Docket No. SA-533

Exhibit No. 7-A

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

AIRWORTHINESS GROUP CHAIRMAN'S FACTUAL REPORT

by

Kristi Dunks

(52 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Western Pacific Region
Seattle, WA 98188

August 6, 2009

AIRWORTHINESS GROUP CHAIRMAN'S REPORT

CEN09MA142

A. ACCIDENT

Operator:	Empire Airlines, Inc.
Location:	Lubbock, TX
Date:	January 27, 2009
Time:	0437 central standard time
Aircraft:	N902FX, ATR-42-320

B. AIRWORTHINESS GROUP

Chairman:	Kristi Dunks National Transportation Safety Board Seattle, WA
Member:	Daniel Baker National Transportation Safety Board Denver, CO
Member:	Daniel J. Vengen Federal Aviation Administration Lubbock, TX
Member:	Guilhem Nicolas BEA Le Bourget Cedex, France
Member:	Vincent Ecalle BEA Le Bourget Cedex, France

Member:	Tom Strom Empire Airlines, Director of Maintenance Hayden, ID
Member:	John Melnick ATR, Director of Technical Support Dulles, VA
Member:	Didier Cailhol ATR Blagnac Cedex, France
Member:	Marion Choudet ATR Blagnac Cedex, France
Member:	Christian Freixinos ATR Blagnac Cedex, France
Member:	Hugo Whitten FedEx Memphis, TN
Member:	Carl W. Mason Pratt and Whitney Canada Little Elm, Texas

C. SUMMARY

On January 27, 2009, at approximately 0437 central standard time (CST), N902FX, an Aerospatiale Alenia ATR-42-320, operating as Empire flight 8284, sustained substantial damage when it collided with terrain short of the runway while executing the Instrument Landing System (ILS) RWY 17R approach at Lubbock Preston Smith International Airport (LBB), Lubbock, Texas. The airplane was registered to Federal Express Corporation, Memphis, Tennessee, and operated by Empire Airlines, Hayden, Idaho. The airline transport pilot rated captain was seriously injured and the commercial rated first officer sustained minor injuries. An instrument flight rules flight plan was filed for the flight that departed Fort Worth Alliance Airport (AFW), Fort Worth, Texas, at approximately 0312 CST. Instrument meteorological conditions prevailed for the supplemental cargo flight operated under 14 Code of Federal Regulations Part 121.

D. DETAILS OF THE INVESTIGATION

The airworthiness group convened on January 28, 2009. The first meeting occurred at the accident site where initial examinations and documentation of the wreckage commenced. At that time, a Federal Aviation Administration inspector retrieved all maintenance records from the operator's facility in Hayden, Idaho, and took them to the Federal Aviation Administration Flight Standards District Office in Spokane, Washington. The on-scene portion of the investigation ended on February 1.

The Airworthiness Group Chairman and members from ATR and Empire Airlines met at the Spokane Flight Standards District Office during the weeks of February 10 and February 23 to review the maintenance records and maintenance requirements as outlined by the Federal Aviation Administration. The group also visited the headquarters of Empire Airlines at their facility in Hayden, Idaho. The Airworthiness Group also visited ATR's facilities in Toulouse, France, as well as the flap actuator manufacturer, Ratier-Figeac, facility in Figeac, France. Follow up examinations of the wreckage also commenced.

The Airworthiness Report consists of the following:

Section 1. Aircraft History and Maintenance
Section 2. Overview of Empire Airlines and FAA Oversight
Section 3. Structural Documentation (Including Powerplants)
Section 4. Systems

Section 1. Aircraft History and Maintenance

1.0 Airplane Information

The Aerospatiale Alenia ATR-42-320 airplane (SN 175) conducted its first flight on January 15, 1990. The airplane was powered by two Pratt and Whitney PW121 engines that were equipped with Hamilton Standard 14SF propellers. The total time on the airframe at the time of the accident was 28,768.0 hours and 32,379.0 cycles. The number 1 engine (SN 120623) was equipped with propeller (SN 891122), and had a total time of 27,121.1 hours and 30,081 cycles. The number 2 engine (SN 121043) was equipped with propeller (SN 891124), and had a total time of 19,846.3 hours and 20,153 cycles.

2.0 Aircraft Records Review

The Airworthiness Group Chairman, a Safety Board air safety investigator, and representatives from ATR and Empire Airlines reviewed the maintenance records. The Spokane Federal Aviation Administration Flight Standards District Office (FSDO) obtained the maintenance records following the accident, and the records were reviewed at the FSDO from February 10-11, 2009. The Airworthiness Group Chairman and representatives from ATR and Empire Airlines visited the Empire Airlines facility in Hayden, Idaho, on February 12.

The airplane was originally owned by Continental Express. On September 10, 2002, the airplane was put into storage in Roswell, New Mexico. On February 14, 2003, the airplane was ferried and prepped for the sale, which occurred on February 19, 2003. The airplane entered revenue service with Empire Airlines on July 11, 2005.

2.1 Previous Accident Data

FAA Aircraft Registry records show that the airplane was originally registered as N15827. The N-number was changed to N902FX on March 24, 2003. While registered as N15827, the airplane was involved in an accident which resulted from a right engine fire. According to the accident report[1], the damage[2] included, "… fire damage to the right engine cowling, and to the right trailing edge wing and wing flap. The wing flaps were set at 30 degrees. Several wires along the aft spar were burned, and examination of the rear spar revealed it had been warped about 1/8 inch."

2.2 Maintenance History

The last major inspections included a 12-year that was completed on June 5, 2007, as well as 2-year and 8-year inspections, which were completed on June 11, 2007. A summary of the inspections and their completion dates follows on Table 1. The last inspection was a 2-month inspection that was completed on January 9, 2009, and 28.6

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[1] NTSB Accident Report NYC98FA062

[2] The repair documentation is located in the Section 1 attachments for this report.

hours had accrued since that inspection. At the time of the accident, there were no deferred maintenance items on the airplane. Empire Airlines had operated the airplane for 1,744.0 hours prior to the accident.

Table 1. Inspection Dates[3]

Inspection	Date Completed	Hours Since	Cycles	Landings	Due
1 YE	11/03/08	104.5	137	137	11/30/09
12 YE	6/5/07	818.6	909	909	6/30/2019
1A	4/19/08	354.2	430	430	28913.8 hours
1C	4/20/05	1743.8	1834	1834	31024.2 hours
2 MO	1/09/09	28.6	34	34	3/31/09
2 YE	06/11/07	818.6	909	909	6/30/2009
2A	7/13/07	772.3	856	856	28995.7 hours
2C	4/20/05	1743.8	1835	1835	35024.2 hours
3 MO	11/7/08	99.3	128	128	2/28/09
3000FC	6/7/05	1738.6	1834	1834	33545 landings
4 YE	6/11/07	818.6	909	909	6/30/11
400FH	6/16/08	274.5	340	340	28893.5 hours
4A	1/12/05	1744	1836	1836	29024 hours
4C	1/12/05	1744	1836	1836	43024 hours
6 MO	11/3/08	104.5	137	137	5/31/09
8 YE	6/11/07	818.6	909	909	6/30/2015
9 MO	7/15/08	243.8	302	302	4/30/09
6533FC	4/11/05	1743.8	1835	1835	37077 landings
7850FC	3/29/05	1430.7	1622	1622	38607 landings
7867FC	8/30/04	1744	1836	1836	38410 landings

2.3 Airworthiness Directives

The Director of Safety at Empire Airlines reviews all airworthiness directives (ADs) from the FAA's website. If a new AD is issued, the information is forwarded to a 4-member internal committee within Empire Airlines that reviews the requirements of the AD and checks the applicability to the fleet. The compliance process is then defined, an engineering order (EO) is created, and the maintenance action scheduled. Once the action is completed, the AD is signed off and entered into a binder. If the AD is recurring, this is entered into "EARL" for continual monitoring and appears on the work planning worksheet. At the time of the accident, Empire Airlines was in the process of creating an AD electronic compliance record.

The airframe ADs were located throughout the airplane’s records. The right engine ADs were listed on an AD tracking form and located with the right engine logbooks. The left engine AD tracking form was not located in the airplane’s records. The records clerk from Empire Airlines reviewed the paperwork and recreated the AD compliance through

[3] All inspection dates were obtained from Empire Airlines computerized maintenance tracking system "EARL." The system "EARL" is an Airline Information Management System developed by Empire Airlines to track maintenance items and was accepted in their FAA Operations Specifications.

work orders and required directives equivalent to the FAA-issued ADs from other countries.[4]

Hamilton Standard calls out individual applicable ADs to sub-assemblies that make up a propeller assembly. Because the maintenance items are tracked through the subassemblies, there are no applicable ADs to the propeller as a whole, only to the subassemblies. Each subassembly AD is tracked through "EARL" and scheduled according to the AD requirement

2.4 Service Bulletins

According to the Operations Specifications for Empire Airlines, they are not required to comply with service bulletins.[5] A review of service bulletins related to airframe flaps, hydraulics, and wings showed that service bulletins SB ATR42-57-0038, SB ATR42-57-0040, and SB ATR42-57-0043 relating to the deicing system on the airplane had been complied with by the previous operator. SB ATRR42-29-00-0009 involving the fittings in the landing gear was complied with by the previous owner.

2.5 Cargo Conversion

The airplane had been modified from a passenger airplane to a full cargo conversion per Worldwide Aircraft Services Inc. supplemental type certificate (STC) ST01189W1[6], and the installation was approved on June 7, 2005.

2.6 Electronic Locator Transmitter

The ELT (SN 1152682-00472) was installed on March 7, 2005. The last check on the ELT was accomplished during the 12-month check on November 4, 2008, at a total airframe time of 28,665.2. The ELT battery expiration date was September 2009.

2.7 Flap History

The electronic maintenance system was queried for all records related to ATA Code 27, Flight Controls, from February 1, 2003 to the present. The results of this query are included in the attachments. On June 25, 2005, it was noted that the right outboard wing flap cam guide pin had a small area of surface corrosion and the corrosion was removed (WO 51999). On June 4, 2007, the flap actuator attachment hardware inspection was completed in accordance with FCD27-05 (WO 67426). On October 31, 2007, during taxi, the takeoff configuration test found that the flaps were not extended. Deicing fluid was

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[4] A representative with Empire Airlines felt that the left engine AD tracking form must have been misplaced during a records review that commenced prior to the accident. Follow up searches for the documents were not successful.

[5] According to FedEx, they specify which service bulletins are completed.

[6] The STC is now owned by M7 Aerospace LP.

cleaned from the cannon plug[7] and the operations check showed that the system functioned normally (WO49940). Additional reports are included in the attachment.

Review of the delivery documentation and the previous owner's maintenance records showed that in February of 2003, flap actuator (PN FE-179-004) serial numbers 663, 317, 691, and 314 were installed in the airplane. Based on information from the flap actuator data plates and delivery documentation from the previous operator to Empire Airlines, the following information was obtained (see Table 2). The flap actuator manufacturer's records showed that the left inboard and right outboard actuator had been recertified at the manufacturer's facility in October of 2000.

Table 2. Flap Actuator History[8]

	Serial Number	Installation Date	Replaced Actuator	Time
Left Outboard	663	At manufacture	N/A	27,016.7
Left Inboard	317	02/17/01	666	3,012.4
Right Inboard	691	At manufacture	N/A	27,016.7
Right Outboard	314	02/19/01	717	3,012.4

2.8 Hydraulic System

The electronic maintenance system was queried for all records related to ATA Code 29, Hydraulic Power System, from February 1, 2003, to the present. The last servicing of the main hydraulic reservoir with hydraulic fluid was on April 17, 2008. Additional results from the query are included in this documentation in the attachments.

2.9 Weight and Balance Summary

No anomalies with the accident airplane's calculated weight and balance were discovered.

Table 3. Manufacturer's Published Airplane Weight Limitations

	WEIGHT (Pounds)
Taxi Weight	37,633
Takeoff Weight	37,258
Landing Weight	36,155
Zero Fuel Weight	34,259

[7] The location of the cannon plug was not entered into the discrepancy.
[8] According to ATR, there are no time limitations on the flap actuators and they are an on-condition component. The times noted are the time of the flap actuators when they were installed on the airplane.

Table 4. Weights as Entered on the Load Manifest

	WEIGHT (Pounds)
Zero Fuel Weight	30,187
Fuel Weight	4,500
Taxi Weight	34,687
Taxi Fuel Burn	200
Takeoff Weight	34,487
Fuel Burn (To Accident Site)	1,770
Estimated Landing Weight	32,717

Section 2. Overview of Empire Airlines and FAA Oversight

1.0 Overview of Empire Airlines Maintenance

Empire Airlines is based in Hayden, Idaho, and is approved for cargo operations under 14 CFR Part 135 and 121. At the time of the accident, the fleet of aircraft consisted of 10 ATR-42 airplanes, 3 ATR-72 airplanes, and 35 Cessna 208 (Caravan) airplanes. Empire Airlines has sixteen bases of operation. Fourteen of these locations conduct 14 CFR Part 121 operations.

The operator employs between 34 to 40 mechanics, with approximately 2 to 3 mechanics at each base of operation. All maintenance information is called into the headquarters office in Hayden, Idaho, where all of the maintenance records are maintained electronically. Paper copies of the work are logged at the base facilities. Maintenance personnel based in Midland completed routine maintenance items. Maintenance personnel located in Hayden completed additional maintenance, including the heavy checks.

The maintenance program is conducted through a Continuous Airworthiness Maintenance Program (CAMP) which follows the manufacturer's maintenance guidance and check requirements. Empire Maintenance Repair and Overhaul (MRO) is also based in Hayden, Idaho, and accomplishes all of the heavy checks on the airplanes.

2.0 Federal Aviation Administration Oversight

Empire Airlines operates under both 14 CFR Parts 135 and 121. Because of this, FAA oversight is conducted under the two separate systems that consist of the National Flight Standards Work Program Guidelines (NPG) and the Air Transportation Oversight System (ATOS).

2.1 National Flight Standards Work Program Guidelines (NPG)

The FAA's Directors, Flight Standard's Service (AFS-1) has responsibility for administering the national surveillance programs and for developing the guidelines for inspectors to use, as published in the NPG, FAA Order 1800.56J[9]. Regional flight standards offices have primary responsibility for implementation of the national surveillance programs at the local Flight Standards District Offices (FSDO).

According to NPG 1800.56, to ensure that the FAA fulfills its statutory and regulatory requirements, four major safety areas have been identified as critical to ensure an overall level of safety within the aviation system. The four identified areas, listed in order of FAA priority, are surveillance, investigation, certification, and aviation education. The

[9] FAA Order 1800.56J, National Flight Standards Work Program Guidelines was effective on September 26, 2008.

NPG also indicated that, "surveillance is one of the most important functions performed by AFS field office personnel to ensure safety and regulatory compliance in the aviation system."

The AFS work program consists of required surveillance work activities, but classified the items as R-items and P-items. According to the NPG, the R-items "comprise the mandatory core inspection program that is based on critical oversight issues, which have been identified at a national level. The required inspection program provides an essential level of surveillance activity for certificate holders." The P-items "provide comprehensive targeted inspections that meet special surveillance requirements for each certificate holder operating within a field office's geographic district." The P-items ideally would provide "special emphasis inspection areas" that should be developed from safety trends affecting aviation safety.

2.2 Air Transportation Oversight System (ATOS) [10]

All surveillance requirements for 14 CFR Part 121 operators are developed under FAA Order 8900.1, Volume 10, Air Transportation Oversight System (ATOS). According to the FAA, the "ATOS implements FAA policy by providing safety controls (i.e., regulations and their application) of business organizations and individuals that fall under FAA regulations. Three major functions further define the oversight system: design assessment, performance assessment, and risk management.

- Design assessment is the ATOS function that ensures an air carrier's operating systems comply with regulations and safety standards.
- Performance assessments confirm that an air carrier's operating systems produce intended results, including mitigation or control of hazards and associated risks.
- Risk management process identifies and controls hazards and manages FAA resources according to risk-based priorities.

ATOS has three primary functions: verification, validation, and risk management. Verification processes (e.g., initial certification and program approvals/acceptance) ensure that an air carrier meets regulatory requirements and safety standards. Validation processes (e.g., performance assessments) ensure that air carrier operating systems perform as intended by the regulations. Risk management processes deal with hazards and associated risks that are subject to regulatory control (e.g., enforcement, certificate amendment, rulemaking) and are used to target FAA resources in accordance with risk-based priorities. System safety is the underlying philosophy of ATOS and postulates that safety is an outcome of a properly designed system. ATOS accomplishes its verification, validation, and risk management activities by using tools that are structured in accordance with safety attributes derived from system engineering and quality concepts. These tools focus ATOS oversight on an air carrier's organization, particularly on the design and performance of processes that an air carrier employs to conduct its business, and on the impact of the operating environment. Safety is an outcome of an air carrier's

[10] FAA 8900.1 CHG 0, effective September 13, 2007.

management of its safety-critical processes. Air carriers, not the FAA, are responsible for safety management, quality assurance, and quality control. While ATOS must enable safety inspectors to make independent judgments, the system is also designed to support data sharing, collaboration, open communication, and voluntary programs such as internal evaluation and aviation safety action programs. Efficient use of resources is accomplished through risk targeting and clearly defined safety priorities.

Safety is not defined in statutory law (i.e., 49 U.S.C. section 44702) or in administrative law (i.e., 14 CFR). The dictionary defines safety as, “freedom from danger, risk, or injury.” MIL-STD-882D, often used as a source of fundamental system safety information, defines safety in similar terms: “freedom from those conditions that can cause death, injury, damage to or loss of equipment or property, or damage to the environment.” Similarly, dictionaries define “risk” essentially as the converse of safety—“[risk is] the possibility of suffering harm or loss.” The U.S. Supreme Court, in a 1980 ruling involving occupational safety, stated that, “safe is not the equivalent of risk free.” The court concluded, “Congress [in the case of the Occupational Safety and Health Act] was concerned, not with absolute safety, but with the elimination of significant harm.” In this context, safety is equivalent to minimizing risk. It is reasonable to assume that the authors of 49 U.S.C. section 44702 had similar reasoning in mind when they delineated the duty of an air carrier to “provide service with the highest possible degree of safety.” For this reason, the concept of risk provides a means to measure safety management efforts. Risk is an expression of the relative severity of hazard-related consequences and their likelihood of occurrence. Consequently, success in safety management and the “level of safety” achieved are measurable in terms of how well factors that influence the severity or likelihood of injurious or loss-producing events are eliminated or controlled."

Two inspection processes are used: safety attribute inspections (SAI) and element performance inspections (EPI). SAIs fall under the design assessment and EPIs fall under the performance assessment. If additional inspections are necessary, inspectors can create a dynamic observation report (DOR) which is sent to the principal inspector to review. If further action is necessary, a constructed dynamic observation report (CONDOR) is created. The program can be modified based on the oversight needs. All SAIs are completed over a period of five years and all EPIs are conducted based on the criticality of the element based on low (3 years), medium (annual), and high (6 months).

3.0 Federal Aviation Administration Inspector Interviews

3.1 Principal Maintenance Inspector

The principal maintenance inspector (PMI) has been employed by the FAA for 29 years and two months. His initial employment with the FAA was as an aircraft mechanic with the FAA Flight Inspection Department Overhaul and Modification section in Oklahoma City, Oklahoma, for 7 years. He then transferred to the FAA's line maintenance facility in Sacramento for 10 years, 3.5 years which were served as a Quality Assurance Specialist.

In 1996, he joined the Spokane Flight Standards District Office (FSDO) as a general aviation airworthiness inspector and became the PMI for Empire Airlines in 2000.

The PMI completed ATR-specific training at Flight Safety on October 24, 2003, and Pratt and Whitney engine specific training on July 22, 2004. Empire Airlines is the only company he oversees. As the PMI for Empire Airlines, his work program has been managed through ATOS beginning in October of 2006. The PMI is required to collect and evaluate data to identify areas of high safety risk. At the end of the quarter, the PMI analyzes the results in order to develop a surveillance plan. Risk analysis is performed through system safety data collection that is set up based on criticality and levels of priority at specific intervals. This allows for flexibility if other areas require focus. The surveillance includes system attribute inspections (SAI) which involves reviewing the operator's process and procedures, as well as enhanced performance inspections (EPI), which determine if the operator is performing according to those processes. Because Empire Airlines also has 14 CFR Part 135 operations, the Program Tracking and Reporting System (PTRS) is used for that portion of their operation.

The PMI feels that the operator is very cooperative and that they have a mutual respect for each other. He has a good working relationship with the company. The PMI indicated that Empire Airlines was consistent about submitting self-disclosures, and he was aware but not involved in any current enforcement actions. The PMI indicated that Empire Airlines was very responsive to problems that were identified. He would normally send a letter and Empire Airlines would respond promptly, with the problem normally corrected by the end of the quarter.

Through ATOS, the PMI visits Empire Airlines approximately 20 percent less than under the PTRS system. In his opinion, through the ATOS process, he is able to develop the in-depth inspection required and ATOS has the references readily available. He also feels that the SAI covers every regulatory item for the inspections. The ATOS does have issues, but they are being worked out in a timely manner.

3.2 Assistant Principal Maintenance Inspector

The assistant principal maintenance inspector (PMI) has been employed by the FAA since 1990. He began employment with the FAA at the Detroit Flight Standards District Office (FSDO) as a General Aviation Maintenance Inspector. In 1991, he was assigned duties with Airborne Express and Kalita. After spending 3.5 years in Detroit, he went to the London International Field Office, and conducted certification and surveillance of foreign repair stations; one was British Airways for 3.5 years. He then came to Spokane where he had general aviation responsibilities. For a period, he served as the Unit Supervisor/Assistant Manager at the Juneau FSDO and then returned to Spokane in 2001 for personal reasons, and he downgraded back to an inspector position. In 2002, he was assigned as the assistant PMI to Empire Airlines and the Principle Maintenance Inspector to the Maintenance Repair and Overhaul (MRO). He was recently hired by FAA, AFS-

900 Certification and Surveillance, and will be working remotely out of the Spokane FSDO.

The Assistant PMI received ATR-specific training at Flight Safety as well as attended familiarization courses at the operator. As the Assistant PMI for Empire Airlines, his work program has been managed through ATOS beginning in October of 2006. The Assistant PMI feels that the ATOS program is good, and inspectors are able to provide adequate oversight on their operators.

The PMI feels that the operator is very cooperative and that Empire Airlines does not hide things or conduct business outside of the scope of the regulatory requirements. Empire Airlines and Empire MRO are sister companies. His relationship with the MRO is similar to Empire Airlines. The Assistant PMI indicated that Empire Airlines was consistent about submitting self-disclosures.

Recently, an audit was conducted on the MRO, which involved five FSDO inspectors unrelated to the MRO. The inspectors were given assignments and found the following problems: missing sign-offs at the turnover station, eyewash station not located at appropriate place, and unserviceable parts were identified in the parts room. The MRO has recently grown from 20-30 mechanics to 80-90 mechanics.

3.3 Principal Avionics Inspector

The principal avionics inspector (PAI) has been employed by the FAA since 2002. He began with the Las Vegas, Nevada, Flight Standards District Office as an avionics inspector, and then moved to Spokane, Washington, in 2007 as a geographic maintenance inspector. On March 2, 2008, he took over the duties of PAI for Empire Airlines.

The PAI serves as the PAI for Empire Airlines as well as the repair station. He received formal ATR training at Flight Safety about 6 months ago. In addition to his work with Empire, he also oversees a small 14 CFR Part 91 operator. In order to perform his job functions, the PAI uses the ATOS business model for Empire Airlines and the Maintenance Repair and Overhaul (MRO) falls under the Program Tracking and Reporting System (PTRS). Recently because the MRO had grown so much, the FAA felt that it would be worthwhile to have a second set of eyes to look at the operator. The inspection did not reveal any regulatory issues, although some best practices issues were identified. The issues were conveyed in a letter, and the operator has corrected some issues and is actively working on the others.

The PAI feels that the ATOS program provides him the tools to do his work properly. The work program is more adaptable to operators and provides more flexibility in the oversight program. The PAI indicated that the ATOS process works if it is used appropriately.

The PAI indicated that Empire Airlines and the FAA have a good relationship. Empire Airlines is very compliant with the problems identified.

Section 3. Structural Documentation

1.0 Accident Site Documentation

The airplane impacted flat, grassy terrain 300 feet north of the overrun on the approach end of Runway 17R, on airport property. Ground scars ran mostly continuous for 2,514 feet south of the initial impact point to the main airplane wreckage. Small pieces of debris and two sections of the right main landing gear door were located between the initial impact point and the runway overrun. Small debris, three propeller blades, and sections of the right main landing gear were located on, or to the east side of the runway, between the north edge of the overrun and the main wreckage. Between the initial impact point and the runway threshold, the approach light system had sustained damage and portions were located within the debris field.

The initial impact point was characterized by two ground scars consistent with touchdown of the right main landing gear. It was located 17 feet east of the extended runway centerline, midway between the last and second to last series of the approach lighting system. The two scars ran parallel to each other on a 170 degree magnetic heading, measuring 16 inches from center to center, 8 feet long, and about 0.5 inches deep.

The second impact point and its subsequent (main) ground scars began 8 feet south of the end point of the initial impact scars and were continuous for 279 feet to the north edge of the runway overrun, intersecting it 38 feet east of the runway centerline. The first 13 feet of the ground scar was characterized as a trench, beginning about 1 foot wide, deepening to about 1 foot deep and widening to about 2 feet. The remainder of this scar consisted of flattened grass and mild soil disruption to the edge of the runway overrun.

Photo 1. Aerial View of Accident Site

Two additional ground scars were located right of, and parallel to, the second impact point. The first scar was about 4 inches wide, 27 feet long, and was 22 feet and 7 inches west of the center of the main ground scar. The second scar was about 4 inches wide, 24 feet 9 inches long, and 27 feet 11 inches west of the center of the main scar (5 feet 4 inches separated the two scars).

A series of 11 ground scars, consistent with propeller strikes, were located about 30 feet south and right of the initial impact point. The 11 ground scars were mostly perpendicular to the main ground scar and measured about 37 feet from the first to last scar. The following lengths were measured between each scar, beginning with the northern most scar:

1	32 inches
2	33 inches
3	31 inches
4	33 inches
5	31 inches
6	38 inches
7	43 inches
8	35 inches
9	45 inches
10	49 inches

The main ground scar continued south from the north edge of the runway overrun until the airplane exited the right (west) side of the runway. The ground scar on the runway consisted initially of a single mark approximately 3 feet wide. This mark angled west and became indistinguishable as it reached the runway centerline, about 300 feet from the runway overrun. This scar was distinguished by light scratches in the runway and was faint in nature.

A second mark began 258 feet from the north edge of the overrun and continued south until it exited the west side of the runway 834 feet from the north edge of the runway overrun. The second mark was 15 feet left (east) of the first mark and was about 3 feet wide. This marking mostly consisted of light scratches in the runway and was faint in nature. The second (left) ground scar continued south from the west edge of the runway 1,380 feet to the airplane wreckage. It diverged from the runway on an approximate 190-degree magnetic heading and increased in diverging angle until ending at the airplane wreckage.

At the point the airplane exited the runway, the ground scar consisted of two well-defined marks, parallel to each other, and about 15 feet apart. The right (western) mark was about 42 inches wide initially, and was defined by burnt grass and hydraulic fluid. It ended under the right wing tip. The left (eastern) mark was about 44 inches wide and was defined by pressed grass and lightly disturbed soil. This mark ended under the right side of the fuselage, under the trailing edge of the right wing root. The airplane came to a rest on a 252-degree magnetic heading. The tail of the airplane was 199 feet west of the runway centerline.

2.0 Structural Documentation

The wreckage was documented at the accident scene. The majority of the wreckage remained intact, although it had sustained impact and fire damage. Overall damage is outlined in Figures 1 and 2.

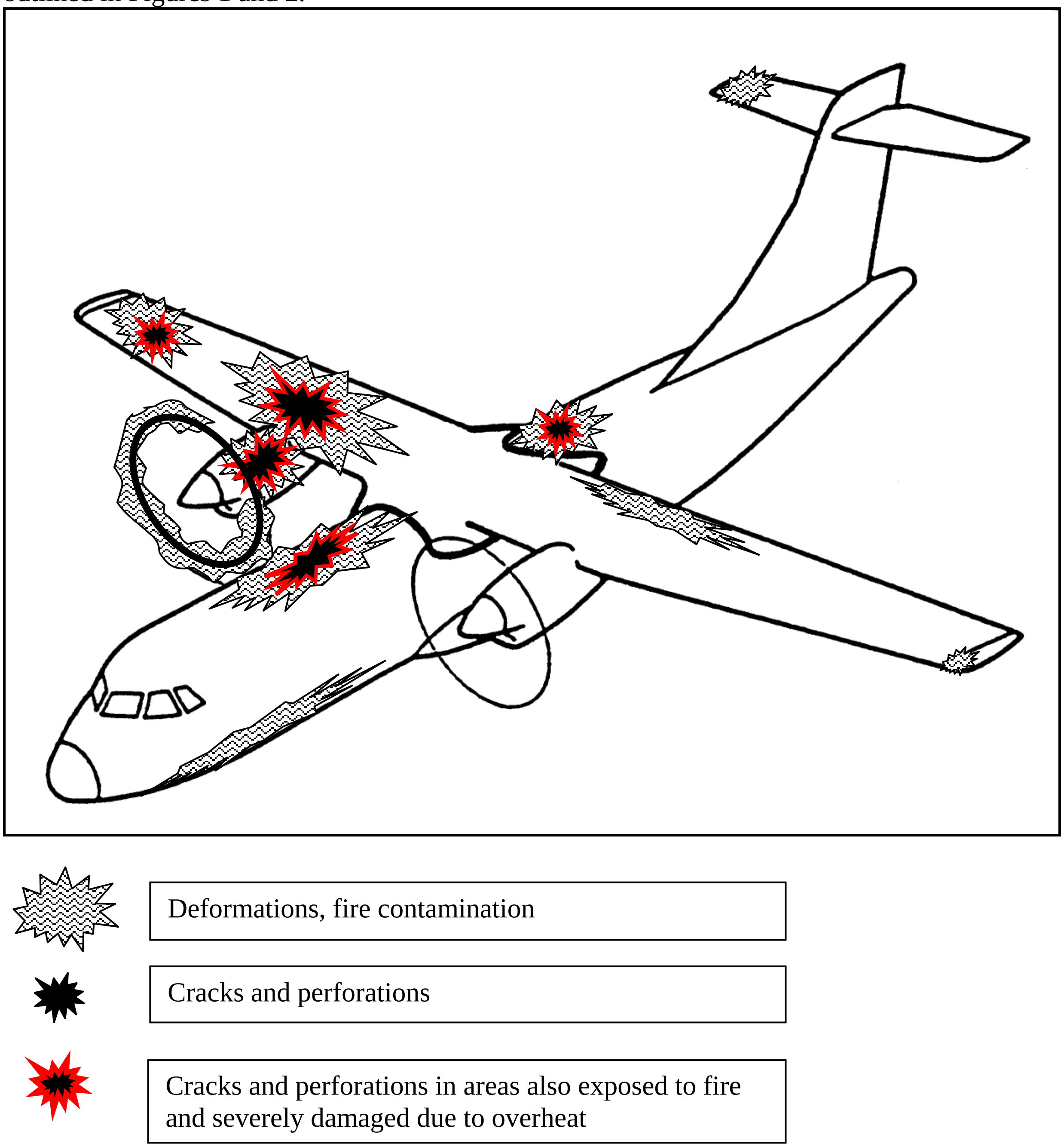

Figure 1. Damage Distribution Topside (Provided by ATR)

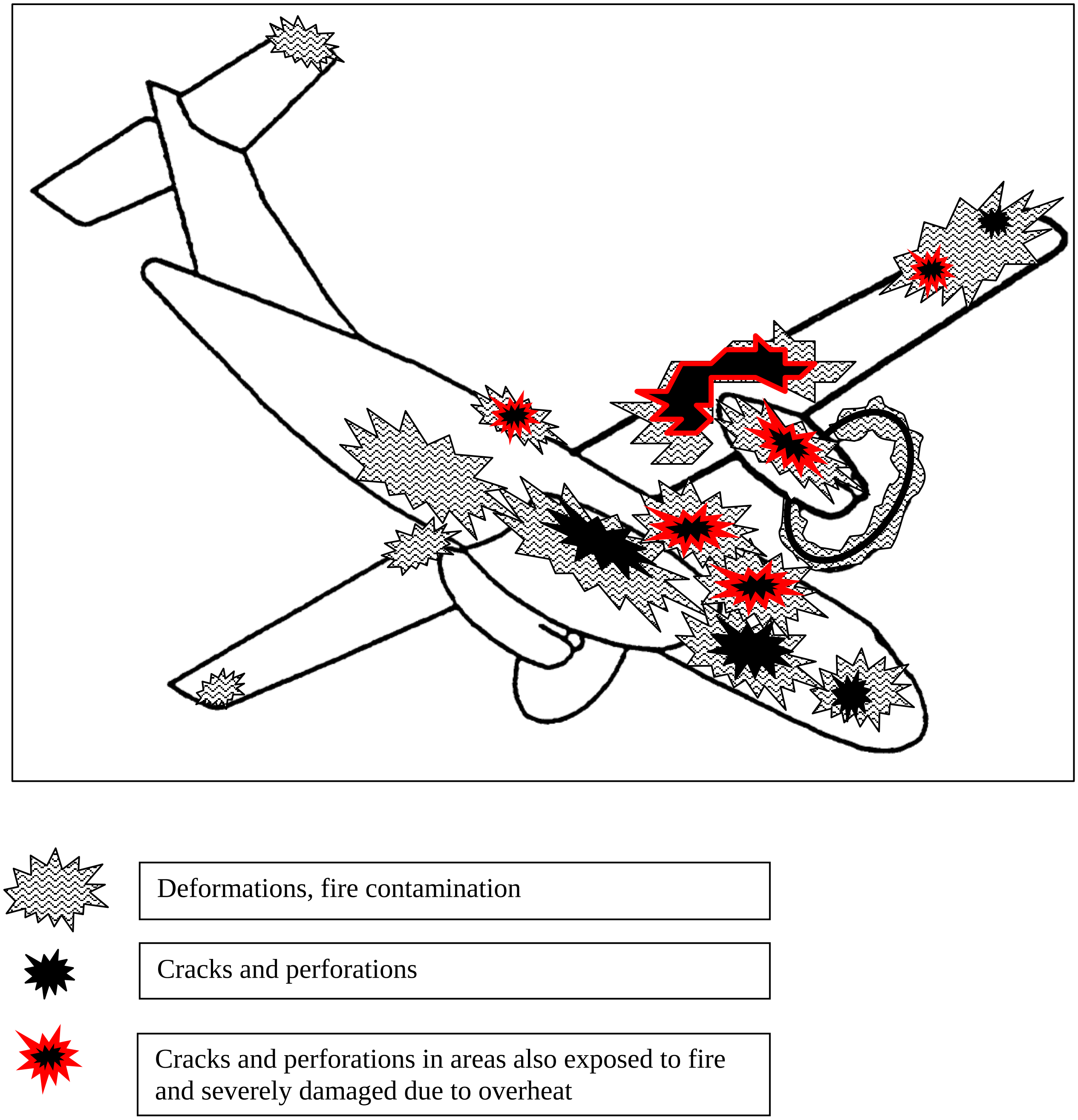

Figure 2. Damage Distribution Underside (Provided by ATR)

The airplane was resting on its fuselage nose section and leaning to the right, with the nose landing gear embedded in the belly of the forward fuselage section. The nose landing gear wheels and nose landing gear sliding leg were identified in the initial debris field at the runway threshold. The right main landing gear fitting, side brace fitting, strut fittings, and struts were identified in the initial debris field at the beginning of the runway. The left main landing gear remained attached to the fuselage.

Photo 2. Accident Site (Provided by FAA)

The center wing section remained attached to the fuselage. The eight attachment fittings and two shear web supports located on the fuselage side sustained sooting, but were otherwise undamaged. The four strut fittings as well as the four frame head attachments, shear webs, and upper torsion boxes on the fuselage side are not cracked or deformed, and the wing remained inline with the fuselage.

The lower forward fuselage was severely crushed from frame 1 aft to approximately frame 7 on the right side. From frame 7 to frame 21, it was crushed on both sides. There was evidence of scoring marks and skin buckling damage. The right lateral upper panels and crown panels between frames 16 and 25 and from the floor line on the right side to stringer 4 on the left side were entirely destroyed by fire. The cargo door on the left forward side of the fuselage and the surrounding frame and structure sustained minimal damage and the door functioned normally when operated. The six cockpit windows were intact and showed no evidence of damage other than the discoloration marks from the fire.

Photo 3. Left Side

Photo 4. Right Side

The belly fairing of the airplane is constructed of composite material/panels and metallic substructures. The forward portion of the right belly fairing suffered impact damage just forward of the ram air intake. A majority of the remaining right belly fairing both fore and aft of the right main landing gear attachment area was missing from the airplane, with several of the components including fairing panels and the right main landing gear door located at the runway threshold. The belly fairing and left main landing gear door remained intact and undamaged. The majority of the composite right belly fairing from frame 21 to frame 32 was destroyed by fire.

The lower surface of the aft fuselage between frame 32 and frame 39 and between the floor line on the right side to BL0 the airplane showed evidence of scraping, minor crush damage, and skin wrinkling. The scraping was along the longitudinal axis of the airplane. The upper fuselage section has been entirely destroyed by fire between frames 27 and 31 and from BL0 up to stringer 4 on the left side.

The heat exchanger from the right air conditioning pack separated from the fuselage and was found at the beginning of the runway. The heat exchanger from the left air conditioning pack remained attached to the fuselage.

The tail section from frame 39 on the lower aft fuselage showed evidence of dirt, sand, and grass intrusion in some areas. The rear door and surrounding frame structures sustained minimal damage; the left rear door was operated, and was in line with its housing. The tail cone and rear lens were found intact and undamaged. The aft fuselage just forward of the tail cone was slightly wrinkled around the circumference of the fuselage on the right side.

2.1 Left Wing

The left wing outer wing box remained undamaged other than paint discolorations and burn damage at the trailing edge panels/flaps between rib 13 and rib 23. The strobe light transparency sustained impact damage. The leading edge boots and ice detector system remained in relatively good condition.

The left center wing box was intact with no damage, except for sooting. The trailing edge panels from rib 4 to rib 23 were deformed and sustained fire damage.

The left flaps had been exposed to fire and the trailing edge panels were severely burnt and deformed with the composite fibers exposed. Both flaps were in the fully extended position and the hydraulic circuit had been opened in several areas. The connecting strut between the inboard and outboard flaps was structurally intact and connected to its respective attachment points. Both actuators were burnt, but remained attached to the wing. The inboard actuator was leaking.

The flaps remained attached to the wing, but the inboard flap separated from its inboard hinge. The inboard flap arm/beam connection failed at rib 4 and the flap beam was deformed and cracked. Visual inspection revealed no additional damage to the left flaps and after the torque tube and actuators were disconnected, both flaps were manually extended and retracted.

Photo 5. Left Wing

Photo 6. Left Wing Inboard

Photo 7. Left Outboard Flap Actuator

Photo 8. Left Inboard Flap Actuator

2.2 Right Wing

The right wing was fractured and partially destroyed due to fire. The right engine was resting on the ground. Half sections of the right hand inboard and outboard flaps were destroyed by fire. The left hand inboard flap inboard hinge and all right hand flap hinges were broken. The right hand outboard flap actuator was fully retracted while the three remaining actuators of the left hand and right hand flaps were found in the fully extended position.

The outboard half of the right aileron separated from the wing and found at the runway threshold, with the horn crushed. Examination of the remaining flight control surfaces and control mechanisms confirmed that they were intact and connected to their respective attachment points.

The right wing outer wing box was fractured at rib 15, and from rib 13 to rib 15 had been destroyed by fire. The right outboard wing section was also fractured and burnt between rib 23 and rib 24. The edge of the fuel tank is located at rib 22 and the fuel tank venting device is located between rib 22 and 23. The fracture occurred just after rib 23. Both sections of the outer wing box remained attached by the forward spar, internal wing structures, and the lower panel. The upper panel between rib 24 and rib 30 showed evidence of skin wrinkling. The leading edge section from rib 22 to the wing tip was undamaged. The flap hinge/beam underneath the wing at rib 21 and its fairings were still in position, but burnt, deformed, and cracked. On the lower portion of the right outboard wing, there was minimal scraping (fore and aft), and damage was localized to small areas. On the remaining sections of the leading edge, there was no evidence of direct frontal impact. The portions of leading edge boots that remained sustained fire damage.

The right center wing section and under wing box were destroyed by fire between rib 7 and rib 13. The engine mounts remained attached to the engine.

The right flap inboard section was hanging from the wing attached from its inboard hinge, but separated from its mid and outboard hinges. The outboard portion of the inboard flap was destroyed by fire. The actuator was hanging and still attached by the hydraulic lines to the rear spar. The actuator was fully extended and bent. The inboard and outboard flap arms at wing rib 13 and the interconnecting strut were not identified, other than small melted pieces.

The outboard flap half outboard section was resting on the ground and partially attached to the outer-wing box. The inboard section of the outboard flap was destroyed by fire. The outboard actuator remained attached to the wing rear spar by a fractured section of the beam as well as a fractured section of the flap arm. The outboard actuator of the outboard right flap was in a fully retracted position.

Photo 9. Right Wing

Photo 10. Right Wing Half Inboard Section of Inboard Flap

Photo 11. Right Outboard Portion of Outboard Flap

Photo 12. Wing Inboard Portion of Outboard Flap

Photo 13. Right Wing Inboard Flap Actuator

Photo 14. Right Wing Outboard Flap Actuator

2.3 Flap Interconnect

The flap interconnecting torque tube, electro-hydraulic flap valve, the flap position feedback unit, and the flap asymmetry detector sustained burn damage, but all remained structurally intact and connected to their respective attachment points with the exception of the torque tube rods, which were both broken.

Photo 15. Flap Interconnect Torque Tube

Photo 16. Flap Position Feedback Unit

Photo 17. Flap Asymmetry Detector

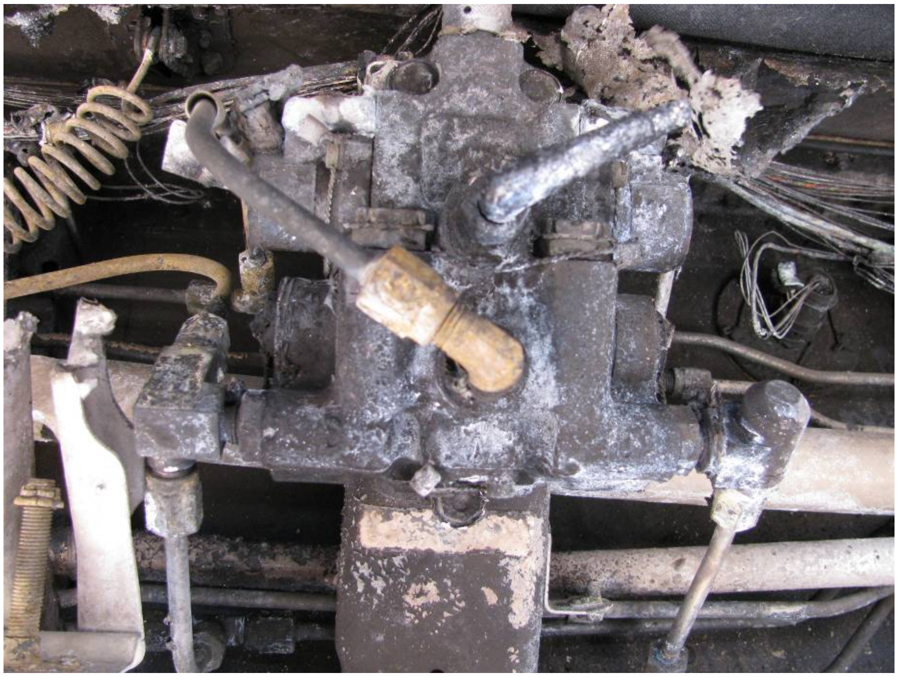

Photo 18. Flap Block Valve

2.4 Aileron and Spoiler Controls

The aileron and spoiler system components, located in the left and right wing and within the center wing box were visually examined and mechanically operated to verify position, proper attachment, and functionality.

The left aileron and its trim tab remained connected to the wing. The trim actuator was in place and remained attached to the aircraft structure. The left wing spoiler was found fully retracted. A visual examination of the spoiler actuator, input linkage, valve block, valve block input linkage, and feedback mechanics did not reveal any discrepancies.

Mechanical actuation revealed no continuity from the center wing box control quadrant via push-pull rods to the aileron. The most inboard push-pull rod was fractured at rib 3, and the third push-pull rod was also fractured at rib 10. The remaining of the outboard aileron push-pull rods were intact and mechanically connected and fully function to the aileron trim assembly. Movement of the push-pull rods resulted in the aileron being deflected up or down.

The right aileron outboard half was separated from the wing and found at the runway threshold. FAA inspectors that responded to the accident reported finding ice adhering to the underside of the control surface. The aileron horn leading edge was crushed. The aileron trim tab was still attached to the remaining section of the aileron attached to the wing. The outboard hinge was not on the aileron and found trapped into the wing rear spar. The aileron separated just after the mid hinge. On the inboard half section of the aileron, the mid hinge fitting was still in place. The inboard hinge fitting was broken at the rear spar. The tab control strut was broken on its forward section, but both parts of the strut remained attached to the tab and wing rear spar. The right spoiler and its mechanisms sustained extensive fire damage. The right aileron control rods and levers located between rib 5 and rib 23 are presumed to have been destroyed in the fire. Of the push-pull control rods, the second was fractured at rib 5.

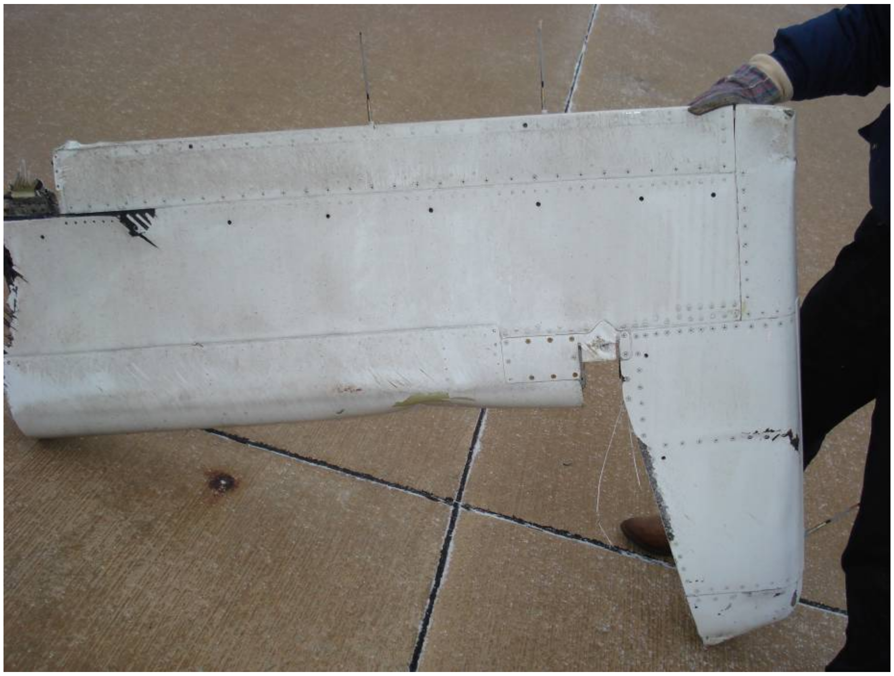

Photo 19. Outboard Right Aileron (Provided by FAA)

Photo 20. Ice on Underside of Right Aileron (Provided by FAA)

The aileron system components located in the center wing box sustained burn damage. The cable quadrants were burned, but structurally connected and both aileron flight control cables were attached. The autopilot roll actuator was found intact and still connected to the aileron cable quadrant.

The components located underneath the cockpit (cables, tension regulator cables, pulleys and inter-connect torque tube) were not examined. The control yokes rotated but were stuck toward the right side. The visible components underneath the cockpit floor were separated from their structural attachment points. The cable tension regulator housing was severely bent, but the cables remained connected to the cable tension regulator.

The aileron trim actuator was measured and 5.5 mm from its neutral position. According to the manufacturer, this setting corresponded to a left aileron tab 2 degrees downward.

2.5 Empennage

There was no evidence of damage to the empennage section of the aircraft, except paint discolorations and burn traces at the right horizontal stabilizer tip and the right elevator horn, which had been exposed to fire. The vertical and horizontal stabilizer remained attached to the airplane, and showed no evidence of impact damage. The entire assembly of the vertical and horizontal stabilizer appeared to be very slightly rotated right about the longitudinal axis of the airplane.

The elevator controls were examined and revealed that the left controls moved the elevator, but the right controls did not. The elevator cables remained routed through and contained with the pulleys and keepers. The elevator system components were visually examined and mechanically operated to verify proper attachment and functionality. Visual inspection revealed no evidence of damage to either the left or right elevator or their tab flight control surfaces. Both elevators and tabs were found intact, and they could be deflected up and down until their respective stops. The left and right elevator surfaces had freedom of movement. Rotation of the left elevator revealed that the pitch uncoupling mechanism, located in the top of the tail, was uncoupled.

The rudder components were visually examined and mechanically operated to verify proper attachment, position, and function. All components were found structurally intact and connected to their respective attachment points. The cable loop was loose, but remained connected, and none of the cables were found broken or separated. Visual inspections showed that there was no damage to the rudder and tab control surfaces. The rudder and spring tab were found intact. Basic checks confirmed that the right and left rudder pedals for the right and left seats could be operated with corresponding movement to the control surface.

Photo 21. Left Horizontal Stabilizer and Elevator

Photo 22. Right Horizontal Stabilizer and Elevator

2.6 Doors and Cockpit

The doors on the airplane were examined. The entry and cargo doors opened and closed using the inner and outer handles. The escape hatch door had been opened by the first officer during the accident, and was found loose within the recovered wreckage. The inner and outer handles worked when manually actuated, and no anomalies were noted with the hatch.

Photo 23. Escape Hatch

The cockpit sustained thermal damage and the surfaces were sooted. The readings are documented in the attachments for Section 3, item 3.2 Cockpit Documentation.

Photo 24. Cockpit

2.7 De-Icing Controllers

The magnetic indicator of the engine/airframe de-icing had triggered (amber color).[11] The magnetic indicator stays flagged as long as there is no reset. The controllers were then examined to verify which system items recorded a problem. The results were as follows[12]:

Controller # 1
- V1 (red) = Channel A of engine 1 wing de-icing boot failure
- V2 (red) = Channel B of engine 1 wing de-icing boot failure
- V3 (red) = Channel A of L/H wing boot failure
- V4 (red) = Channel A of R/H wing boot failure
- V5 (red) = Channel A of horizontal stabilizer boot failure
- Fault (red) = Controller failure

Controller # 2
- V1 (red) = Channel A of engine 2 de-icing boot failure
- V2 (red) = Channel B of engine 2 de-icing boot failure
- V3 (red) = Channel B of L/H wing boot failure
- V4 (red) = Channel B of R/H wing boot failure
- V5 (red) = Channel B of horizontal stabilizer boot failure

2.8 Powerplants

The Pratt and Whitney PW121 turboprop engine has two centrifugal impellers driven by independent axial turbines, a reverse flow annular combustion chamber, and a two-stage power turbine, which provides the drive for the reduction gearbox. The engine has two modules: a reduction gearbox and a turbomachinery module. The engine produces 2,150 shaft horsepower.

The number 1 engine, SN 120623, was visually examined from the ground. It remained attached to the left wing. The propeller rotated freely and minimal damage was noted to the propeller blades.

The number 2 engine, SN 121043, was examined. The right engine came to rest on its right side and sustained extensive thermal damage. All of the accessories remained attached to the engine. Extensive damage was noted to the hub assembly. One propeller blade remained attached and the other three blades were located in the debris field leading up to the main wreckage. The reduction gearbox remained attached to the inlet case; however, the rear inlet case had separated from the flange "C" low-pressure diffuser case. Blade damage was noted at the last stage of the power turbine.

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[11] According to ATR, this indication shows that a failure has been recorded but there is no means to determine when this failure occurred (during previous flights, during this flight, before or after the crash), as there is no time record. ATR indicated that due to the number of failures recorded and no corresponding warnings to the flight crew, the failure indication most likely occurred during the accident sequence.

[12] According to ATR, of the failures displayed, most would have triggered a warning inside of the cockpit to include a single chime, master caution light, and local warning.

Photo 25. Left Powerplant

Photo 26. Right Powerplant

2.9 Electronic Locator Transmitter

The airplane was equipped with a Honeywell electronic locator transmitter (ELT), part number 1152 682-1, and serial number 1152 682-00472. The ELT was mounted on the 12-oclock position between frames 32 and 33. The unit was in the "ARMED" position and did not activate during the accident sequence.[13]

2.10 Weights of Cargo and Fuel at Accident Site

Following the accident, the cargo was removed from the airplane and placed into containers. The cargo was weighed in the containers using an Avery Weight Tronics Model W1-125 scale, and these weights are depicted in Table 5. Approximately 300 pounds of fuel were drained from the left wing.

Table 5. Weights

Container Number	Zone	Tare	Actual
7873	3	301 (1770)	1469
13098	4	308 (2517)	2209
2631	5	300 (1870)	1570
6402	5	300 (1030)	730
3468	6	295 (2250)	1965
10493	7	296 (608)	304
A115	7	305 (600)	295

[13] The operation of the ELT is documented in the Survival Factors Group Chairman Report for this accident.

Section 4. Systems

1.0 Airframe Systems Operation[14] and Testing

1.1 Flap System Information

Lift augmenting for takeoff, approach and landing is performed by four trailing edge flaps, which rotate on hinges located below the wing. The flaps can be commanded in four stable positions :

- position 1 : flaps at 0° (cruise)

- position 2 : flaps at 15° (take off/approach)

- position 3 : flaps at 30° (landing)

- position 4 : flaps at 45° (emergency) : stop tool and sealing wire

Commands are transmitted by electrical signals. A flap asymmetry detection mechanism and a flap untimely retraction warning system are associated with the control system. The position of the flaps is indicated in the flight compartment.

The flap system consists of the following:
- a flap control lever, which can be moved through a four notch gate
- a flap control switch unit
- a flap position feedback unit
- a flap asymmetry detector and associated circuit
- a flap untimely retraction detection circuit
- a flap extension and retraction valve block
- a test circuit
- a flap torque tube
- four flap actuators

The flap control lever is installed on the center pedestal. It moves through a four notch gate. The lever is composed of :
- a handle
- a pin attached to the handle
- a spring on the lever, which maintains the pin in a normal position
in a notch in the gate.

Before changing notches, the pilot must raise the handle to compress the spring thereby disengaging the pin from the notch.

The flap control switch unit comprises :
- an input lever connected to the flap control lever by a rod
- an input shaft attached to a cam, which controls opening and closing

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[14] All system descriptions obtained from ATR Airplane Maintenance Manual (AMM), revision 5, issued in August of 2008.

of four microswitches identified S1, S2, S3, S4.
- a brake providing a resistive torque of between 0.3 and 1 mN
(0.22 and 0.74 ft/lb) to the input shaft
- an electrical connector.
For each position of the input lever corresponding to a flap control lever preselected position, one microswitch is closed and three open.

The flap position feedback unit comprises :
- an input lever connected to a rod, a bellcrank and a torque shaft linking the flaps on both wings
- a cam attached to an input shaft commanding opening and closing of eight microswitches
- three extension command microswitches identified S2E, S3E, S4E,
- two retraction command microswitches identified S2R, S3R,
- three monitoring microswitches identified S2M, S3M, S4M,
- a brake providing a resistive torque of between 1 and 3 mN (0.74 and 2.22 ft.lb) to the input shaft
- an electrical connector.

Movement of the flaps results in rotation of the input lever and micro switch configuration change. When the flap control lever is placed in notch 1, microswitch S1 in the flap control switch unit is closed energizing the flap valve block retraction solenoid valve, and maintaining the actuators against their retracted position stops. To aid understanding of the rest of the extension/retraction sequence, let n be the notch commanded, Sn the flap control unit microswitches, SnE and SnR the flap position feedback unit microswitches; n can take the value 2, 3, or 4 (except for SnR as there is no S4R).

When the flap control lever is placed in notch n, Sn microswitch is closed allowing electrical supply via the closed SnE or SnR microswitches. If the flaps do not extended sufficiently, electrical is supplied to the extension or retraction solenoid valves causing flap extension.

Interruption of extension or retraction is obtained by cutting off of the electrical supply to the extension (or retraction) solenoid valve caused by opening of the SnE (SnR) microswitch, which is commanded by the flap position feedback rod when the selected position is reached.

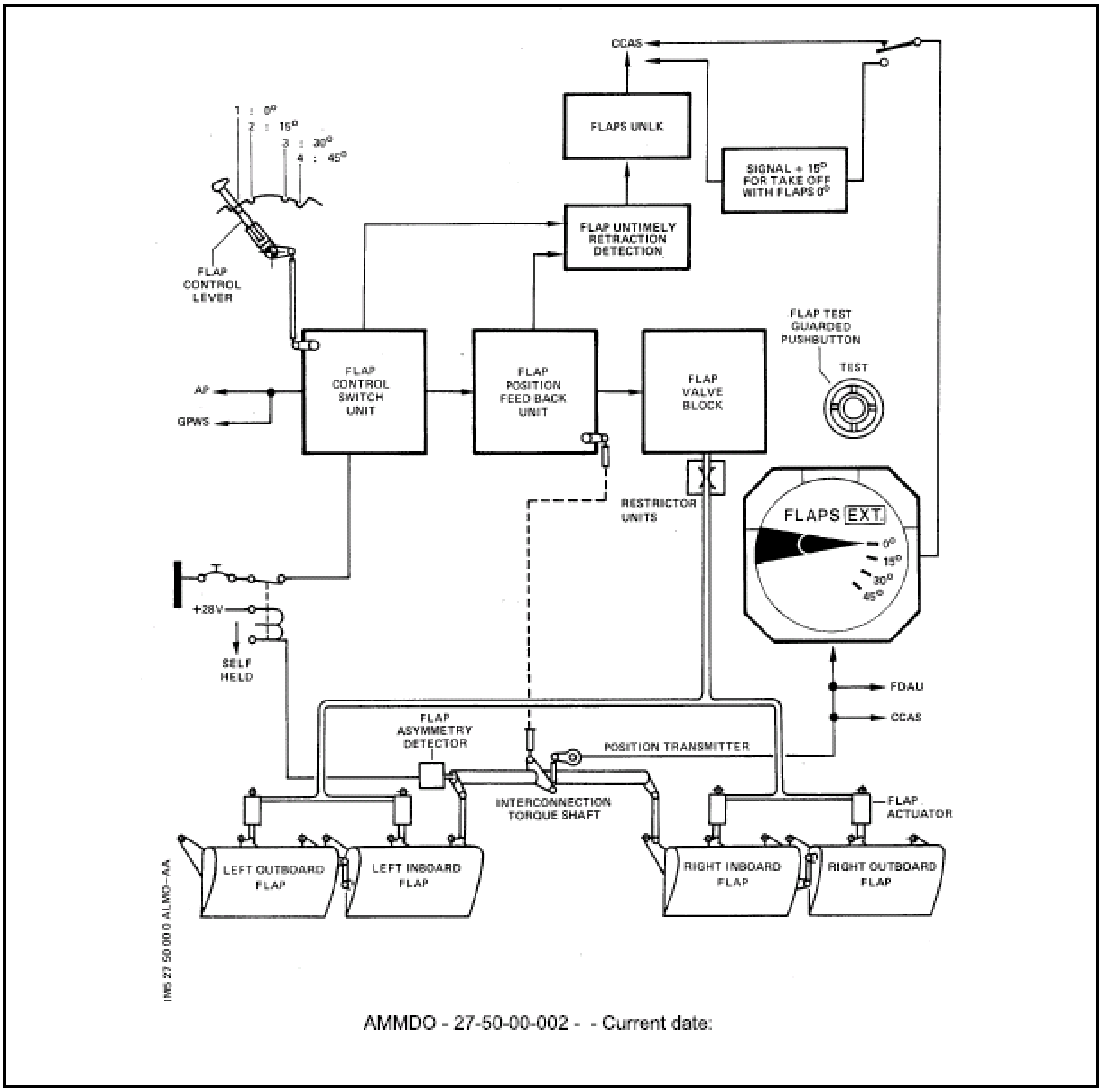

Figure 2. Flap System Schematic (ATR AMM)

1.1.1 Flap Asymmetry

The purpose of the flap asymmetry detection system is to interrupt commands when the average asymmetry of the left wing flaps with respect to the right wing flaps is 8 to 10 degrees.

This system utilizes:
- the interconnection torque shaft connecting the inboard flap of each wing
- an interconnection shaft torque detection mechanism consisting of a concentric shaft with one end linked to the interconnection shaft and the other end free

- a microswitch, 5CV[15], which closes for a difference in torsion between the two shafts superior to 8 to 10° of flap asymmetry (This microswitch is integrated in the flap asymmetry detector.)
- relay 4CV.

If the flaps are commanded to extend or retract and asymmetry between the left and right flaps exceeds the predetermined value[16], torsion of the torque detection shaft connecting the two inboard flaps causes microswitch 5CV to close. This microswitch then supplies self latching relay 4CV, cutting off supply to the flap control switch unit. The extension or retraction solenoid valve is no longer energized, and the flaps remain in the position reached before the power supply cut off. Movement of the flap control lever now has no effect on the system and the indicator provides the average position reached by the flaps.

When the ATR 42 was certified, it was determined that a cockpit indication of a flap asymmetry was not required. Later models were designed with the cockpit indication. [17] Although it was demonstrated that a flap asymmetry did not result in an unsafe flight condition[18], later models used the multi-function computer to display the indication, first on ATR 72 airplanes, and then on ATR 42-400/-500 airplanes.

According to the European Aviation Safety Agency (EASA), the original certification bases for the ATR 42-320 was JAR change 8 for paragraph 25.699 and was similar in content for FAR 25.699 amendment level 25-23 effective on May 8, 1970. With the flap asymmetry monitoring system working properly, when a flap asymmetry develops it is limited to no more than 10 degrees. Through certification, it was shown that this asymmetry did not create an unsafe flight condition.

The airframe manufacturer's review of prior flap asymmetry data showed that a flap asymmetry event had been reported in 1996 on an ATR 42-500 (SN 480), and the reason for the occurrence was not determined.[19]

[15] ATR uses functional identification numbers such as 4CV and 5CV.
[16] According to ATR, the flap asymmetry range varies between 8 to 10 degrees, dependent upon the flap position selected.
[17] According to ATR, all ATR 42-200/-300/-320 do not feature a flap asymmetry indication in the cockpit. All ATR 42-400/-500 and ATR 72-101/-102/-201/-202/-211/-212/-212A have a flap asymmetry indication in the cockpit.
[18] Federal Aviation Regulation 25.699 states "(a) There must be means to indicate to the pilots the position of each lift or drag device having a separate control in the cockpit to adjust its position. In addition, an indication of unsymmetrical operation or other malfunction in the lift or drag device systems must be provided when such indication is necessary to enable the pilots to prevent or counteract an unsafe flight or ground condition, considering the effects on flight characteristics and performance."
[19] According to ATR, the incident involved ATR 42-500 was a maintenance positioning flight. The previous day, a problem with the right powerplant was encountered. During the positioning flight, the flight crew was trying to reproduce the event at altitude. As the flaps were extended, the asymmetry occurred. The flight landed without incident.

1.1.2 Flap Actuator Tests

The actuators were examined at the manufacturer's facility, Ratier-Figeac, Figeac, France. According to the original airplane delivery documents, it was delivered with actuator part number FE 179-004-A and serial numbers 663 (left outboard), 666 (left inboard), 691 (right inboard), and 717 (right outboard).

During the examination, it was noted that the left outboard actuator was SN 663 and the left inboard actuator was SN 317. The data tags for the right actuators had burned away and were not recovered. As noted in Section 1 of this report, the serial numbers of the right flap actuators were later determined as SN 691 (right inboard) and SN 314 (right outboard) through the review of the airplane maintenance records. All of the actuators sustained thermal damage, with the right actuators more thermally damaged than the left actuators. The left actuators and the right inboard actuator were found extended; the right outboard actuator was found retracted.

The actuators were removed from the sealed container and photo documented. They were then placed separately in an X-ray chamber so that the internal components could be examined. All actuators showed normal location of their internal components, excluding the right inboard actuator, which showed a cloudy shape near the end of the piston. Later disassembly showed that internal components in this area had melted.

Left Flap Actuators

Removal of the hydraulic lines attached to the actuators produced minimal hydraulic samples in the left actuators. The samples were brown colored. Additional hydraulic fluid samples were obtained from the left actuators when they were placed on a test bench.

The extension of the piston rod for the left outboard actuator was 206 millimeters (mm). Free movement of the bearing was observed for the spherical bearing of the rod end, and was in conformity with acceptance criteria. Free movement was also observed on the spherical bearing of the body. The piston extension for the left inboard actuator was 197 mm. Both spherical bearings were in conformity with acceptance criteria.

The left actuators were filled with hydraulic fluid and then installed onto a test bench. No leak was observed on the left outboard actuator, and a slight leak was observed on the left inboard actuator at a hydraulic line fitting. The left actuators were placed on a tension machine, and two successive cycles of compression and tension were performed.

A modified leak test was developed. The left actuators were cleaned and placed in a container of hydraulic fluid and vacuum chamber. They were then placed on a test bench, and loads up to 700 daN were applied. The left outboard actuator showed no leakage, and the left inboard actuator showed minimal leakage. Investigators noted that a small hydraulic leak had developed at the hydraulic transfer tube fitting at the body end.

Right Flap Actuators

No hydraulic fluid samples were obtained from the lines of the right actuators. During the disassembly of the right inboard actuator, a small fluid sample was obtained. When removing the attachment between the aircraft structure and right outboard actuator, the bearing remained attached to the bolt and became fully unseated from the rod end.

The piston extension for the right outboard actuator was 70 mm. The spherical bearing was removed during the attachment axis removal, and no torque was measured. The spherical bearing of the body was jammed, but its internal ring was free in the attachment axis direction. The piston rod extension for the right inboard actuator was 206 mm. A free movement of the spherical bearing of the rod end was observed. The spherical bearing of the body was jammed.

The right actuators were placed on the tension machine under dynamic load and no movement was obtained from either piston. The right outboard actuator was placed on the tension machine, and a static load from 100-500 deca newtons (daN) was applied. No movement was obtained. The right inboard actuator was bent. Therefore its installation on the bench required adaptation and after the first load application (up to 80 daN), it was decided not to increase the load further. Due to the lack of movement of the right actuators and the external seal damage, no leak test could be performed. Cursory examination of the right outboard actuator revealed that the small chamber fitting connector appeared completely obstructed. A sample of the material was obtained for analysis.[20]

Following the examinations and testing, the actuators were then disassembled, and a cursory examination was conducted. The actuators were submitted to the NTSB Materials Laboratory for further examination and testing.[21] The hydraulic samples were taken by the BEA for analysis to determine identification of fluid and nature of any contamination.[22]

[20] Refer to NTSB Materials Laboratory Report 09-052.
[21] Refer to NTSB Materials Laboratory Report 09-050.
[22] Refer to NTSB Materials Laboratory Report 09-052.

Photo 27. Right Outboard Flap Actuator Piston Rod

Photo 28. Right Inboard Flap Actuator

1.2 Hydraulic System Information

The aircraft is provided with two independent hydraulic systems identified as the green and blue systems. The flap system runs off of the blue system. The fluids used are phosphate ester based, type IV and are wholly mixable. Both hydraulic systems operate simultaneously during all normal conditions providing 3000 +50 -0 psi (206,9 + 3,45 -0 bars) supply pressure. They are fed by a two-section reservoir (one section per each system) and pressurized by two variable displacement electric pumps (one per each system). The two power systems (green and blue) are identical, except for the subsystems served, each of them including:

- a section of the common hydraulic fluid reservoir ;
- an electric pump ;
- an accumulator ;
- a section of the common pressure module ;
- a return module ;
- two quick-disconnect fittings for connection of an external hydraulic power supply.

The blue system also includes an auxiliary electric pump.

All the components of blue and green power systems are grouped in the rear area of the left main gear well.

The hydraulic indicating system warns the crew if a hydraulic fluid low level, low pressure, or over temperature occur. These indications are given by caution lights, which come on when the respective limit value is reached. The pressure indicating is provided with a continuous display (triple indicator).

1.2.1 Hydraulic System Tests

Hydraulic samples and filters were obtained from the hydraulic pressure module. All fluid samples appeared clean except for the sample obtained from the green main pressure (inboard) location. This sample contained green/turquoise- colored specs of material. The filters and hydraulic samples were sent to the NTSB Materials Laboratory for further testing. No contamination was observed in the samples.[23]

Hydraulic fluid samples taken from the actuators during the initial examinations in France were consistent with Skydrol 500B4. In two of the samples, derivatives of phenol[24] were observed.[25]

1.3 Deicing and Anti-Icing System Description

[23] Refer to NTSB Materials Laboratory report 09-052.
[24] According to a Safety Board chemical engineer, phenol can result from fire and/or high temperatures.
[25] Refer to NTSB Materials Laboratory report 09-052.

The ice and rain protection system permits airplane operation[26] in icing conditions or heavy rain. Airplane ice protection is provided by a pneumatic and electrical system adapted to the critical areas.

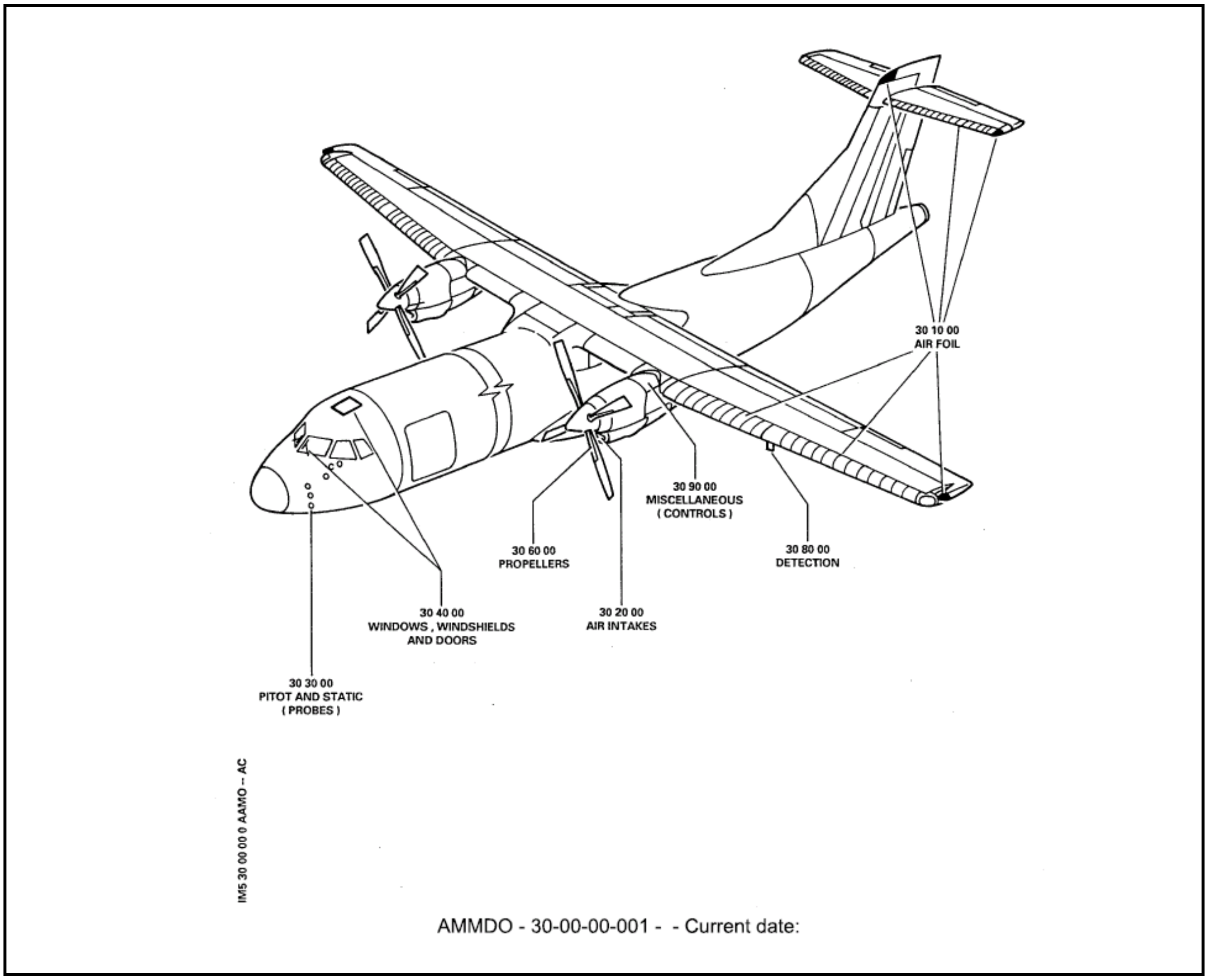

Figure 3. Deicing System (ATR AMM)

The airfoil ice protection system is composed of the following systems:

- pneumatic de-icing system for wings and empennage
- horn electric anti-icing system

Airframe deicing is ensured by pneumatic de icers featuring boots A and B installed side by side, inflated alternately by air bled from the engine compressors. This air is distributed to the deicers via dual distributor valves. The deicing system air supply can be provided by a single engine if required.

[26] There are restrictions for flight in icing conditions as noted in the limitations section of the Aircraft Flight Manual.

The horn anti-icing prevents all ice deposits between the wing structure and the moving parts of the control surfaces.

The airfoil pneumatic de icing system is composed of the following components:

- De icing controllers
- Pressure switch
- Dual distributor valves
- Pressure regulator and shut-off valves
- Pneumatic de icers
- Water separators
- Automatic water drains
- Shut-off valves
- Overheat thermal switches.

The pitot probes, static probes, air temperature probe (TAT) and angle of attack, for reasons of flight safety, are able to receive and transmit true pressure and temperature indications, for which they are designed to operate in humid or icing conditions. All these probes are installed in zones subjected to ice formations, for which they are protected by heating elements.

The engine ice protection system is a pneumatic system. This system is designed to prevent reduction or total loss of engine performance in icing conditions. The anti icing system of the engine propeller blades is an electrical system. It is designed to reduce and to avoid loss of propeller performance and possible damage, which could result from propeller operation in icing conditions.

The purpose of the ice detection system is to help the crew to detect icing conditions. The primary mode of detection remains visual detection of ice formation by the crew. The ice detection system is composed of the following systems:

- ice detection
- anti icing advisory system (AAS)
- ice visual indication[27] (ice evidence probe or propeller spinner)

The purpose of the AAS is for the following:

- improve icing conditions detection by the crew
- improve protection in icing conditions

[27] The ice evidence probe was not installed on the accident airplane.

The system consists of two components, a flasher and a crew alerting computer. The flasher modulates the power supply, and the crew alerting computer ensures acquisition and management of fault signals and generates associated audio and visual markings.

The electronic ice detector installed on the mid part of the left wing provides advisory signals upon icing encounters. This ice detector is part of the AAS which includes three cockpit lights: ICING (amber), ICING AOA (green) and DE-ICING (blue). The crew alerting computer generates the appropriate alerts (audio and visual) according to the ice protection system status and the detected icing conditions. This system alerts the crew to implement the correct procedures when flying in icing conditions.

1.3.1 Deicing and Anti-Icing System Testing

All the de-icing functions are monitored from the engine bleed air to downstream of the dual distribution valves that supply each boots chambers. The only condition that is not indicated to the flight crew is a single failure of one boot chamber (chamber A or chamber B that inflate alternatively on each boots). In case of a failure on one chamber (A or B), there is no warning as long as a second failure is not detected on the other chambers (B or A).[28]

The anti-icing and deicing systems were examined. The pneumatic deicing boots on the right wing were damaged by fire and impact and could not be tested. The pneumatic boots on the left wing were tested. The outer boot was damaged during removal of the airplane from the accident site so full inflation could not be obtained. The other boots were inflated with air and no leaks were detected. The pneumatic deice boots on the horizontal stabilizer were supplied with air, inflated, and no leaks were detected. The distributor valves for the airframe pneumatic boots were tested using an external power source and an air supply. All of the valves opened and closed and air was able to pass through the valves. The deicing annunciator panel was submitted to the NTSB Materials Laboratory.[29] There was no observed filament stretching.

The electrically heated components were removed, and a resistance was obtained. The following recordings were recorded:

[28] According to ATR, it has been shown during initial certification through icing tunnel test and flight test that upon a single failure, the pneumatic boots keep sufficient de-icing performance with the remaining chambers.
[29] Refer to NTSB Materials Laboratory report 09-051.

Table 6. Resistance Readings[30]

Component	Reading
Left Aileron	9.0 ohms
Right Aileron	9.5 ohms
Left Horizontal	11.8 ohms
Right Horizontal	18.7 ohms
Rudder	9.6 ohms
Left Pitot Heat	32.4 ohms
Right Pitot Heat	31.8 ohms
Right Backup Pitot Heat	32.0 ohms

Photo 29. Left Horizontal Pneumatic Boot

[30] All readings met or exceeded the manufacturer's specified resistance values.

Photo 30. Right Horizontal Pneumatic Boot

Photo 31. Left Wing Pneumatic Boots

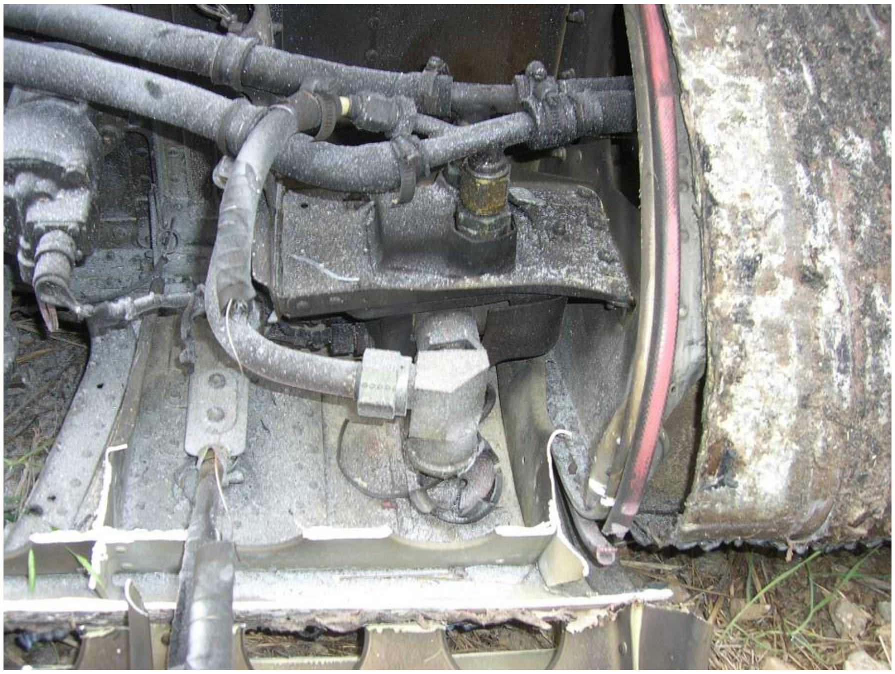

Photo 32. Distributor Valve Right Wing

1.4 Autopilot Disconnect System Tests

To ensure correct functioning of the autopilot disconnect system, the crew alerting computer, flight computer, flight controller, and flight display unit were all functionally tested through service centers specializing in the components. The disconnect signal originates in the computer when the flight crew depresses the autopilot disconnect switch. The controller also contains disengage switches. The autopilot display then displays “AP OFF” when the autopilot is disconnected. The crew alerting computer then sounds a chime indicating that the autopilot has been disconnected.

1.4.1 Crew Alerting Computer

The crew alerting computer (PN 350A23008314, SN 254) was inspected and then tested on a test bench at a service center. The unit was connected to a test computer, and the autopilot disconnect warning was tested. The unit passed the test. During the test, the unit activated the aural warning. No malfunctions with the autopilot disconnect warning were observed.

1.4.2 Honeywell Flight Guidance Computer, Flight Guidance Controller, and Advisory Display Unit

The Honeywell flight guidance computer (PN 7003974, SN 89102019) was tested at the manufacturer’s facility. The autopilot disconnect operation functioned normally. When the computer was put through the acceptance tests, it was discovered that the localizer setting was slightly off. Further examination and discussions with Honeywell representatives indicated that thermal damage to the unit could result in the error. Prior to the accident, no localizer errors had been recently reported, and the flight crew did not report a difficulty in this area.

The flight guidance controller (PN 7003975-602, SN 89040920) and advisory display (PN 7003652-602, SN 96022536) were tested at the manufacturer's facility. The examination and testing of the flight guidance controller showed no identified problems, and all final acceptance tests were passed. The following failure areas were noted with the advisory display: the screen calibration tests did not meet the limit, although the information presented on the screen was clear and readable; no backlighting was present for the two left buttons; both lamps were intermittent for the RESET annunciation; and a logic test failed when the reset lamp did not extinguish. No problems with the autopilot disconnect system were identified.