization, with the OEMs, and with the airlines.

MR. ANDERSON: Could I ask you to turn to Exhibit 8F, please? Exhibit 8F is the overview, I would call it, of the FAA's ANNE-180 evaluation report of Pratt & Whitney quality systems.

THE WITNESS: Yes, sir.

MR. ANDERSON: And on page 3, please, in paragraph 2, I would like to read something and ask a question about it. Have we found it?

THE WITNESS: Page 3, paragraph --

MR. ANDERSON: Page 3, paragraph 2.

THE WITNESS: Yes.

MR. ANDERSON: And I'll quote from that. It's a short paragraph. It reads, "The scope of this evaluation is extremely narrow due to the complexity of the Pratt & Whitney quality system. Although narrow in scope, ample team was allocated to conduct an in-depth evaluation of each subsystem. It was not the intention

of this evaluation to determine root cause of the failure of the number one fan hub on Delta flight 1288, but rather to verify that Pratt & Whitney is in compliance with FAR 21.165, subparagraph A and B."

My question, sir, is what is the nature of that compliance? What does that paragraph require of Pratt & Whitney?

THE WITNESS: I'm not sure that I'm able to answer that question.

MR. ANDERSON: Is the -- have you seen that paragraph before in the FARs?

THE WITNESS: Yes, I have.

MR. ANDERSON: And the nature of this doesn't lead to the report or is it placed here, perhaps, in error?

THE WITNESS: No, it was a -- it's a paragraph that is under the auspices of our manufacturing inspection. And it's not a paragraph that I generally deal with in aircraft certification.

MR. ANDERSON: I'm at least familiar with paragraph B, which states that the manufacturer or paraphrasing it, is responsible or held responsible by the FAA to deliver a safe part. And that's the wording, safe part. It doesn't give any other details.

Is this an issue that you frequently deal with at the certification office?

THE WITNESS: It certainly has the expectation that a part conforms to the acceptable type design.

MR. ANDERSON: And what type of activities do your people undertake in cooperation with the manufacturers or the original equipment manufacturers of subparts to assure that this paragraph is complied with?

THE WITNESS: My people in aircraft certification, on the certification side, do not get directly involved. That's handled by our manufacturing inspection.

MR. ANDERSON: And that would be who?

THE WITNESS: One of our earlier witnesses.

MR. ANDERSON: Mr. Gidious?

THE WITNESS: Mr. Gidious.

MR. ANDERSON: The one person assigned to Pratt & Whitney?

THE WITNESS: That's correct.

MR. ANDERSON: I see. Are you familiar with the FPI evaluation on the report, which is Exhibit 8G? This would be known as the FAA inspection of Delta's

FPI process.

THE WITNESS: Yes, I am familiar with the report.

MR. ANDERSON: During the testimony, I just wish to bring it up for -- to have it available, but I don't wish to quote from it. My question in this area is, were people from your group involved in this inspection?

THE WITNESS: Not directly from my staff. That is correct.

MR. ANDERSON: Okay. Were you -- have you read this report or were you aware of its content in the course of your duties?

THE WITNESS: Yes, I am.

MR. ANDERSON: Could you share with me the impact of seeing the issues raised in this document that had on your assembling the airworthiness directive for this particular part?

THE WITNESS: It certainly establishes or sets the stage for trying to make a determination of the safety threat. In other words, is there an ability to identify certain populations of parts that need to have a more stringent requirement associated with them.

MR. ANDERSON: What type -- were there any

issues that come to your mind as being the most important in this case?

THE WITNESS: That there are a couple of issues. One being the effectiveness of coolant channel drills and producing similar types of damage, as seen in the particular fan hub that we're talking about. And the second issue would be the method in which Volvo and Pratt & Whitney had to go through in order to produce that kind of material, which is certainly outside of the normal range of normal processing of this particular hub.

MR. ANDERSON: Yes, it was -- I think you would describe it as a rare event --

THE WITNESS: That's correct.

MR. ANDERSON: -- in your experience. Could you describe some of the experience or the knowledge that you gained by looking at the blue etch indication -- excuse me -- blue etch anodized process, which became an issue in this case?

THE WITNESS: Could you elaborate on your question?

MR. ANDERSON: Yes. In other words, immediately early into this particular accident investigation, I think it was clear that blue etch

anodize was a process that received a lot of attention. And it was certainly one that was mentioned and dealt with in the AD note that was airworthiness directive that was eventually issued.

Could you comment on the use of the BEA in that context?

THE WITNESS: The engineering interpretation of the mark that was identified on the traveler relative to the failure hub was associated, in our mind, with a blue etch anodize inspection. And certainly through association of other discs of the same type of notation, would have a higher -- a higher risk or a higher threat to safety associated with it. Based on that determination, we issued our priority letter AD for their removal.

MR. ANDERSON: So, that the blue etch indications that were gone back and looked -- found in the records were a part of your strategy in formulating that AD. Is that a correct summary?

THE WITNESS: That is correct.

MR. ANDERSON: Moving along, part of that AD -- and I think we have that here, an exhibit 8R. I would ask you to turn to 8R, and within Exhibit 8R, page 29. I would like to just read paragraph D there.

I think I see that you've reached the page. It's talking about cracked fan hubs that are -- first let me ask, is this airworthiness directive now in effect, sir?

THE WITNESS: Yes, it is.

MR. ANDERSON: One of the requirements, if I understand it correctly, I quote, "Report findings of cracked fan hubs in accordance with accomplishment instructions..." And then I jump down, "....within 48 hours after inspection to Robert Guyotte, Manager of Engine Certification Branch," et cetera. Could you tell us what type of activity there has been in this reporting system?

THE WITNESS: At this point in time, there has been none, in accordance with the AD. However, we have reports of five rejectable indications on five different hubs that were found prior to the effective date of the AD.

MR. ANDERSON: Could you share with us some of your knowledge to the types of indications and the progress that's been made in analyzing them?

THE WITNESS: Yes, I can. Of the five rejectable eddie current inspection hubs, one was found with a crack, resulting from stress corrosion, which is

a different mechanism than the failure hub. That hub is still under investigation as to the cause of the stress corrosion.

There was one hub that was brought back to Pratt & Whitney, analyzed, and was determined to be a false call, was returned to the operator. There were three other hubs returned to Pratt & Whitney and were analyzed. Two of those were determined to have typical handling damage or surface type induced damage, slight scratches.

And there is one other hub still under investigation.

MR. ANDERSON: So, in the case of the two hubs that had surface damage or handling damage, were these damages outside of the shop manual visual inspection limitations or were they only found by eddie current?

THE WITNESS: They are found by eddie current. In one case, the operator had elected to use a slightly higher sensitivity. And when reinspected at the normal thresholds of our airworthiness directive requirements, it was still detectable, but it was later determined to be nothing more than a slight scratch.

MR. ANDERSON: So -- or my question, again,

is, was it returned -- are these two serviceable or potentially serviceable after repair?

THE WITNESS: The only part that I know about that's been returned is one part. And that was not the two that I'm talking about.

MR. ANDERSON: So, it would be safe to say that the analysis has not been completed yet on the with the handling scratches?

THE WITNESS: It may not be.

MR. ANDERSON: I understand. In the case of the stress corrosion cracking, is that a fair characterization, stress corrosion cracking?

THE WITNESS: Stress corrosion cracking and a granular cracking.

MR. ANDERSON: Yes. Is it fair to say that this type of cracking would be of similar hazard to the hub if left uninspected in terms of propulgation?

THE WITNESS: There is a possibility it could -- it could propulgate the failure.

MR. ANDERSON: So that the stress corrosion cracking must be identified by the in-service inspection process?

THE WITNESS: The current inspection requirements that are in place are adequate to detect

that kind of failure mechanism.

MR. ANDERSON: And, I guess, yes, you've answered my question. I would just like to clarify that you've made a decision that this rather new finding or perhaps it is a new finding of a different type of cracking is being covered as far as its -- you know, its crack propulgation rate will be covered by the current inspection program.

THE WITNESS: That's correct.

MR. ANDERSON: Was there any indication in your knowledge that this stress corrosion cracking was induced at manufacture?

THE WITNESS: We have not been able or I have not heard any information coming forth yet that identifies root cause for stress corrosion cracking. That's still part of the ongoing investigation.

MR. ANDERSON: Thank you.

DR. LOEB: Excuse me. Mr. Anderson, are you going to raise the issue whether any of these hubs had been subjected to FPI prior to this, whether any indications had ever been received? Or let me ask you, would you do that, please?

MR. ANDERSON: I wasn't, but I will be happy to do that, sir. I would pass the question through, of

course --

(General laughter.)

THE WITNESS: I will answer the question. The five hubs were FPI inspected. No indication found.

DR. LOEB: Thank you.

MR. ANDERSON: And in your opinion, in the case of the stress corrosion cracking, when you analyzed the depth and extent of these cracks, are you still studying whether they were -- should have been detected under the FPI?

THE WITNESS: Again, that investigation is ongoing.

MR. ANDERSON: Thank you.

THE WITNESS: I don't have those results.

MR. ANDERSON: Mr. Guyotte, we've heard some earlier testimony and you're kind of the clean up hitter here today to resolve any open issues and we wanted to talk to you a little bit about the obligations between the manufacturer of a part or an engine or appliance and the operator. Could you describe what was talked about a little bit about previous witnesses in terms of how the FAA enforces compliance on not only maintenance procedures, but inspections and how that chain of authority works?

In other words, who -- we know who inspects who. We've been through all that. But we would really like to know were the chain of authority is. Who is obligated to who to do something?

THE WITNESS: Well, I can start from the top. Relative to the OEM's maintenance manuals, although, other than limitation sections of the manual, which are FAA approved, the recommended maintenance requirements in the manual are also approved at time of certification.

So, we have a document, a manual that is FAA approved, that prescribes the maintenance requirements for that particular engine.

MR. ANDERSON: So, in a hypothetical situation, if an operator, which is using the OEM maintenance manual is found not to be complying with its instructions, what is the FAA's action?

THE WITNESS: Again, let me clarify that it is recommended procedures, that we have approved, but are not required as part of the maintenance, unless it's brought into the overall maintenance plan by FAA approval.

MR. ANDERSON: I think you misunderstood. Perhaps, I phrased the question wrong. If they are

using it -- they being a Part 121 operator in this case, since this is the situation -- if it is part of their approved maintenance manual and an FAA inspection reveals that they are not following that procedure and they are not following the updated procedures issued by the OEM, then are they not in violation of the FAA rules?

THE WITNESS: As you have proposed the question, I believe the answer would be that they would be.

MR. ANDERSON: That they would be in violation of the FAA's FARs?

THE WITNESS: It's part of their FAA approved maintenance plan to use the engine manufacturer's manual for maintenance. And if they don't follow the manual, it would be my understanding that that is not consistent with the requirements.

MR. ANDERSON: Ms, could you give us a distinction between the approved and the accepted as it applies to a Part 121 operator?

THE WITNESS: I cannot. I don't deal with Part 121.

MR. ANDERSON: Okay. Those are all of the questions I have at this time, Mr. Chairman.

CHAIRMAN GOGLIA: Are there any further questions from the Technical Panel? Mr. Conroy?

MR. CONROY: Yes, sir, just one more. And that's in regards to follow up what Mr. Anderson was just asking you, sir. Have you been here for all three days of testimony?

THE WITNESS: Yes, I have.

MR. CONROY: And you heard Mr. Weaver's testimony on Monday -- correction, Wednesday and Mr. Dokter's testimony yesterday?

THE WITNESS: Yes.

MR. CONROY: The record will show exactly what they said, but if I can attempt to summarize. There seemed to be some difference regarding who places -- who makes recommendations and who places requirements regarding whether an inspection is needed, such as on hubs, such as these, when an engine is disassembled, whether it's required at all, and if so, when changes occur?

Could you please clarify who makes the recommendations and who makes the requirements?

THE WITNESS: If an inspection is required to meet the life requirements of a life limited part, the FAA would make that approval. If the life limit of the

part stands with not having to have a required inspection, then that would be left up to either a recommendation for an inspection by either the OEM or by the owner of the part.

MR. CONROY: They would make the recommendation to the FAA?

THE WITNESS: That's correct.

MR. CONROY: And the FAA makes the final requirement?

THE WITNESS: The FAA, if it's accepted within the maintenance plan and approved by a flight standards inspector, it would be a requirement at that time. That's my understanding.

MR. CONROY: Thank you very much, sir. Thank you, Mr. Chairman.

CHAIRMAN GOGLIA: We'll go the parties. McDonnell Douglas?

MR. STEELHAMMER: No questions, MrChairman.

CHAIRMAN GOGLIA: Delta?

MR. VALEIKA: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Pratt & Whitney?

MR. YOUNG: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: ALPA?

MR. MCCARTHY: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: FAA?

MR. DONNER: No questions, Mr. Chairman.

CHAIRMAN GOGLIA: Dr. Ellingstad?

DR. ELLINGSTAD: No questions.

CHAIRMAN GOGLIA: Getting close.

(General laughter.)

DR. LOEB: You're not there yet.

CHAIRMAN GOGLIA: Oh --

(General laughter.)

CHAIRMAN GOGLIA: Mr. Haueter? DrLoeb.

DR. LOEB: My line of questioning here is not going to be much of a surprise to you, Mr. Guyotte. Given the testimony that we've heard, the accidents that we've talked about where cracks have not been detected until catastrophic failure of heavy parts, rotating parts, what is the FAA's position right now in terms of the possible need for re-evaluating the propriety of the safe life versus damaged tolerance concept for these heavy rotating parts, high energy parts?

THE WITNESS: We agree with the conceptthat there needs to be some kind of supplement to the safe life of older parts. And we have begun a process to develop criteria for looking at those parts.

DR. LOEB: Can you elaborate a little bit on this process and perhaps the timing of when we may actually see some changes and the kinds of things that you're considering at least?

THE WITNESS: The process or consideration would be to have focused inspections at some time within the part's life, to assure that the assumptions that were made in determining safe life are still valid. Where we are in the process is we're developing the criteria. We plan to have a meeting with the OEMs in May and a hearing with or a meeting with ATA and the airline some time in July.

DR. LOEB: When did this process start within the FAA?

THE WITNESS: In terms of our consideration of looking at --

DR. LOEB: Yes.

THE WITNESS: -- these types of parts?

DR. LOEB: Yes. Is this something recent or is this a -- I mean, the genesis of this in the aftermath of Sioux City or is it more recent?

THE WITNESS: Well, it really has its original roots after Sioux City. As you know, we implemented additional inspections for similar type

design parts, similar to the Sioux City part. We've transitioned to bringing the rest of the industry into the same thought process. We began that activity several months ago.

DR. LOEB: Are you handling newly certificated engines differently? Is there a process -- this sort of process underway now in the newly certificated engines?

THE WITNESS: Newly certificated engines for at least the fan hub, we've gone to a more damaged tolerant design. The companies have gone to a multiple lobe path type of design. We've lifed the parts based on a flaw type of fracture mechanics analysis to ensure that if there is a flaw, that we have enough design in the part to prevent a failure.

DR. LOEB: Is this likely to find its way into heavy rotating parts other than -- the high energy parts other than just the fan hub?

THE WITNESS: Those are being considered.

DR. LOEB: They are being considered now?

THE WITNESS: Yes, sir.

DR. LOEB: Again, do you have a time frame for what sort of time frame this may take? I mean, are we talking about something that is likely to come to

fruition over the next year, let's say?

THE WITNESS: Well, it depends on how many new engines that are going to be designed from a new center one.

DR. LOEB: Well, what I'm really getting at is the concept itself and the application of the concept. I mean, you're still evaluating it. What I'm looking for is some sort of feeling for when this -- when you may reach a conclusion on --

THE WITNESS: Well, the concept is being worked as the OEMs begin to design new engines. They are putting in damaged tolerant concept into their design.

DR. LOEB: Is the intent then to have -- I assume that we will continue to do major portions of the inspections using FPI. Is that correct?

THE WITNESS: We will continue to use FPI as a global inspection.

DR. LOEB: Right.

THE WITNESS: But we'll be looking at focused inspections and selecting the right inspection for the right features.

DR. LOEB: So, that there will be supplemental inspections required in those areas of

concern?

THE WITNESS: That's correct.

DR. LOEB: Well, I'm certainly glad to -- I'm certainly glad to hear that. It's a good way, as far as I'm concerned, to bring these hearings to a close, to learn that that kind of progress is now actively underway. And I appreciate it, and I would like certainly the FAA to keep us apprised and, hopefully, we'll get some briefing from you.

THE WITNESS: We will arrange to do that.

DR. LOEB: Okay. Thanks. I have no other questions, John.

CHAIRMAN GOGLIA: Mr. Haueter?

MR. HAUETER: Just one quick one. On the calculation of the life cycle or whether the safe life of a part, does the FAA do that calculation independently of the manufacturer?

THE WITNESS: No, we do not.

MR. HAUETER: You take the manufacturer's calculations and go from there?

THE WITNESS: We understand the processes that they use in making that determination. We look at it from an engineering sense. And those processes have been approved.

MR. HAUETER: The processes themselves are FAA approved?

THE WITNESS: The processes in which they make their determinations has been approved by the FAA.

MR. HAUETER: Okay. Thank you.

CHAIRMAN GOGLIA: Any additional questions from anyone? Okay. Hearing none, Mr. Guyotte, thank you very much for your testimony. Again, it's a pleasure to have someone that talks like me around here.

THE WITNESS: Thank you, Mr. Chairman.

(Witness excused.)

CHAIRMAN GOGLIA: Properly, Mr. Loeb. No accents. We have been holding one witness for possible recall. And despite two pages of questions from the Pratt & Whitney people of the Pratt & Whitney witness, we've decided not to recall the witness.

(General laughter.)

CHAIRMAN GOGLIA: And so that being the last piece of business that we have, I get to read the closing statement, unless anybody has anything they want to say. I see nobody volunteering.

With the last witness having been hearing, 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 the issues presented.

The Board may, at its discretion, reopen the hearing in order that such information may be made part of the public record. The Board welcomes any information or recommendations from the parties or from the public, which may assist in its efforts to ensure the safe operation of commercial aircraft.

Any such recommendations should be sent to the National Transportation Safety Board, Washington, D.C. 20594, within 30 days after the receipt of the transcript of this hearing. All evidence developed in this investigation and hearing and all recommendations received within the specified time will be presented and evaluated in the final report on this 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.

Also, I want to thank -- also, I want to express sincere appreciation for all those groups, persons, corporations, and agencies who have provided their talents so willingly throughout this hearing.

The record of the investigation, including the transcript of this hearing and all exhibits entered into the record, will become part of the Safety Board's public docket on these accidents and will be available for inspection at the Board's Washington office. Anyone wanting to purchase the transcript may contact the Court Reporter directly.

I want to assure members of the victim's family and the public, that the Safety Board will pursue every lead towards an ultimate solution.

I now declare this hearing to be in recess indefinitely.

(Whereupon, at 2:25 p.m., the hearing was adjourned.)

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