UNITED STATES OF AMERICA

NATIONAL TRANSPORTATION SAFETY BOARD

OFFICE OF ADMINISTRATIVE LAW JUDGES

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In the matter of:

PUBLIC HEARING IN THE MATTER OF THE LANDING OF US AIRWAYS FLIGHT 1549, N106US, IN THE HUDSON RIVER, WEEHAWKEN, NEW JERSEY, JANUARY 15, 2009

SA-532

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National Transportation Safety Board
490 L'Enfant Plaza East, S.W.
Washington, D.C. 20694

Thursday,
June 11, 2009

The above-entitled matter came on for hearing, pursuant to Notice, at 8:00 a.m.

BEFORE: ROBERT L. SUMWALT, Chairman
DR. JOSEPH KOLLY
JOHN DeLISI

APPEARANCES:

Technical Panel:

ROBERT BENZON, NTSB, Office of Aviation Safety
DAVID HELSON, NTSB, Air Safety Investigator, Operations/Human Performance Co-Chair US Airways Flight 1549 investigation, Office of Aviation Safety
NICOLAS MARCOU, BEA (Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile)
BRIAN MURPHY, NTSB, National Resource Specialist – Aircraft Structures, Office of Aviation Safety
JOHN O'CALLAGHAN, NTSB, National Resource Specialist - Aircraft Performance, Vehicle Performance Division, Office of Research and Engineering
JASON FEDOK, NTSB, Survival Factors Investigator, Office of Aviation Safety
MARK GEORGE, NTSB, Survival Factors Investigator, Office of Aviation Safety
KATHARINE A. WILSON, NTSB, Air Safety Investigator, Operations/Human Performance Co-Chairman of US Airways Flight 1549 Investigation, Office of Aviation Safety
HARALD REICHEL, NTSB, Aerospace Engineer, Powerplant Group Chairman of Hudson River Flight 1549 Investigation, Office of Aviation Safety

Parties to the Hearing:

PAUL MORELL, US Airways
CAPT. RUDY CANTO, Airbus
CAPT. DAN SICCHIO, US Airline Pilots Association
CANDACE KOLANDER, Association of Flight Attendants
BRUCE MILLS, CFM International
HOOPER HARRIS, Federal Aviation Administration

PETER KNUDSON, Public Affairs Specialist

I N D E X

P R O C E E D I N G S

(8:00 a.m.)

CHAIRMAN SUMWALT: Good morning. If everyone will please take your seats, we'll begin very shortly. Thank you.

Good morning. We are back in session for day three of the public hearing involving U.S. Airways Flight 1549, and I think we have received very good testimony and cooperation from all involved for the previous two days. And I know we will continue that into today.

Mr. Benson, are you ready to proceed with the next panel?

MR. BENSON: Yes, sir. Our last topic is certification standards for bird ingestion into transport category airplane engines, and the Board calls Marc Bouthillier, Robert Ganley and Les McVey to the witness stand please, and remain standing. Gentlemen, raise your right hands.

(Witnesses sworn.)

MR. BENSON: Have a seat. And beginning with Mr. Bouthillier, could you give your full name and your job description please.

MR. BOUTHILLIER: My name is Marc Bouthillier. I'm an engineer, work for the FAA Engine and Propeller Director Staff which is part of the Aircraft Certification Service.

MR. GANLEY: Good morning. My name is Robert Ganley. I'm the manager of the Engine and Propeller Directorate Standards

Staff also located in Burlington, Massachusetts, and part of Aircraft Certification.

MR. McVEY: Good morning. My name is ~~Lesley~~ Leslie McVey. I've been a flight safety investigator with CFM at GE for over 10 years. I'm also the ~~principal~~ Principal ~~engineer~~ Engineer for ~~environmental~~ engine~~,~~ environmental safety, and as such I track bird ingestions amongst other things. Also in 2000-2002, I served on the Rulemaking Committee which developed the latest bird ingestion rules for large flocking birds.

MR. BENSON: Okay. Our principal questioner will be Harry Reichel. Go ahead, Harry.

TECHNICAL PANEL QUESTIONS

MR. REICHEL: Good morning, gentlemen. I'm going to present the questions in four broad topics. I'd like to start off with the history of the bird ingestion certification requirements, and then continue and discuss the description of the FAA Type Certification process for turbine powered engines. Then I'd like to go to specifically the CFM56 compliance with the bird ingestion standards, and then to finish off, I'd like to discuss the development and the amendments to the engine bird ingestion standards paragraph 33.76 in the CFM.

So I understand that you also have a presentation and I'd like to -- are you prepared for it right now to give the presentation?

MR. GANLEY: The FAA is ready.

MR. REICHEL: Okay.

MR. GANLEY: Okay. I'm going to provide a very brief presentation to give an idea of the actions the FAA has taken to keep pace with this growing threat.

I think as we have heard in previous testimony, that certainly the bird threat in the National Airspace System has been increasing. You know, the goose population has been on the rise for the last 30 years and continues to rise. I think we heard some testimony from Dr. Dolbeer stating that the large goose population, Canadian good population, has increased fourfold since the 1990s.

In addition, you know, aircraft flights have been increasing on the order of 2 to 3 percent per year.

With this increase in population and flights, I think it's to be expected that our chances for large bird encounters would also increase.

A little bit on the history of the rule. We added specific engine bird ingestion requirements in 1974 via Amendment 6 of our regulations. At this point, it addressed small, medium and large birds up to 4 pounds. We've had two major revisions to our regulations since 1974, in the year 2000 and the year 2007.

In 2000, we changed the bird sizes, the bird quantities, the test conditions and the test fail criteria. Later in 2007, we also introduced large flocking birds.

The changes in 2000 and 2007 were driving based on the observed change in threat in service. The standards were also deemed necessary to ensure that we had a fleet-wide acceptable level of safety that met our safety objective.

A little bit on our safety objective. All type certification rules have a basic intent or objective that is related to safety. Items, environmental threats for things like bird, icing, rain and hail, the threat that we're trying to address and to ensure is continued safe flight and landing.

Specifically for bird ingestion, the threat that we've seen in service have been multiengine power loss. As a result, our safety objective is to ensure that we don't have any significant accidents due to multiengine power loss due to flocking birds to ensure that they do not occur at a rate greater than 1 in 1 billion airplane flight hours.

This rate is sometimes referred to as extremely improbable. It's a very conservative aviation industry accepted safety standard. It reflects the FAA's view of long-term acceptable risk, and it is also consistent on how we handle many critical aircraft systems such as flight controls.

In light of that, certainly this event is telling us something that I think we need to take a look at. The FAA has already the engine and propeller record, made contact and initiated activity with both industry and EASA to update our bird ingestion rule database through 2008 to better reflect the current threat in service.

Of note is that our last update was in 2000. Our 2000 database was the basis for our current rule. Our current rule is very data driven. It includes data that covers a 30-year time period. This 30-year time period includes in excess of 325 million civil turbine engine fleet flights worldwide. It includes over 8100 specific bird ingestion events.

Basically, once we update this database, there will be a reevaluation of our rule effectiveness and determine whether or not it still meets our overall safety objective. Depending on the outcome of that determination, that will drive any future action. That action may include rule updates, policy or guidance updates.

At this point, just to mention that, you know, our National Airspace System safety is high but events do occur. The purpose of this slide is to show that no single element of threat management can address the concern alone.

This pie chart depicts aircraft certification. Our bird updates in 2000 and 2007 are intended to address that piece of the pie. I believe that, you know, we've heard a lot of testimony early on about airport bird control and wildlife mitigation. We heard a lot about bird radar research, enhanced visibility, avoidance. That's another piece of the puzzle here. Also awareness, vigilance, air traffic control operations, what do you do if you encounter birds? And lastly some of the off airport wildlife and management at the state and local level as well.

So I think all of these organizations contribute to the overall mitigation of the bird threat.

In conclusion, you know, it's not reasonable to assume that we can design an engine that can withstand birds of any size under any condition. I mean there are some technological and design limitations within an engine. So what's really needed is a high level systems management approach to address this issue.

To just kind of put things in perspective a little bit, you know, we've heard from prior testimony that, you know, one engine ingested 2 large 8 pound birds for a total bird mass of 16 pounds. Another engine ingested at least one large bird. So 8, perhaps 16 pounds of birds.

When the 5B engine was certified, at that time the test was conducted with a 4 pound bird. If that test were conducted today under our current certification standards, it would be tested to a 6 pound bird.

So this event far exceeded any of our current certification requirements.

The performance of the engine exceeded our certification requirements for the ingestion of a large bird. The requirements for the ingestion of a large bird are safe shutdown. A safe shutdown is identified as things as no uncontrollable fires, no release of hazardous material through the engine casings, you know, things like that.

Certainly the engines on U.S. Air Flight 1549 exhibited safe shutdown. One engine safely shut down. In fact, one of the engines continued to operate at a power level that allowed the engine to still generate electrical and hydraulic power which partially contributed to the successful forced water landing of the airplane.

And kind of a takeaway from that is, even though an engine test might be run to a 4 pound bird standard, it doesn't mean that if it ingests a 4.1 pound bird, that it would not be able to withstand that. I think that does point to the inherent conservatisms that are built into the engine designs in relation to the certification standards.

That concludes the FAA presentation. I'm ready for any questions.

MR. REICHEL: Thank you, Mr. Ganley. My next questions are directed to the FAA, either witness, and I'd like to talk bout the airworthiness standards for aircraft engines, paragraph 76, and I'd like to ask you to please provide a brief history of the rules of foreign object ingestion, from the time they were introduced in 1974 to the present, and to also please highlight the significant technical changes that each amendment introduced.

MR. BOUTHILLIER: Yes, you're correct. The engine certification requirements are located in Part 33. The current bird standard is under Section 33.76. The bird standards were originally introduced in Part 33 in 1974. That was under Amendment 6. Those new standards had three elements to them, small and medium flocking birds, and a large single bird. The flocking bird requirements represent the multiengine ingestion scenario, similar to -- well, the same as U.S. Air here, and the single large bird test represents a severe single engine event.

The bird sizes at that time were 3 ounces for small birds, and 1 1/2 pounds for the medium flocking bird and 4 pounds for the large single bird. The flocking bird standards do require run on. The run on for these original standards was 5 minutes, with no throttle movements, with a thrust loss no greater than 25 percent, and theses tests were run at the rate of takeoff power and at critical target locations.

The number of birds that are required for the flocking test are a function of the engine size. Larger engines are required to ingest a greater number of birds, but the number of birds that are required, they're targeted on critical features on the front of the engine, to exercise those, you know, in a conservative manner.

The large single bird standard does not require a run on. That's a safe shutdown requirement. I think Bob had hit on that. The requirement there is that there would be no uncontained failure, or no fan blade failure that would result in a radial expulsion of debris, not through the engine casings, no fires, no compromising of flammable fluid carrying components. Mount integrity will be maintained so the engine stays with the aircraft, and if the engine does continue to operate, the engine does need to be able to be controlled at least to a safe shutdown.

So those were the original standards.

Since that introduction, those standards have two significant revisions, and, as Bob had mentioned, in the year 2000 and 2007, that was Amendments 20 and 24. The Amendment 20 standard was a significant revision to the original standards. There were some significant changes to the bird sizes and the numbers as a function of engine size, the run on requirements, pass/fail criteria and some items related to how the tests were actually conducted.

The main features of the Amendment 20 change in 2000, was a change to the medium bird size, where originally it was 1 1/2 pounds for larger engines. That was changed now to a mix of 1 1/2 and 2 1/2 pound birds as a function of engine size where the bigger engines get bigger birds and more of them.

Another significant change was to the large single bird size which originally was 4 pounds for all engines. That was changed to 4, 6 or 8 pounds again as a function of engine size, where the larger engine gets the larger bird.

The third major change was to the run on requirements for the flocking bird tests. Originally they were five minutes of run on with a locked throttle, no throttle movements. That was revised to a 20-minute run on requirement with throttle manipulations. The throttle movements are in the form of a profile that would simulate an air turn back scenario.

For example, if you had a multiengine bird ingestion during takeoff, and there was a need to return to the airport, this 20-minute demonstration would show the ability of the engines to be handled, modulate thrust so you can safely fly the airplane back to the airfield.

And these changes, these Amendment 20 changes, were the result of bird threat studies that had been conducted in the late eighties to the later nineties, indicating a worsening threat and the need for some more stringent requirements to maintain safe operations into the future.

The 2000 standards were further revised in 2007. The mean feature of this change was the inclusion of a new test requirement for new bird threat class. This is the threat class we call large flocking birds, and we define that as birds greater than 2 1/2 pounds. This is a flocking bird requirement, also requires run on. The bird sizes for this particular test are either 4, 4 1/2 or 5 1/2 pounds as a function of the engine size, where the bigger engine gets the bigger bird. Bird quantity is one in this case. With the small and medium flocking birds it was variable, but it's one in this case.

The run on requirement is the same 20-minute air turn back scenario with throttle movements showing that the engine could be handled so that the aircraft can be flown safely back to the airport. And a little bit different than the medium test where the maximum thrust loss is 25 percent. For this large flocking bird test, the maximum thrust loss allowed is 50 percent.

And this standard was also the result of a continuation of the bird studies I had mentioned from the 1980s right up to 2000 indicating an increasing threat, worsening threat, you know, in service and the need for more stringent requirements to maintain safe operations into the future especially for this new threat class, the large flocking birds or those greater than two and a half.

Now the rulemakings were also joint efforts with the European Authority, EASA or JA at the time. They were joint efforts and our current requirements in Part 33, 33.76 are identical to the EASA standards and the certification specifications. I think it's CS-E 800. So they are identical.

So just a real quick summary, original standards, bird ingestion standards and for the engine cert code, in 1974, two significant revisions since then, in the year 2000 and 2007. Those changes were a result of bird threat studies showing, you know, a worsening situation and the need for more stringent requirements, and we went forward and modified or revised the rules to try and keep pace.

MR. REICHEL: Thank you. One of the questions I had, with respect to triggering, these amendments, the ones in 2000 and 2007, was there an event that triggered them or is there someone who analyzes the data, and is the data analysis triggering it? What causes an amendment to be started?

MR. BOUTHILLIER: Well, in general, for the bird rule, or for I guess probably all the rules, if it becomes evident to us that the safety objective of the rule is not being met, then we would certainly institute some sort of a formal program to understand that situation, and potentially go on and revise our rules or revise our methods of compliance, what have you.

Specific to birds, again if our safety objective is not being met or if it becomes evident to us that the bird ingestion rates are higher than our rule assumed or if any products are not performing in accordance with our expectations for some reason. Those would be reasons to go and conduct a study to understand what that situation is and then develop a plan to get back on track.

Back in history, the driver for these other changes again were a large number of bird threat studies that started in the seventies, into the eighties and those studies I believe were on and off a little bit. But these were the results. These changes were the results of threat studies primarily in the later eighties, through the later nineties.

MR. REICHEL: Thank you. If the bird ingestion certification regulation were amended today, what engines would be affected by this change? Specifically, would the CFM56-B be affected or would only future engines be affected?

MR. GANLEY: Only new engines would be affected by the rule updates. Basically what occurs is that you have an effective date to a new rule. Any application that comes in after that effective date needs to comply with the current standards.

MR. REICHEL: Thank you. I'd like to address the next few questions to the FAA, and this is a description of the type certification process for turbine powered engines. Would you please briefly describe the overall process that a manufacturer must follow to obtain type certification for a turbine engine?

MR. GANLEY: The overall type certification process is outlined in Part 21 of our regulations, and more specifically in FAA Order 8110.4. At a very, very high level, the process begins when an applicant submits an application. Following the receipt of an application, we typically hold a preliminary type board meeting with the applicant.

It's at that point we begin to discuss the overall certification basis and other specific project details. Following that, typically a detailed compliance checklist and compliance plan is put together that describes in more detail the specific methods of compliance to each of the regulations.

Following that, typically test plans are submitted, analysis plans are submitted. They are approved. The applicants go off and actually execute the tests. Upon completion of the tests, the results of the tests and/or analysis are documented in certification reports. The certification reports are approved.

Upon approval of all the pertinent reports and demonstrated compliance to all the applicable regulations, a type certificate is granted. At a very high level, that's our type cert process.

MR. REICHEL: Thank you. And could you please briefly describe the kind of bird ingestion tests that are conducted on aircraft turbine engines to satisfy 33.76, and what the pass/fail criteria generally are for each type of test?

MR. BOUTHILLIER: Yes. Again 33.76 does contain our bird ingestion standards for engines. 33.76 is also a test requirement. It's not an analysis requirement. It is a test requirement. So there will be a series of certification demonstrations that the manufacturer would have to, you know, conduct.

For large transport category engines, the program generally has three elements. There will be a medium flocking bird test, a large flocking bird test and a large single bird test. The medium flocking bird test is a full engine test. We require ingestion of a varying number of 1 1/2 and 2 1/2 pound birds as a function of engine size.

The ingestion occurs at a series of critical conditions, ready to takeoff power, the number of birds that are required to be ingested will be targeted at critical locations on the front face of the engine. Bird speed is also optimized to get the maximum slice mass, you know, into the fan blades for a fan engine. So critical bird speed is used, too. So there's a series of very conservative parameters that go into the test.

The test fail criteria for this test is the ability to conduct, as I mentioned, a 20 minute run on profile. For the medium test, the maximum thrust loss allowed is 25 percent, but the engine has to complete its 20 minute run on profile, the throttle manipulations, representing an air turn back. That profile includes a period of hands off after the event and then a sequential reduction in power to approach, and then a burst to go around power and then finally coming back down and shutting it down. So it's a very conservative test from our perspective.

The large flocking bird test really is similar although the bird size and numbers are different. Again, this will be full engine test that will be conducted. Bird quantity is one. Size of the bird is anywhere from 4, 4 1/2 or 5 1/2 pounds as a function of engine size.

This test is also conducted at high power and there is a 20 minute run on requirement also with throttle movements to simulate the air turn back situation. However, the maximum thrust loss allowed for the large flocking bird test as I mentioned is 50 percent. It's 25 percent for the medium flocking test, but for the large flocking test, it's 50 percent. So that would be the second major test.

Third would be a large single bird test. This can be a full engine or it can be -- there are a couple of different methods of compliance that an applicant can choose. Bird sizes here are either 4, 6 or 8 pounds as a function of engine size. A larger engine gets the larger bird. No run on required for these large single birds. These are safe shutdown requirements.

Again, those requirements are that there will be no uncontained failures, you know, no radial expulsion of high energy to breathe through the casings that could impact the airplane or its systems. No fires, no compromising of flammable fluid carrying components, mount integrity.

The engine needs to remain with the aircraft, and again if the engine does continue to operate, it must be controllable, you know, to a safe shutdown. And again the ability to run on is not required.

If you also do look at the 33.76 standard, you also find a small flocking bird test in there. There are small flocking bird requirements for all engines, from the smallest to the largest. However, we typically don't do small flocking bird tests for the transport category engines.

There is a clause or an exclusionary element to the rule that allows the small flocking bird test to be eliminated under certain conditions, and those conditions relate to inlet design. If the inlet is designed such that a medium bird can pass through unimpeded and impact the first rotating fan stage, then the small flocking bird test is not required.

The rationale there is that the medium bird can pass unimpeded, that it's a much more significant demonstration of adjusting capability than the small flocking bird test would be, and one of the rationale, small birds tend not to cause, you know, a lot of damage, and also the small flocking birds historically have not been a significant player in power losses.

Conversely, if the inlet is designed with other inlets, structural-like inlet guide ~~veins~~ vanes or if the engine is small enough where a medium bird may not pass through unimpeded, then a flocking bird test would be conducted, but for our typical large transport category that we're talking about today, they tend not to have inlet structures like that. So the small flocking bird tests are generally not required.

And that's a summary of the type of testing that these engines would normally undergo.

MR. REICHEL: Thank you. This is a question specifically, this particular engine, and if you would please describe the joint certification process, that is with the FAA and the EASA cooperation, that is unique to the CFM engine products, and how differences in the regulations between FAA and EASA are addressed?

MR. GANLEY: Yes. The CFM engine program has a unique arrangement that's been in place since the early seventies. It's unlike really any other certification/validation type process that we have in place. I think in testimony yesterday, that Mr. Breneman described the typical validation process. In this process, the procedures are documented in the management plan at the time of the certification of the 5B. The management plan was between the FAA and the DGAC France.

Obviously today it's between the FAA and EASA. This management plan is actually even outlined in the implementation procedures for airworthiness that are called out in our bilateral agreement.

Basically it's a parallel process. I think Mr. Hooper mentioned that yesterday. What that means is that both authorities are basically jointly certifying the engine together. It's not a serial process where the French is the stated design certificate and the FAA validates it. It's done concurrently.

All meetings are held jointly between both authorities. CFMI is the type certificateholder, basically demonstrates compliance to both regulations and all of their certification test plans, reports. The authorities jointly approve all test plans, all reports, and when both authorities are satisfied that the documents meet the requirements of each country, Part 33 on our side, JAR-E back in, you know, the days of JA and CS-E requirements today, then we both issue our type certificates simultaneously. So at a very high level that's the way the process works.

Again, really it's a parallel process that we get to the point at the same time rather than a serial process where the FAA may follow a foreign authority.

MR. REICHEL: Thank you. Are there any differences between the current FAA standards and the current standards of EASA's CS-E for bird ingestion?

MR. BOUTHILLIER: The current standards for the FAA in 33.76, Amendment 24, are identical to the CS-E 800, I think it might be Amendment 1. So the current requirements are identical.

MR. REICHEL: Okay.

MR. BOUTHILLIER: And the rulemakings, they were concurrent. They were cooperative efforts between ourselves and EASA, JA at the time.

MR. REICHEL: Great. Thank you. I'd like to talk about Advisory Circulars and specifically AC 33-2B, which contains the FAA guides material for engine type certification. The guidance allows foreign object protection devices such as screens or S-shaped ducts to be incorporated into engines. Has any turbine engine manufacturer ever applied to incorporate any fan protective devices for certification?

MR. BOUTHILLIER: You're correct that the rule does have a provision for inlet protection devices. A provision of that type was included in the original standards also and was carried forward.

As far as fan engines go, I have no experience with an applicant including a fan inlet protection device as part of their engine type design or their overall program. It is allowed. There are provisions in the rules, and there is a statement in the Advisory Circular about that, but I'm not familiar with any fan engine protection devices.

If we looked at say Rotocraft, sometimes they will have like plenum-type inlets that are not direct line of sight and have filters and things for dust and gravel and what have you, but as far as the fan engines, relative to your question, I'm not aware of any inlet protection devices that were ever evaluated under the rule.

Having said that, we have gotten suggestions in recent times about inlet protection devices. Folks have been recommending screens in front of engines, screen devices, mesh devices, to be placed in front of an engine inlet. Again, we've never had any manufacturer, engine or airplane, you know, propose to do that that I know of.

We, at the FAA, we have concerns with that type of a structure and that type of a device. We do think that there are some serious technical challenges to that, that could result potentially in a lesser level of safety overall than a greater one.

Some of the problem areas with screens, if that's a part of your question, problems with operability and laboratory stresses on airfoils. A screen upstream of the engine will have, you know, turbulent flow downstream of it, and there will be inlet pressure distortion patterns that will be passed through the engine. Engines can be very sensitive to that, more prone to surge stall, flame out.

The same provides stresses on airfoils. These distortion pressure patters that will get passed through can drive airfoils closer to residence (ph.) or to residence so there could potentially be a greater chance of high cycle fatigue failures with those types of devices.

We do conduct surge and stall testing and vibes stress testing for certification and some manufacturers actually have used screens to introduce a certain level of distortion, you know, to better test the engines under those circumstances. So we think that would be a challenge.

Icing conditions would be another with screens, a mesh screen in front of an engine, you know, in flight, icing conditions is common, and we believe that type of a structure would probably accrue ice, you know, readily. Any bridging of the meshes with ice in an icing environment, you know, could result in, you know, flow reduction or again distortion issues, and any structures that due accrue ice, you know, eventually will shed it, and any significant amount of ice on an inlet screen like that, when it is shed, most likely would be passed through the engine and the potential is there for some significant damage and enough engine (sic) can, you know, put the fire out in the combustor, too. So those are some significant areas.

Failure of a screen, a screen mounted in the front of the engine will have to be a very heavy structure, very strong to withstand any anticipated or any possible impacts but the mechanical systems, you know, do fail at times and if a large structure, such as this failed in front of a large turbine engine, the potential exists for some significant damage and an uncontained failure, and that's a concern.

Even if the device did not fail directly into the engine, if it went off to the side, then the potential exists for impacting the airplane structure, wings, horizontal stabilizer, vertical stabilizer, control surfaces, with a large structure like that. So that is a concern, of course.

Another potential problem area with screens, like in front again there will be reduction in airflow, say windmilling conditions, and that would reduce the rotor speeds in the engine during windmilling, and if there's a need to restart, that's a more serious place to start from if your over speeds are down and may even be more sensitive to the core lock issue.

So inlet protective devices, they're accommodated in the rules. I'm not aware on the fan engine that one has ever been proposed. As far as specific screens go, we think there are some significant technical challenges to overcome to do that, but the potential exists for maybe a lesser level of safety than a greater one given some other things I had talked about.

MR. REICHEL: Thank you. I'd like to address my questions to the CFM witness, Mr. McVey. My first question is if you could give a brief description of the engine and highlight the damages to those parts that were germane to the event. Now I understand that you have a presentation as well?

MR. McVEY: I do.

MR. REICHEL: Would you like to give that one now?

MR. McVEY: Yes, please.

MR. REICHEL: Yep.

MR. McVEY: This is just a short presentation, and a lot of this has been covered already by Mr. Bouthillier and Mr. Ganley.

It summarizes bird ingestions and the requirements for certification on the CFM56-5 engines and covers briefly what we found in the accident engines.

All larger engines have to demonstrate compliance with medium and large bird ingestion regulations. The number and weight of birds, as was said, depends on the size of the engine because the larger the engine, the more likely it is to ingest a heavier and higher number of birds.

~~The~~ At the size of the CFM56-5 when it was certified in the early nineties, it was required to ingest ~~7 -~~seven 1½ ~~1/2~~ pound birds at takeoff power without losing more than 25 percent thrust or require shutdown within 5 minutes, or even result in a hazardous condition to the aircraft. So to demonstrate success, you had to produce at least 75 percent thrust for at least 5 minutes after the ingestion.

The large bird test required a 4 pound bird ingestion without hazardous consequence such as fire, uncontained fragments or losing the ability to shut down. However, there's no requirement as was stated for continued thrust

~~protection~~production. It's a safe shutdown test.

In the late eighties, there was a joint industry/agency working group meeting, and they were studying the need to increase the ~~median~~ medium bird requirement. This, as mentioned by Mr. Bouthillier, resulted in Amendment 20 to the regulations.

The CFM and DGAC of France at that time agreed that the CFM56-5 should certify to a special condition in anticipation of these new regulations, and they would require 2 1/2 pound birds aimed at the fan ~~air to~~ outer panel and also ~~what they call~~ at the core ~~--~~ the maximum thrust loss of 25 percent wasn't changed. However, the run on requirement was increased to 20 minutes including ~~--~~- throttle excursions to show ~~off ability~~ operability. This was a significantly more stringent test requirement.

The CFM56-5B and 5B/P demonstrated full compliance with all these bird ingestion cert requirements including the special condition.

When we perform bird ingestion testing, as was mentioned here, the medium bird test, you ~~fly~~ fire the birds in across the fan face. The birds ~~flew in~~are aimed, at least one, at the core, the rest of them at critical locations across the fan blades. The test does use dead birds by the way.

The birds are fired in a volley which must be within one second ~~as~~ and that's to simulate a flock encounter. The engines are ~~maxed~~ at max. takeoff fan speed and the birds are fired at critical speeds and this maximizes the fan blades stress condition.

It's a deliberately stringent test and it's designed to simulate the worst encounter that you could get in service.

When we ingest birds in service, it's typically much less severe than the certification test. All birds will strike the fan blades on the way into the engine but the vast majority pass through the bypass duct which is, as you can see that arrow, bird through bypass. It's the large area out there. Ninety percent of the air goes out of there and most of the birds go out there, too. Even those that strike the spinner in the center will hit ~~this~~it, and they'll be deflected out through the bypass mainly. Some parts might go through the core.

The pink region on the diagram shows the narrow annulus that a bird must be in to possibly enter the core. This is just a small percentage of the inlet frontal area, and even then, the bird will probably strike the fan blades and parts will be centrifuged out into the bypass again.

Also when you ingest birds in service, typically it's not at max takeoff power which we did in the certification test. In fact, more than 50 percent of ingestions are on approach, at more idle powers. So ingesting birds at max takeoff power into the core is unusual.

I'd like to clarify one typical misconception that's often stated. ~~You know~~It's that~~,~~ birds are not sucked into engines unless the engine's taxiing or standing still~~.~~, ~~That's~~

that's when you'll suck birds into engines. But, ~~once again,~~ once the aircraft is moving down the runway at more than 50 miles an hour, whatever is in the way of that engine will get ingested but it's only when it's in a direct line, that's why that pink area. If the bird's not in that pink area, it will not enter the core.

For all these reasons, it's highly unusual to get a significant amount of bird into the core at takeoff power, and it's even more remote to get it into two engines in the same flight. However, in this event, that's what we seem to have had.

When we looked at the FDR data, and I won't belabor this because it was covered the other day by Mr. Benzon, we saw the ingestion event as the aircraft climbed through about 2800 feet doing 220 knots. The thrust decreased simultaneously on both engines. The number one engine, the left engine, the core speed still stayed relatively high. So it was providing electrical and hydraulic power.

However, the fan speed was low ~~and~~ meaning little thrust was available. The number two engine rolled back to sub-idle and was safely ~~to~~ shut down. The result was insufficient thrust available to maintain flight, and the emergency landing was necessary.

When we dismantled the engines, we found bird remains throughout the core and bypass~~, flow pass~~flowpaths of ~~to~~ both engines. These were sent to the team at the Museum of Natural History at the Smithsonian and identified as Canada geese, a bird which averages around 8 pounds, and as it's been stated, this is significantly heavier than the large bird requirement for these engines, and that's for the safe shutdown requirement. They're more than three times the weight of the medium bird requirement which is continued thrust.

From the booster inlet damage, it was clear there was ingestion into the booster and the core of both engines. The evidence indicates that only part of the bird entered the booster. However, based on the damage that we observed, the mass of the bird that entered was heavier than we saw during certification testing.

We found consequently significant mechanical damage throughout the core, and that caused the loss of thrust on both engines.

Notwithstanding these findings, the engines did react safely as required for large bird ingestion. One was safely shut down and the other continued to operate.

That concludes my prepared material.

MR. REICHEL: Thank you. I'm wondering if you could please give a description of the actual bird test conducted specifically on the CFM56-5B and summarize the test results.

MR. McVEY: There was a series of tests performed on both the 5A, the 5B and 5B/P. We performed component tests where we fired 2 1/2 pound birds at the spinner, the fan blades and the booster IGV. For the fan blades and booster IGV, we then took those components, installed them in engines and performed run on tests to show that they met ~~first~~ thrust requirements and also durability requirements of the rules. We did the test I described, the medium bird test, ~~7 -~~seven 1½ ~~1/2~~ pound birds, 2 of them aimed at the core. We performed that run on. In that test, we lost less than 5 percent thrust which was well within the 25 percent thrust limit.

We did an engineering test early on in the program with 2 1/2 pound birds aimed at the core and at the fan ~~air to~~ outer panel. In that test, we lost less than 10 percent, again well within the 25 percent thrust limit.

In fact, after the medium bird test with 1 1/2 pound birds, when we assessed the damage, that only the 5 minute run on but the damage was not severe. We believe it would have ~~went~~ run on significantly longer at much more than 75 percent thrust.

When we certified the 5B/P again, we did component testing, firing 1 1/2 pound and 2 1/2 pound birds. The 5B/P was a derivative of the 5B model, and that is the engine installed on this aircraft, the 5B/P. We put aerodynamic and ~~duo --~~durability improvements through the core, and we tested 2 1/2 pound birds and 1 1/2 pound birds on the booster IGV, the modified IGV, and also performed a medium bird test where we fired medium birds into the core.

In that test, we used the ~~Danish~~ damaged fan blades from the previous 5B medium bird test because we hadn't changed the fan at all. After the volley of birds into the core, there was no change in thrust. So again we met the thrust ~~--~~loss requirement, and we performed the 20 minute run on as required. And that's about it. These tests were accepted by the ~~--~~-DGAC and the FAA as showing full compliance with the regulations.

MR. REICHEL: Thank you. How large is the worldwide fleet of the CFM56 engine?

MR. McVEY: We have something like 15,600 engines actually flying on commercial airplanes. There's another 2, 2 1/2 thousand on military aircraft and there's, you know, we've produced about 20,000 engines altogether. So total CFM time is over 120 million hours, and we've done nearly half a billion ~~natural~~ actual engine flight hours. The CFM56-5 is about 25 percent of these numbers.

MR. REICHEL: Thank you. I'd like to talk about the engineering, some engineering solutions, and my question may be difficult but I'll address it anyway. Are there any other reasonable engineering solutions that could be incorporated into engine designs that may have prevented the Hudson River accident?

MR. McVEY: You've got to look at the ~~--~~turbofan and the way it's developed over the past 30 to 40 years. It's matured to a fairly similar design across the industry. It's a very balanced design. It's proven to be very safe, very reliable and very efficient.

When I say it's a balanced design, it has to meet a lot of different requirements from the regulatory agencies, from aircraft manufacturers and for our own design practices. And, in part of these, you have to show airworthiness, the safety requirements, the noise emissions requirements. You have to produce high thrust with high reliability and high efficiency.

Just to try and improve single components for a specific requirement such as, you know, a very large bird, we could upset this balance and change the whole balance of the engine and in doing so, you might not meet many of the other requirements such as icing, operability and things like that.

So to answer your question, no, I really don't see any reasonable engineering solution that can be applied to these engines at the moment. You have to remember that the heaviest bird we have to ingest into the core is a 2 1/2 pound. In this event, we ingested 8 pound birds, which is more than 3 times that requirement. So this wouldn't be just a simple incremental improvement. This would be a major change in technology, a step change, to do that.

MR. REICHEL: Thank you. As mentioned previously, Advisory Circular 33-2B allows for fan protective devices to be incorporated into engine design. Could you please comment on this particular design feature on large turbofan engines and also as a follow up, has CFM ever tried to certify a fan protective device?

MR. McVEY: To develop on Mr. Bouthillier's comments, no, we have never tried to certify anything like that. You know, we've studied the options. If there's something possible out there, we would probably try and design it. We've looked at screens. My colleagues at ~~--~~Snecma went away and diligently tried to calculate one, you know, how you would design a screen.

You have to remember, the engine or the aircraft is moving at 250, 300 miles an hour say, and if you have a screen on the front, it's going to ingest an 8 pound goose, there's a lot of energy to be dissipated. It couldn't be handled by a simple mesh or chicken wire or anything like that. We're talking half inch titanium rods in a 4 x 4 mesh, and it would be a huge structure to try and withstand that impact.

And as Mr. Bouthillier mentioned, you know, the consequence, other things that would happen, distortion of the airflow in the inlet, icing, you get pounds and pounds of ice building on that thing, and you would end up shedding ice into the engine constantly in icing weather.

The consequence of screen failure, where you're going to impact the screen with a bird, you'll still end up with the bird and pieces of metal now going into the engine which is going to be worse than the bird itself, and then other possibilities such as poor inflight restart performance.

In this event, they did do the inflight restart on the way down, and that could have been affected. T~~t~~he engine~~. --~~, n~~N~~umber one, it did restart. It spooled down and fired back up. Again, that might not have happened with something like a screen on the front blocking the flow.

So the detrimental effects totally outweigh any positives as far as I'm concerned.

MR. REICHEL: Thank you. The next one is going to be a long question. So if you bear with me. We know that the event engines did not flameout at any time during this particular event, and from the review of the internal damage to the two engines during the tear down, I think we agree that it is unlikely that any start attempt would have been successful in having the engine produce any further thrust.

However, the crew was unaware of this fact, and they followed the checklist for dual engine failure, and they still attempted to restart the engines and now subsequently once we reviewed the engine, we found it was not possible to start them.

And while it is unreasonable to have the crew diagnose engine problems during emergency situations, are there enough sensors within the engine, and can the engine digital controller be used to recognize such a situation so that it can alert the crew to forego any further start attempts and thus reduce their workload and save time for other priorities?

MR. McVEY: I think we'd have to study that very carefully. The sensors in the engine are there for controlling the engine and modern engine, modern -- -- FADEC, full authority digital electronic controls, have a lot of power. If you look at some of our recent engines, you know, we can do stall detection logic where you can detect a stall, and you can pulse the fuel flow to clear a stall. So there's capabilities there that can be studied for an auto restart which might relieve the crew workload.

I think in this case, you know, the crew did see that the number one engine was operating with a relatively high core speed and low fan speed which could indicate that the engine was in a stall and the restart procedure might clear it.

In this case~~,~~ it wasn't that, because the engine core was damaged sufficiently that the airflow was just very low in the core and you just couldn't run the fan.

So I don't think it was a waste of time attempting that restart for this crew, but we ~~did~~ do just have to go and look at what could be done and what sensors we have and what the possibilities are. I don't want to take authority away from the crew, you know, if it's a safety issue. If the crew can possibly get more thrust out of that engine, you've got to give it to them, and to have a control say no thank you, you know, we're not going to let you, you don't want to do that.

MR. REICHEL: Thank you. My next questions are addressed to the FAA again, and these questions are concerning the development and amendments to the bird ingestion standards. I wonder if you could please explain the overall process used to develop new bird ingestion rules as for the 33.76 paragraph rules.

MR. GANLEY: Again at a very high level, our process for rulemaking is covered by Part 11 of our regulations. More specifically, we have a rulemaking manual, a FAA rulemaking manual that's managed by our Office of Rulemaking within Aviation Safety, the AVS organization.

Basically, the first step of our rule process is to determine the need for rulemaking. I think as Mark had indicated earlier, this need could be based on, you know, adverse field service experience. It might be an accident such as we're discussing today, safety analysis, you know, items like that actually determine the need for rulemaking.

Once it's determined that rulemaking is needed, our formal process takes over within the FAA where we obtain approval to move forward. The first part of that process, the process that was used specifically on these bird regulations, is for the FAA to formally task an ARAC committee to go off and, you know, evaluate, make recommendations. These recommendations would involve, you know, recommendations related to changes to the rules and/or the policy and guidance that goes along with those rules.

Usually the first step is to go off and put some work groups together. Specifically for the bird rules, these work groups included representatives from, you know, domestic and foreign engine manufacturers, you know, the -- and the Pratts of the world, as well as foreign engine manufacturers, airplane manufacturers, Boeing in this case, foreign airworthiness authorities, JA at the time, EASA today, Transport Canada, as well as ALPA groups. My understanding is ALPA was also involved in this committee.

The team goes off. They make recommendations to the FAA. The FAA receives those recommendations. In this particular case, the recommendations on our bird rules, because the FAA was selectively involved as well as JA in the generation of these recommendations, they were accepted fully by the FAA, and at that point, the internal FAA process takes over, where we go through the internal FAA comment process, the public comment process, the final issuance of the rule, and at each step of the way, any comments that are received are formally dispositioned and, if need be, the rule changed.

But going back to the specific rule, the rule was adopted as received by the ARAC recommendation.

MR. REICHEL: Thank you. I'd like to talk a little bit about the database itself right now, how you actually gather the data and also how it's used. So -- and that's my question exactly. What data is collected? Who collects the data to support the rulemaking projects? And then, how is it used?

MR. BOUTHILLIER: I can answer that. Our current requirements do have a database supporting them. It's an extensive database. So our rules are data driven. The data was collected and analyzed by the FAA ARAC rulemaking team, and I think Bob had mentioned some of this previously, but our data does cover a 30-year period through January of 2000.

During that period, that does reflect about 325 million turbine aircraft operations, and the actual number of bird ingestion events in the database is a little over 8100.

That data also covers a full spectrum of civil operations, 2, 3 and 4 engine airplanes, all the major western engine manufacturers, western aircraft manufacturers, all their customers worldwide and all the airports that those customers fly into and out of.

The event data that was collected for each of these 8100 events, we tried to be as complete as we could. You know, date, location, airplane information, the engine model information, numbers of birds that were ingested, the species, that's difficult to come by sometimes, so that's not 100 percent on that, but the results of the event, power losses, the effect on the flight, if there was any. So for each of these events we tried to be as complete as we could. There are a lot of fields that we needed to fill in.

Now the way that we did it was to work back through the manufacturers' field representatives to the operators, the folks who actually fly the airplanes that have the events. The manufacturers have field reps assigned, you know, to their customers permanently and those folks work closely on a variety of issues, economic issues, safety issues, a variety of issues, and there's, we believe, a good working relationship and we thought it was a great way to go back and get the data directly from the operators. So we feel that that was a very efficient and useful way to collect data.

This is not a situation, not a database that's based on voluntary submittals. We actually aggressively went to the source to collect the information, and we think from the, you know, 121 world, the 135 world, that we collected a very good set of data, you know, for our purpose which was very specific to engine ingestion.

The manufacturers also did some cross checking, the information that they did collect from the field reps, and they did some cross checking with their airframe customers, just making sure that important events were not missed because, you know, obviously the airframers have their own, you know, bird strike information also.

Then there was also some cross checking with the FAA wildlife database, again just looking for some of the major events, making sure that nothing important was missed.

So once the data was collected, it was further analyzed by the rulemaking team and the important outputs of the data effort were very specific bird ingestion rates as a function of bird size and engine size, engine power loss rates as a function of bird size and engine size, and that from those two, we get a feel for what the dual engine power loss rates have been from those.

So those three items were the important things that the rulemaking team, it was then able to use to try and design a rule. But again, the important thing is that again this database was not based on voluntary submittals. Our needs were different, you know, very specific. So we actively went out again to the operators, to the folks who fly the airplanes, to collect whatever data they had, try and fill in the blanks as best as we could on all the different, you know, parameters for the event, and we think we do have a good significant database from which to, you know, we drew our conclusions.

Having said that, and again as Bob had mentioned earlier relative to this accident, it's telling us something. So we're going to back and we're going to do that all over again. We've already initiated a program to do that, put the team back together to update our database through 2008. We'll also be looking at, you know, and trying to look at what the threat really looks like as far as the ingestion rates go, determine whether we can meet our safety objective, still meet our safety objective, and we're also going to look at some other things such as our methods of compliance, the type of testing that we're doing, make sure that we're doing good tests and getting out of it what we need to get out of these tests.

And we'll probably also talk some engine technology issues, you know, where things have gone since this rule team last, you know, did some formal work. So we already have that program in place and are moving forward with that.

But that's a summary of kind of the database activity and how the information was used.

MR. REICHEL: Thank you. You talked about a group that meets, and I'd like to know who this group is. Who meets -- do they meet periodically or do they meet only when an amendment is due? And, who comprises this team?

MR. BOUTHILLIER: Okay. First of all, we do not maintain a standing study group for our engine bird ingestion rule. That we have not done.

What I'm referring to was a formal, the convening of a formal team for a specific purpose. When we did the two rulemaking efforts, Amendments 20 and 24, we had a rulemaking team that was worked through our ARAC process that has representatives from all the major engine manufacturers, the authorities, FAA, JA, EASA and Transport Canada. We did have representation from some other groups. The last rulemaking, we had representation from ALPA. It is open to, you know, any organization that wants to participate.

But, we generally convene that type of a working group when there's a specific task at hand. So we knew we needed to do some rulemaking. So we convened that group to, you know, to do that job and do it right. But, in between those, you know, specific efforts, we do not maintain a standing study group to continuously monitor, and that we have not done.

MR. REICHEL: So if I can clarify, there's a USDA database that exists. Then there is the data that you actually collect when an amendment is pending. These are the two databases you're working from. And the one that is the amendment type of database is only started periodically. So when the next amendment is due, it looks back in the, you know, for the last series of years.

MR. BOUTHILLIER: Yes, that's the way we've worked our bird ingestion rulemaking database again specific to engines. The FAA wildlife database is not specific to engines. That covers all of aviation, but when we're doing rulemaking or if we're doing guidance and policy work, too, we could possibly do the same thing but, yeah, we would convene a specific working group to actively go and obtain the data that we needed for our specific purpose, and that's what I had explained a few minutes ago, how we do that.

MR. REICHEL: Right.

MR. BOUTHILLIER: But in between those efforts, which are significant efforts and takes some time to manage and execute in between those major efforts, so we do not maintain any other type of a group or populate any other formal database in between those efforts. Again the rulemaking or the FAA wildlife database, which was discussed a couple of days ago, that's a very extensive piece of work, too, and I think, from the folks on the airport side, I think that works very well for them. And I think, as Dr. Dolbeer said, that it gives a really good overview of the threat, you know, in North America, that we're confronted with, but we're just a subset of that.

So we actively go and collect very specific data that we need to do our engine rule work. And what we have collected, too, is worldwide, all of the customers or manufacturers worldwide, you know, provided us with data. So we think what we did was very appropriate for what our particular task was.

MR. REICHEL: Thank you. The span that you had between the last two amendments, let's say 2000 and now you're starting a new one in 2009, the data that is accumulated at that time, are you satisfied with the validity or that that data has actually accumulated and save somewhere at the manufacturers?

MR. BOUTHILLIER: Yes. Well, the manufacturers do collect a lot of this data maybe on a year basis. I think for their customers, they're continuously asking them for what their experiences with their products. And, again, that's done through the field reps. So, yeah, we're confident that in between our formal rulemaking activities that a substantial amount of data, you know, useful data is collected and will be available when we need it, when we conform a formal group to do something, do some work.

MR. REICHEL: Thank you. We know that the engines in the Hudson River event were certified to the bird ingestion rules in effect in 1993. Since then we know that two significant amendments have been made to the ingestion rules. So the question is if a similar sized engine such as a CFM56 were certified to the latest bird ingestion standards, that's Number 24, would it be capable of sustaining a strike such as that in the Hudson River event?

MR. BOUTHILLIER: I think it's probably impossible to say whether any Amendment 24 product would survive this event. As was mentioned earlier, our regulations don't go there. This was two Canada goose birds into one engine and one or two into the other. That's beyond the cert requirements for any size engine currently. So it would really be speculation --

MR. REICHEL: Right.

MR. BOUTHILLIER: -- to try and state whether any Amendment 24 engine could survive it, but certainly the Amendment 24 requirements with our new large flocking bird standard, engines will be more tolerant of these larger birds, you know, the Canada goose, that size also, but again a lot depends on the parameters of the event, you know, what the power setting is, the wheel speed, the impact location on the front of the engine. There's an awful lot of factors involved that, you know, determine what the result of the event's going to be, but we just couldn't say that other Amendment 24 products would survive this.

MR. REICHEL: Right. Maybe that was incorrectly phrased, but certainly the present standard of weights is significantly less than what the event engine experienced.

MR. BOUTHILLIER: For this size engine, that's true. The maximum bird size for CFM size is a 6 pounder, and that would be at a safe shutdown requirement. But our large flocking bird requirement under Amendment 24 does require run on with birds up to 5 1/2 pounds, you know, for the larger size engines.

So there will definitely be an improvement in, you know, overall fleet capability for that reason. And we think, too, also that with newer engines coming on line, they are performing better in a bird environment and that all the products and as older products are retired from service, that, you know, we believe the overall fleet capability is going to definitely continue to increase and get better. We just hope that the threat doesn't get worse at the same time.

MR. REICHEL: Thanks. And my final question has to do with the small birds and also power settings. My first question is why would the certification regulations only require bird ingestion tests to be performed at high power settings? And let me continue with the question to give you the whole intent.

On a recent accident, many small birds were ingested into the engines of an aircraft during the landing phase. The engines were at a partial power setting at this time, and both engines stalled and did not recover until the aircraft struck the ground.

Should there be certification standards to deal with bird ingestions during a part power condition such as during landing conditions?

MR. BOUTHILLIER: Okay. Well, you're correct that our regulations do focus on the high power situation. That's certainly the most critical. For fan engines, that's certainly the most critical for fan stages, and those high power conditions are going to occur during takeoff roll, rotation, initial climb and the multiengine ingestion of birds under those conditions and multiengine power losses at that point, you know, could be extremely challenging for flight crews.

So we still do consider that those high power conditions to be, you know, extremely important and we need to maintain our whole focus on that, but as far as the low power issue goes, that's probably more important for the core ingestion situation, you know, which we had core ingestions here with the lack of centrifuging at lower power conditions with a shot, you know, with a bird impact aimed at the core inlet.

So that's probably an area where we need to focus on more and that is actually an area that we're going to talk about or discuss with our database update team when we talk about some technology issues and method of compliance issues. We're really exercising that situation properly or enough because our core shots are conducted at high power right now the way that we have the test laid out.

So that is something that we do need to, you know, discuss internally in the FAA and with industry in the future. We do need to do that.

As far as the event that you talked about, that accident is still under investigation, and we don't have a lot of information about that just yet, but that appears to be a situation where the airplane flew through a extremely large flock of birds. We don't know how many were ingested into the engine or into the core, but -- I'm not sure that event right now is going to be a low power versus high power debate. A turbine engine is very sensitive to a foreign matter and whether it's bird mass or hail or ice or volcanic ash or whatever, enough mass going into the core is going to cause operability problems.

So we're aware of that event, and we need to understand that better and consider the low power situation also.

MR. REICHEL: Thank you. That concludes my questions.

CHAIRMAN SUMWALT: Okay. No more questions from the Technical Panel? Yes, please.

MR. O'CALLAGHAN: Good morning, gentlemen. Thank you. I just have a couple of follow ups. The first one, in one of the slides it was shown that a safety objective is to not have dual engine loss due to bird ingestion and something like a billion flight hours, the one, the 10 to the minus 9th objective, and I was just curious a little bit on how that number is counted. I think I heard something that on like the CFMs, we have maybe half a billion, but I'm just curious as to how many hours on the fleet we have already and whether it includes all engines or just specific types and kind of where the clock starts in that counting.

MR. BOUTHILLIER: That 10 to the minus 9 is the extremely improbable level of safety, that's the objective that we established for the rulemaking, and we tried to design a rule that could meet that objective, that level of safety for a fleet that fully complies with Amendment 24 basically. So where the time starts and stops, I guess officially it would start with the adoption of Amendment 24 and include Amendment 24 engines into the future, but obviously that's not the way, you know, that industry works. All the products are there and they continue to operate.

But again, that safety objective was established for Amendment 24 with the intent that a world fleet that met Amendment 24 should be able to operate at that level of safety.

Now for a perspective on kind of where it seems to be today, since the start of service of the large turbine aircraft in the sixties, you know, air carrier type aircraft, we have over 550 million flights since then and over 1 billion hours since then, air carrier hours and flights, and in that time period right now we have two forced landing whole losses due to multiengine power loss due to bird ingestion, U.S. Air being one. A previous accident that occurred in 1988 was a two-engine transport. It was an accident in Africa. It was a multiengine ingestion of rock doves and multiengine power loss in an accident there.

So those are the two events that we're recording right now that our safety objective was specifically targeted for. It's the multiengine ingestion, multiengine power loss situation.

That's where we're trying to provide this extremely improbable level of protection for.

This third event that we just discussed a minute ago with the smaller birds, again that was also a multiengine power loss situation. That's still under investigation, and we need to understand that so we're not characterizing that one way or the other at this point, but that puts a perspective on kind of where we think we are.

MR. O'CALLAGHAN: Okay. Thank you. And just to make sure I understand you, and I think we have over a billion hours but two, maybe three events. Is that correct?

MR. BOUTHILLIER: Two or three events of multiengine ingestion, multiengine power loss where sufficient thrust was not available for safe flight and landing. That's correct.

MR. O'CALLAGHAN: Thank you. This next question might be kind of silly, but I'll ask it anyway. And I understand that the U.S. Air event because of the bird masses is way outside the cert criteria, but the question regards the safe shutdown criteria and the preclusion of disk rupture or catastrophic failures or fires, and Mr. Campbell in his testimony on Tuesday, characterized one of the engines as being a bonfire, and understanding that we're outside the cert criteria, but I'm just wondering if that description would be precluded for a safe shutdown within the criteria.

MR. McVEY: If you look at the two engines, one was safely shut down. That was the number two, the right-hand engine, and Mr. Campbell was speaking about the left-hand engine, number one, which continued to run. And from what we can tell from the data and what we see in the engine, the large bird requirement says does not catch fire. That is an external fire really, not what we saw in this engine.

What happened on this engine was the core was severely damaged and had little airflow flowing through it. So although it could keep the core rotating at something like 80 percent speed, the fan didn't have enough airflow through that core because of the damage to power the fan.

So what we ended up with was it was feeding it fuel and the fuel was coming out the back, out of the nozzle, the core nozzle, and once it got to the oxygen on the outside it could burn there. So you're seeing a fire out of the nozzle which was just unburned fuel. It didn't catch fire as would be defined for the large bird requirement.

MR. O'CALLAGHAN: Okay. Again, so to be clear then, so while that -- spectacular, from a safety point of view, it wasn't really a danger, as risky a fire as the sort of fire you're contemplating in the cert rules. Is that a fair statement?

MR. McVEY: That's correct, yes.

CHAIRMAN SUMWALT: Okay. Thank you. And lastly, I was wondering if you could help me understand why the single engine or, I'm sorry, the single large bird requirements' masses are dependent on engine size. Is there a statistical connection between the size of the bird and the likelihood that it's going to go into an engine of a particular size?

MR. BOUTHILLIER: That is correct. For all the bird sizes, the data that we collected, the database that we have, the bird ingestion rates that we've observed, you know, it was function of bird size and engine size, is a clear difference between the sizes and numbers that are typically ingested. Large engines have a strong tendency of ingesting larger birds, this accident aside. They also have a tendency to ingest many more of them.

As far as the large flocking birds go, those greater than 2 1/2, large engines will have single ingestion rates 2 to 3 times higher than the smaller engines. The multiengine rate will be 10 times higher, and the size of the single large bird really is the same thing, that the larger engines will have a tendency of taking larger birds and also to maintain an equivalent level of safety, they need to be challenged higher for that reason.

MR. O'CALLAGHAN: Okay. And by going into the engine, we're talking anywhere in the fan area, not just the pink area that Mr. Ganley showed. Is that correct?

MR. BOUTHILLIER: The single large bird test, the target needs to be the critical location and that means that's the feature on the engine that's least likely to survive and pass the test. So there's going to be an analysis done ahead of time to determine what the critical feature is for a particular engine. It could be the core. It could be a fan feature, but that does need to be determined before the test is conducted.

MR. O'CALLAGHAN: Okay. And I'm sorry for not understanding completely but the statistical correlation that you mentioned between the large engines and the large birds, is that referring to the birds that go into the core because I presume then the larger engine, that core size, that pink area will be larger or is the statistic applied to large birds going anywhere through the fan?

MR. BOUTHILLIER: The statistical correlation is the inlet area, the larger inlet area. So the very large engines have different ingestion rates than the smaller engines do. So it is the inlet area, not the core, inlet area, that drives the bird size for the large single test.

MR. O'CALLAGHAN: Okay. And I understand that that's what the statistics show and it's interesting. Do you have any idea from a physical sense why that might be? Why the larger engines might attract larger birds of whatever?

MR. BOUTHILLIER: It has a lot to do with the size of the target. I guess to go beyond that would be maybe speculating but I do know from the FAA's wildlife database, where they have some information in there about the different features on an airplane and how they're struck, in general strikes seem to take place relative to the area of the feature that you're considering.

So, yes, we do believe it has a lot to do with just the size of the target.

MR. O'CALLAGHAN: Okay. Thank you. That's all I have.

CHAIRMAN SUMWALT: Thank you. Any other questions from the Technical Panel?

Okay. We've been in here about an hour and a half. Let's take a break. Let's take about a 12-minute break and be back at 9:40. Thank you.

(Off the record.)

(On the record.)

CHAIRMAN SUMWALT: Okay. If everybody will please take their seats, we'll get restarted.

Okay. Thank you. We'll start back with the question from the parties and FAA and CFM International both have witnesses. So Mr. Harris, you would like to go in which order.

MR. HARRIS: We have no preference, sir.

CHAIRMAN SUMWALT: Okay. Very well. And, Mr. Mills.

MR. MILLS: Mr. Chairman, CFM would appreciate going last.

CHAIRMAN SUMWALT: All right. We'll just keep it in order because I believe we're starting with USAPA. So we'll just keep it in order at the table. So USAPA.

PARTY QUESTIONS

CAPT. SICCHIO: Thank you, Mr. Chairman. Good morning, gentlemen. I'd like to start if I can with Mr. McVey, a couple of operational questions if you don't mind. Regarding the fire that was described by the passenger witness, you gave us I think a very good technical answer for how and why, but is it safe to characterize that fire as something similar to tailpipe torching on an engine start?

MR. McVEY: Yes, it would be.

CAPT. SICCHIO: Okay. Thank you. And obviously a very innocuous type of event?

MR. McVEY: In flight~~s~~ especially because the flames ~~--~~ ~~anyway~~are not near anywhere it can cause danger.

CAPT. SICCHIO: Thank you. Okay. And, Mr. McVey, you are familiar with the flight data from Flight 1549 I assume?

MR. McVEY: Reasonably, yes.

CAPT. SICCHIO: Based on that, let me ask you, in a situation of Flight 1549, are there any other flight crew procedures that would be applicable that might gain the crew thrust from the engine other than attempting to restart or the relight?

MR. McVEY: I can't think of anything else. They saw the engine was running. They attempted to restart which could possibly clear any stall. Beyond that, there's nothing else they could have done.

CAPT. SICCHIO: Okay. Thank you. And had the engines been capable, without the obvious damage that they suffered, did you see anything in the data that would have limited those engines from starting at that point or restarting?

MR. McVEY: No, other than they weren't really in the restart envelope, but when they did that restart on number one, it came down and it came straight back up, ~~immediately~~ admittedly at lower thrust level because of the damage but there was nothing preventing them starting.

CAPT. SICCHIO: Okay. And are you familiar with the relight envelope that is provided in both the Airbus and the U.S. Airways procedure and QRH and so forth?

MR. McVEY: A little bit. I don't know the details.

CAPT. SICCHIO: Would it be appropriate, would you mind referring to that. At this point, it is an exhibit. I understand you're not responsible for that exhibit.

MR. McVEY: Yeah, if they can find it.

CAPT. SICCHIO: Okay. Could I have Exhibit 2AA please?

CHAIRMAN SUMWALT: Now, Mr. Sicchio, this witness is not tagged to this Panel, is it?

CAPT. SICCHIO: That's correct.

CHAIRMAN SUMWALT: Mr. McVey, you may answer the question if you know the answer, but you're not required to because you're not -- it's not specific to your Panel.

MR. McVEY: Okay.

CAPT. SICCHIO: Yes. Mr. McVey, if you don't mind, would you, and I understand this is quite small here, but the top chart is the relight envelope for the CFM engines in the Airbus

QRH I believe. Looking at the quick relight envelope, does it appear to you that between sea level and 3,000 feet that it is in the range of 190 knots? Is that fairly accurate?

MR. McVEY: Yes, that's correct.

CAPT. SICCHIO: Okay. And is it your understanding that the aircraft was operating just above that speed for most of the duration of the flight?

MR. McVEY: I know the ingestion was 220 on the descent. I know they slowed down. I'm not sure where they were when they did that relight attempt. They might have been around 190, but I don't know.

CAPT. SICCHIO: Okay. Thank you. That's great. Thank you very much, and I appreciate you attempting with a piece of evidence that was not your responsibility. Thank you.

Okay. Moving onto the certification side, Mr. McVey, you did mention that you had been involved in the ARAC rulemaking process. Is that correct?

MR. McVEY: Yes.

CAPT. SICCHIO: And were you involved at the working group portion of that process?

MR. McVEY: Yes, that was for the latest amendment, we meet in 2000, 2002.

CAPT. SICCHIO: Okay. And -- oh.

MR. McVEY: And Mr. Bouthillier was the Chair.

CAPT. SICCHIO: Oh, great. Thank you. And we will also ask you on this subject as well shortly, sir.

During that process, it seems from all of the testimony on this Panel, that the working group seemed to have great results. Did you folks find good levels of cooperation and was the work done in a timely process?

MR. McVEY: I thought we cooperated very well, and we did that in I'd say 2 years, I think it was about 25 months.

CAPT. SICCHIO: Okay. Very good. Thank you.

Now, Mr. Bouthillier, was that your experience also?

MR. BOUTHILLIER: Are you talking Amendment 24 rulemaking activities?

CAPT. SICCHIO: Yes, the group that you were on with Mr. McVey.

MR. BOUTHILLIER: Right. I believe the tasking was done under the FAA ~~reg~~ ARAC process. I believe the tasking was in 2000, and I believe the ARAC rulemaking team completed its work and delivered its product to the FAA maybe around the end of 2002, and that was very, very efficient in my experience, you know, working rulemaking projects. So we were happy with the cooperation, all the members and we thought, you know, we were very efficient about it.

CAPT. SICCHIO: Okay. Thank you. Yes, it sounds as if you had a very good team and worked well together.

That being said, could you describe the process once it leaves the working group, what happens to the rulemaking at that point?

MR. BOUTHILLIER: Once the work is complete within the ARAC working group, they deliver a recommendation to the FAA. At that point, it's up to the FAA to process the rule. So the folks that worked on that ARAC rulemaking team are now not actively engaged in the processing of the rule.

CAPT. SICCHIO: Okay. And could you tell me how long that process, from the time it left the working group until final rulemaking, could you give me an --

MR. BOUTHILLIER: It was approximately five years.

CAPT. SICCHIO: Five years. So it's correct to say then that the working group accomplished their work in approximately two yeas, but it took the FAA yet another five years to actually publish the rule?

MR. BOUTHILLIER: That's correct.

CAPT. SICCHIO: Okay. Thank you. And thank you. No further questions.

CHAIRMAN SUMWALT: Thank you, Captain Sicchio. AFA.

MS. KOLANDER: Mr. Chairman, AFA has no questions.

CHAIRMAN SUMWALT: Thank you, Ms. Kolander. FAA.

MR. HARRIS: Thank you, Mr. Chairman. We have a few number of questions actually. Mr. Ganley, you were present I believe yesterday when Mr. Breneman testified to the FAA certification of the aircraft relative to the bilateral agreement.

MR. GANLEY: Yes.

MR. HARRIS: And in that discussion was the recognition that FAA, for example, could have independently declined or disapproved the application for the aircraft even if DGAC chose to approve it. In this joint certification process, particular to the CFM products, is that the same relationship? Can one authority certificate without the other authority agreeing, too?

MR. GANLEY: I'm not sure I can answer that 100 percent. I can say in my experience that it's never occurred. Each authority is responsible for their own regulations, and to my knowledge every certification has been done jointly.

MR. HARRIS: Right. And so, in fact, in history they've jointly issued in that respect, correct?

MR. GANLEY: That is my understanding, yes.

MR. HARRIS: Thank you. Again to Mr. Ganley, Mr. Bouthillier spoke of the potential of up to two to possibly three multiengine power losses related to bird ingestion resulting in whole losses of aircraft. Of course, as we recognize, U.S. Air 1549 is one of those, in roughly the 1 billion flight hours flown since the 1960s. Do you remember that testimony?

MR. GANLEY: Yes, I do.

MR. HARRIS: And also the discussion was that the target level of safety of Amendment 24 was 1 in 1 billion flight hours or roughly 10 to the minus 9th.

MR. GANLEY: That is correct.

MR. HARRIS: But, in fact, is it not true that if we were to look at those flight hours accumulated from the 1960s, over the five decades, of those flight hours accumulating, the vast majority were not involving aircraft certificated under Amendment 24, the 2007 amendment. Is that correct?

MR. GANLEY: That is correct.

MR. HARRIS: And even a substantial number of those were not under the Amendment 11, under the 2000 amendment. Would that be correct?

MR. GANLEY: I believe that would be true also.

MR. HARRIS: And there's even a fair number of aircraft engines that were certificated prior to Amendment 6 which was the 1970 amendment. Would that be correct also? Worldwide. And fair is a rough number. So are they present in the fleet and certainly in those hours accumulated?

MR. GANLEY: Yes, I think when you look back at four, close to five decades of worldwide fleet experience, I think it's safe to assume that many engines are very old in that timeframe from the 1960s forward. So I think that's a fair assessment as well.

MR. HARRIS: Okay. Thank you. So that more or less puts that in perspective in terms of the numbers of events over the years relative to Amendment 24. Maybe you can comment on that.

MR. GANLEY: I think that is indeed the case. The vast majority of the service experience as I just noted are on pre-

Amendment 24 engines, and even though that is the case, I think that the field experience is quite well, and I guess I'll leave it at that. Thank you.

MR. HARRIS: Thank you very much, sir. And, Mr. McVey, just one minor question. It was earlier discussed from the USAPA folks that the "bonfire" as Mr. Campbell referred to it, was similar to tailpipe torching. Is this the kind of fire in the exhaust stream like that, is this the kind of fire that typically triggers an~~d~~ airframe fire warning system in the cockpit?

MR. McVEY: No, it doesn't.

MR. HARRIS: Okay. Thank you very much. We have no questions, sir.

CHAIRMAN SUMWALT: Thank you, Mr. Harris. Airbus.

CAPT. CANTO: No questions, Mr. Chairman.

CHAIRMAN SUMWALT: Thank you, Captain Canto. U.S. Airways.

CAPT. MORELL: No questions, Mr. Chairman.

CHAIRMAN SUMWALT: Thank you, Captain Morell. CFM International.

MR. MILLS: We have no questions, but I'd just like to say how thorough I think the Panel has been in answering the questions. Thank you, Mr. Chairman.

CHAIRMAN SUMWALT: Thank you. Any follow-up questions at all from the Parties?

CAPT. SICCHIO: None from USAPA, Mr. Chairman. Thank you.

CHAIRMAN SUMWALT: Thank you. Seeing none, any follow up from the Technical Panel?

Great. Board of Inquiry. We go to Dr. Kolly.

BOARD OF INQUIRY QUESTIONS

DR. KOLLY: Yes. Mr. Ganley, can you answer why was a 4 to 6 pound bird chosen as the mass for the large bird when we saw testimony yesterday from Dr. Dolbeer about the numbers of birds and the sizes, their masses, which there are a significant amount much, much larger than that?

MR. GANLEY: To be honest, I think not being part of the actual ARAC rulemaking process that Mr. Bouthillier would better suited to answer that question, but it is my understanding that the rulemaking team did consider birds much larger than where the standards ended, but the specifics, how they came to 4, 6 or 8 pound birds, I'm not that sure to be honest.

MR. BOUTHILLIER: Is the question relative to the large single bird requirement?

DR. KOLLY: Yes.

MR. BOUTHILLIER: Yeah, the data that was collected and evaluated, you know, indicated to us that the size engines that those three sizes of birds would be applicable to, that those are substantially the worst case single large bird or single engine event sizes that we had experienced, and that is primarily how that was selected. Birds greater than 8 pounds I don't think showed up in the data that we had, even for the large engines. That was a while ago.

But anyway, they were selected based on actual observations, of what had actually happened in service.

DR. KOLLY: And so how does this incident affect your thinking in that?

MR. BOUTHILLIER: Well, this accident, this level ingestion to this size of engine is I guess unprecedented in our data, and as we go back and update our database, we need to take a good hard look at what happened here and reevaluate that, no question, but again, we will be looking at the various ingestion rates and the engine power loss rates and taking a step back and reevaluating what we did, you know, back in the 2000 time period, no question we need to do that.

DR. KOLLY: Okay. Thank you. Mr. McVey, I have a couple of questions for you. I wonder if we could pull up slide 11 from your presentation. Could you explain to me what is the threat posed by bird ingestion to a modern turbofan engine? There's been a lot of discussion about if a bird is ingested into the booster inlet versus the bypass duct. Can you tell me what types of damages occur in those scenarios?

MR. McVEY: In the majority of ingestions, I mean as I said earlier, you know, all birds go in the front and they hit the fan blades at some stage. Typically the booster inlet, anything headed towards the booster, you're talking maybe 10 percent of the time you may get something in the booster. The fan blade is the most critical part in most ingestions and every bird hits it. So you have to look at maintaining the integrity of that blade. We see, typically 80 percent of the time, no effects at all. Beyond that when the birds get heavier, you'll see damage to the fan blades. We get distortion. We get dents, tip curls, stuff like that. You might also get other minor damage to the ~~OGDs~~ OGV's which are in the bypass duct and the outer panels, just from the impact of the bird being slung out there.

Once the bird enters the core, depending on the mass that's entered into that core, that's when you get the more consequential damages that we saw in this event, in this accident, when we had a large amount of meat into the core and it severely damaged the booster and then consequently damaged the HPC downstream.

DR. KOLLY: And it's the damage to the core that primarily prevents the relight, the ability to relight the engine?

MR. McVEY: Typically if you get a severe core ingestion, it would be, yes, but you can get cases where you've got severe fan blade damage where the engine cannot run on.

DR. KOLLY: You talked about the possibility of any future designs and they might be, I guess, they might be able to take bird strikes better let's say. And you said that it didn't appear that there was anything that you could identify immediately. I wonder in the area of advanced materials, I know that your engine groups are constantly looking at new modern materials, is there any promise in the future that you're aware of in using these advanced materials that may toughen the engine up and maybe mitigate the effects of a bird strike?

MR. McVEY: If you look at the more recent engines, the larger engines, we're moving to ~~compasses~~ composites on the fan blades, and they've been a step change in capability on the fan blades. They've improved but that technology can't be extended down to the small sizes of core blades. Also they won't take the temperatures in the back end of the compressor. So it gets very difficult in materials. The technology at the moment to take a huge, you know, something the size of a goose into the core is beyond current technology really.

DR. KOLLY: Okay. Thank you. And I have one clarification. Mr. Ganley, we were talking about new engines being affected by new rules. Do you mean newly manufactured or new engine designs would be the types of engines that are affected by any new rulemaking?

MR. GANLEY: It would basically be any new engine for which an applicant submitted an application for a new type certificate. So, for instance, if CFM International came forward with a CFM56-8, and it was a derivative engine model of the current -5, that would not be susceptible to the latest regulations. So it would be a new engine model that came forward.

As part of our process, I mean there is something, our

21101 requirement, even for amended type certificates, requires that people look at the latest amendment and they need to determine whether or not we should be looking at the latest regulations as we move forward in our certification programs.

But in general, something like bird ingestion probably with the types of changes that we see in these amended models would not rise to that level. So, again, new cert, new engine.

DR. KOLLY: Okay. Thank you. I have no further questions.

CHAIRMAN SUMWALT: Thank you, Dr. Kolly. And Mr. DeLisi?

MR. DeLISI: Thank you. Mr. Bouthillier, perhaps you could help clarify something that is confusing to me, and it seems to be a bit of a dichotomy in the certification standards. You were talking about the standard, the new standard for large flocking birds, and I think you described, that the requirement is to ingest one of those birds. Is that correct?

MR. BOUTHILLIER: That is correct. The Amendment 24 revision that included the new test for large flocking birds is for a single bird ingestion.

MR. DeLISI: Right. So if we're identifying that those birds are flocking, why would the standard imply that you'd only take one?

MR. BOUTHILLIER: Well, the standard's implying that more than one engine on an aircraft is affected during the same encounter. So that one large flocking bird in one engine, the assumption is that there will be another one in another engine. So it's there to represent a flocking situation relative to the airplane, not necessarily a flocking situation relative to any individual engine.

MR. DeLISI: Okay.

MR. BOUTHILLIER: So, again, there's run on requirement for that new standard, and that's under the assumption that there's going to be multiple engines on the airplane affected.

MR. DeLISI: Well, thank you. And then the other half of that dichotomy to me is the large single bird test standards. We heard testimony from Dr. Dolbeer that large birds fly in flocks, dozens, hundreds, thousands. Certainly this event identified large birds flying in flocks, yet that standard is defined as a large single ~~birth~~bird. Why don't we acknowledge the flocking nature there?

MR. BOUTHILLIER: Well, the key is to look at the difference between the flocking standards and the single large bird and relative to the size of the engine that you might be interested in. The flocking bird standards will be smaller -- for a given engine, the flocking bird standards are smaller than the single large bird, and that gets back to the nature of what our data is telling us, so the types of birds, the sizes of birds that typical engine sizes generally ingest and the rates they do so. So a smaller engine that may only be required to ingest 1 1/2 pound birds is going to have a 4 pound single large bird standard which is quite a bit larger.

So you have to look at the two together but, yeah, we do understand that there are birds much greater in size than Canada geese, and they do flock but again to get back to the data and our safety objective, in trying to develop something that provides for a high level of safety but also standards that can be met.

MR. DeLISI: Thank you. And I'd like to just get the Panel's general thought on this idea. Certainly the testimony from this morning makes it clear that an encounter with a larger bird, greater than 4, 6, 8 pounds, we don't expect a turbine engine to be able to continue to operate.

So it would seem to me that an important take away from the Flight 1549 accident would be that we really need to stress the technology and the procedures to avoid encounters with flocks of large birds, and I wonder if you'd care to react to that.

MR. GANLEY: I think, as I had shown earlier in one of the slides, you know, it's obviously a very complex issue. I don't think any single element can address the threat. So I agree that I think that a concerted joint effort in trying to look at all aspects is needed to mitigate the threat. So I do agree.

MR. DeLISI: Great. Please.

MR. BOUTHILLIER: Just one other comment, too. Relative to the cert requirements, again we've established them for, you know, as a function of engine size, but I think as we seen in the accident engines here, that engines don't fall off the cliff when you go just a small amount above what the certification standard is.

There's a lot of margin built in overall to the cert process, to the engine design process, and even with the larger birds, the 8 pound birds that you mentioned, certainly with our large flocking bird standards, even those that are required, the largest bird there was 5 1/2 pounds. That's an average snow goose. That's another threat species. There will be capability beyond what the cert standards do require, and that was part of their evaluation. We understood that, you know, in designing the rule, and expectations that there will be.

But again, it gets down to the parameters around a given ingestion, the target location, the wheel speed, power setting, other factors. But we do believe that the capability is going to continue to improve, you know, into the future.

MR. DeLISI: Thank you. Yes, Mr. McVey?

MR. McVEY: One ~~of the~~ other comment~~s~~, just backing that up, I mean we do see ingestions in service with large birds, 4, 6, 8 and there's sometimes no effect on the engine. It's totally dependent on the ingestion condition. So it's not that there's no capability with a 4, 6 or 8, but it just depends how it's ingested.

MR. DeLISI: Thank you. And, Mr. Bouthillier, you reminded me of something that I had jotted down when Mr. Ganley was speaking. You talked about how there isn't really a cliff and I think you were mentioning at a 4 pound standard, if a bird was 4.1 pounds we might very well have an engine that could withstand that. You used the word withstand. I just wanted to be sure that we're clarified. By withstand, you don't mean continue to run and operate?

MR. BOUTHILLIER: Well, what I meant was it would still comply with whatever the standard was --

MR. DeLISI: Right.

MR. BOUTHILLIER: -- that was in question. So for safe shutdown, CFM, for example, its cert basis was 4 pounds. Under the current amendment, it would be 6. But at least one of these engines ingested two Canada geese at high power setting, in two different locations on the fan, and performed, you know, quite well relative to the safe shutdown standard. So this is a good example of where the engines that, you know, we certify and are being produced, don't fall off the cliff.

MR. DeLISI: Great. Thank you.

CHAIRMAN SUMWALT: Thank you, Mr. DeLisi.

Mr. Bouthillier, you had mentioned that multiengine, multi-ingestion power loss accidents, and I believe you, of course, referenced the U.S. Air 1549 accident and one in Africa which might have been Ethiopian Airlines.

MR. BOUTHILLIER: That is the Ethiopian event, yes.

CHAIRMAN SUMWALT: Yeah. And that was in --

MR. BOUTHILLIER: 1988.

CHAIRMAN SUMWALT: Okay. How about the -- and were you just referred to civilian airplanes?

MR. BOUTHILLIER: Yes, just civilian airplanes and western aircraft that we have ~~responsible~~ responsibility for and information about.

CHAIRMAN SUMWALT: Any other accidents in perhaps military fleets involving the CFM56 engine that you can recall?

MR. BOUTHILLIER: There was a major accident, Elmendorf, back in the nineties. I wasn't aware if it was a CFM powered airplane but, yeah, that was a large transport type aircraft.

CHAIRMAN SUMWALT: Okay.

MR. BOUTHILLIER: But those are snow geese I believe that they had a problem with.

CHAIRMAN SUMWALT: Yes. Okay. Twenty-four fatalities out of that one I believe, 19 -- I forget the year.

MR. BOUTHILLIER: It was probably around '96 or '98, in that time period.

CHAIRMAN SUMWALT: Thank you. But the point is, is that that was a bird ingestion, transport category airplane. In fact, that airplane, the ~~AC135~~ KC135 would be the same as a Boeing 707 which is not in use anymore but nevertheless it is a transport category airplane I would assume. Is that correct?

MR. BOUTHILLIER: Yeah, they're a large transport category aircraft.

CHAIRMAN SUMWALT: Right. Thank you. Yeah, a large transport category. Thank you.

Mr. Ganley, the bird population as we've heard, we've received testimony that the bird population is increasing, and we talk about the historical perspective of how these engines do. There have only been two accidents involving commercial transports in the last 21 years or so, but is using a historical perspective reasonable when we had a dual engine flameout in November of last year with Ryan Air and then three months later, two months later, we had the U.S. Airways accident.

So when we talk about a historical perspective, is that realistic when figuring our risk assessment with probability, things like that?

MR. GANLEY: I mean certainly the two events that you're noting there have given us pause that we need to go back and reevaluate the overall level of safety of the fleet, our safety objective. So, you know, I think we need to gather that data and analyze it and see what changes, if any, need to occur.

I mean, statistically speaking, it's pretty incredible that those, you know, two events happened, you know, in the timing that they did, but that's something we need to go back and evaluate. I don't think it would have been forecast.

In fact, it's my understanding even when the rule team did their work, they tried forecasting 10 years into the future which would have put us out until about 2010, and I'm not sure they would have anticipated these two events occurring, you know, at the timing that they did.

CHAIRMAN SUMWALT: Thank you. And I think it lends even more weight to what Mr. DeLisi posed just a few minutes ago, that it does, and you agreed to that, that it needs to be not a single bullet but a comprehensive systemwide approach to addressing this issue.

And so it's a complex -- it's an easy question to ask but I'm sure a very difficult one to answer. Are the current certification standards, are they adequate? Are they sufficient?

MR. BOUTHILLIER: We do think they are. We've had two recent rulemakings in 2000 and 2007. Those are based on bird threat studies that were conducted through the 1990s to the year 2000, and we attempted to address that changing threat with a very conservative safety objective for the rule, and as part of that, what we also did, we did predict out 10 years what we thought the bird ingestion rates would be, given the continuous increase in populations that we're seeing, especially in the larger flocking birds. So we made an attempt to try and, even though our data was to 2000, we made an attempt to try and get to 2010 at least with the bird ingestion rates, and the bird ingestion rate was a very important parameter in the rule design, how often things happen. So we did make an attempt to do that.

Also, too, you know, with new products coming on line, and the fact that a lot of engines that were certificated even in the mid nineties were anticipating the rule changes. So those engines were being designed with more in mind. So we think newer products are going to continue to perform even better in service, but again like Bob just said, that, you know, we've got some data points here that we need to deal with and understanding.

CHAIRMAN SUMWALT: Thank you. Mr. Ganley, your comments. The current certification standards, are they adequate?

MR. GANLEY: Yeah, I think until such time as we analyze and see if there is a need, I guess I would say they are satisfactory today until shown otherwise.

CHAIRMAN SUMWALT: Thank you. And, Mr. McVey, same question.

MR. McVEY: Yeah, I have to agree. I think, you know, when you look at the data, we need to review it, but I think we're meeting the intent of the regulations at the moment.

CHAIRMAN SUMWALT: I had briefings from members of the -- the head of FAA certification a few weeks ago on engine certification standards and, you know, basically I walked out of that meeting or they walked out of that meeting with my thinking that really we can't do a whole lot more with engines.

We might be able to beef them up just a little bit more, but I mean we can't design and build aircraft engines that can fly on airplanes that can withstand a 20 pound bird or something like that. I suspect that's true, but I also believe that until you identify a need that something needs to be changed, you won't achieve it.

I look at, for example, crash survivability issues in automobiles. We've done a lot in that area over the years. Fuel economy in automobiles, we've done a lot over the years. You know, a few years ago, a car would get 16, 15 miles to a gallon. Now they're around 25 miles to a gallon, and the President has just announced ~~--~~ CAFE standards that says that the manufacturers have to come up with automobiles that have 35 mile an hour standards (sic).

So, you know, we can keep moving that bar, and so I just throw that out there, that maybe we can if we raise the bar and that will be perhaps something that the Board will look at, is are the current certification standards adequate and can they be reasonably raised, and that might be something that we would look at.

Mr. Ganley, I want to ask you, these high bypass turbofan engines are remarkable. They are very fuel efficient compared their predecessors. They are much quieter than their predecessors. But I started flying with a ~~JTAD~~ JT8D engine which was probably about this wide and it had inlet guide ~~veins~~vanes, fixed inlet guide ~~veins~~vanes, at the very front of the engine.

Now we look at these CFM engines which I could stand up in and the very front of the engine is the actual fan part, and that's the part that's moving. So there's nothing to deflect objects other than the centrifugal force of something actually hitting it.

Are we more susceptible to engine bird strikes with these larger engines? I mean you would stand to reason that since the diameter of them is much larger, you would think that that in itself would create issues. So tell me about that.

MR. GANLEY: I think, as Mr. Bouthillier had mentioned earlier, birds hitting the engine, it's a function of the frontal area or the exposed area the birds come in. So when you talk a CFM engine that's roughly about a 5-foot diameter, or some of the largest engines out there, 10-foot diameter, you would expect many more bird strikes on a huge 10-foot diameter engine.

You know, getting to your comment on, you know, inlet guide ~~veins~~vanes, certainly anything upstream of the fan blades that are rotating, that could conceivably minimize the impact of a bird coming in as a benefit, but as you said, you know, there's tradeoff and balances of weight, efficiency, SFC, emissions and other things.

So all those things need to be taken into account, and again, I think it just gets back into, you know, the exposed frontal area for which the birds are being projected to.

CHAIRMAN SUMWALT: Thank you very much. We're about to wrap it up, and as we do, I want to thank the Parties for your excellent questions and for your cooperation.

Captain Sicchio, I'd like to thank you and your colleagues at USAPA. Ms. Kolander, you and the Association of

Flight Attendants, thank you very much.

Now we address the FAA. Mr. Harris, as usual, thank you. Airbus, Captain Canto, thank you very much for your participation. Captain Morell, U.S. Airways, thank you. And CFM International, Mr. Mills, thank you and your team for being here.

So with the last witness having been heard, this concludes this phase of the Safety Board's investigation.

In closing, I want to emphasize that this investigation will remain open to receive at anytime new and pertinent information concerning the issues presented, and the Board may at its discretion, again reopen the hearing in order that such information may be part of the public record.

The record of the investigation including the transcript of the hearing and all exhibits entered into the record will become part of the Safety Board's public docket on this accident, and will be available from the Safety Board's Public Inquiries Office or the website. Anyone wanting to purchase the transcript including the parties to the investigation, may contact the Court Reporter directly.

So there's the inevitable question. When will this investigation be completed. Well, there's still a lot of work to be done, a lot more work to be done before the staff will be able to present a report to the Board. Again, we're still in the fact finding stage at this point, and this hearing is a very important part of that fact finding process. But I assure you that we will conclude the investigation as soon as possible.

So I do want to thank again all of the parties for their cooperation, not only during the proceeding, not only during this hearing, but throughout the entire investigation.

I want to express my sincere appreciation to all of those groups, persons, corporations and agencies who have provided their talent so willingly during this hearing. I thank the audience and the media for being here to show your interest and to help get the word out as to what's being done to improve safety in this country.

There are a lot of people who work behind the scenes to make these things happen, and people that never get seen or recognized. Rochelle, Eunice, Fernando, up in the audio booth, providing tech support and audio, we've got Greg and Brian and Antoine. We walk by these security guards every day. We probably wonder why we have to put our keys and our Blackberry on the belt and all, and then we learn of a tragedy such as occurred yesterday, just a few blocks from here, it all sort of brings it back home. Those people are here to protect us, and I appreciate what they do.

And finally, I want to thank my special assistant, Heather, who will leave this job next week for a much more important job, go take care of her child, and I appreciate very much the fact that she was willing to stay on for an extra couple weeks to help me get through this hearing.

I now declare this hearing to be in recess indefinitely. Thank you very much.

(Whereupon, at 10:30 a.m., the hearing was adjourned.)

CERTIFICATE

This is to certify that the attached proceeding before the

NATIONAL TRANSPORTATION SAFETY BOARD

IN THE MATTER OF: PUBLIC HEARING IN THE MATTER OF THE LANDING OF US AIRWAYS FLIGHT 1549, N106US, IN THE HUDSON RIVER, WEEHAWKEN, NEW JERSEY, JANUARY 15, 2009

DOCKET NUMBER: SA-532

PLACE: Washington, D.C.

DATE: June 11, 2009

was held according to the record, and that this is the original, complete, true and accurate transcript which has been compared to the recording accomplished at the hearing.

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Timothy J. Atkinson, Jr.
Official Reporter