

**Research Request:**

Turbine powered fixed-wing aircraft that have departed a contaminated runway during the takeoff sequence.

**Research Response:**

A search of existing databases revealed 183 events involving fixed-wing turbine aircraft that have departed contaminated runways during the takeoff sequence. Of these 183 events, 25 resulted in accidents investigated by the NTSB and 46 resulted in incidents that were reported to the FAA. The most severe of these accidents took place on January 13, 1982 when a Boeing 737-222 failed to remain airborne on takeoff at Washington Dulles International Airport. There were 78 fatalities. A full report of this accident is available on <http://www.nts.gov/publictn/publictn.htm>. This event and others have prompted NASA, FAA, and the United States Air Force (USAF) to conduct studies relating to high skid-resistant pavement surface design and the application of proper maintenance techniques and procedures. Ryan King and Jim Patterson of the FAA are leading projects to develop more affective means of the de-icing and anti-icing of runways and airplanes during winter operations. Details of their studies can be found at <http://www.airporttech.tc.faa.gov/safety/surface.asp>

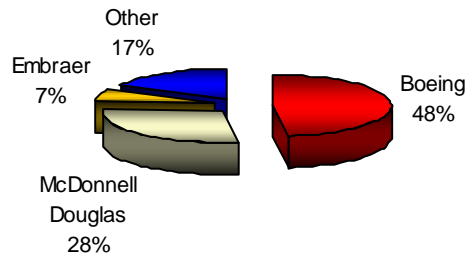


ASFT (Airport Surface Friction Tester) offers friction testing systems mounted onboard cars rear axel systems. ASFT Continuous Friction Measuring Equipment (CFME) is referred to as the 'skiddometer' principle, or fixed slip device. The advantage of a slip measurement is that it can provide a continuous record of the friction.

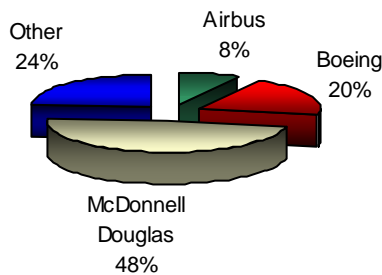
**Analysis of Contaminated Runway Takeoff Accidents**

A break-down of the 25 accidents discovered in the database shows that 19 were operating underneath an airline and 6 were operating as private business aircraft. 20 of the aircraft involved were turbojets, the remaining 5 were turboprop.

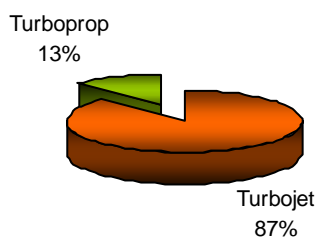
**Make / Model of Turbine Aircraft involved in Contaminated Runway Incidents during Takeoff**



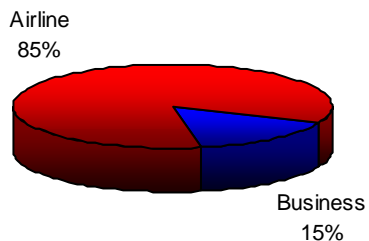
**Make / Model of Turbine Aircraft involved in Contaminated Runway Accidents during Takeoff**



**Turbojet vs. Turboprop Aircraft  
involved in Contaminated  
Runway Accidents during  
Takeoff**



**Airline vs. Business Aircraft  
involved in Contaminated Runway  
Accidents and Incidents during  
Takeoff**



**Examples of Pertinent NTSB Reports****NTSB Detail: DCA96MA029****General Information**

Local Date/Time: 12/20/1995 1136  
City, State: JAMAICA NY  
Airport: JFK - JOHN F. KENNEDY INTL  
Injury Severity: SERS  
Aircraft Damage: SUBS  
Operator Name: TOWER AIR  
Aircraft Make/Model: Boeing 747-136

**Narrative**

On December 20, 1995, at 1136 eastern standard time, a Boeing 747-136, N605FF, operated by Tower Air, Inc., sustained substantial damage during an aborted takeoff at the John F. Kennedy International Airport, Jamaica, New York. The two airline transport rated pilots and one flight engineer were not injured; nor were there injuries to eleven of the flight attendants or two cockpit jump seat occupants. One flight attendant received serious injuries. There were 24 minor injuries among the 441 passengers. Instrument meteorological conditions prevailed, and an IFR flight plan was filed for the flight, which was destined for Miami, Florida. The passenger/cargo flight was being conducted under 14 CFR Part 121.

The airplane, Flight 41, was de-iced at the gate, prior to passenger boarding. It was towed from the gate about 1036, and de-iced again, prior to commencing taxiing. Flight 41 was cleared to taxi to runway 4L, which was the active runway for departures, while snow removal was in progress on runway 31. Flight 41 was cleared for takeoff at 1136. Shortly after initiating the takeoff, the pilot reported that the airplane veered to the left of centerline. He attempted to correct the change in direction with rudder and steering tiller, but the airplane continued to turn left. The airplane exited the left side of the runway about 2100 feet from the start of the takeoff roll. The pilot stated that he initiated an aborted takeoff before the airplane exited the side of the runway, by retarding the throttles to idle and applying maximum braking.

After the airplane departed the runway, the number 4 engine impacted a concrete structure, containing electrical wires, and the entire pylon separated from the wing. As the airplane continued in soft terrain, the right wing landing gear and nose gear collapsed. The airplane came to rest between two taxiways, approximately 4800 feet from the start of the takeoff roll.

The captain determined that there was no sign of fire and the injuries to passengers were not serious; therefore, he elected to not order an emergency evacuation. The removal of passengers was conducted in an orderly manner by airport personnel.

Runway 4L had been plowed and sanded about 1.5 hours prior to the accident, and an estimated 22 aircraft had departed on that runway. The wind was reported from the control tower as 330 degrees at 11 knots, as Flight 41 was cleared for takeoff. The pilot reported that he was able to see the runway centerline during line-up, even though there was packed snow covering portions of the runway.

**Probable Cause**

The captain's failure to reject the takeoff in a timely manner when excessive nose wheel steering tiller inputs resulted in a loss of directional control on a slippery runway. Inadequate Boeing 747 slippery runway operating procedure developed by Tower Air, Inc., and the Boeing Commercial Airplane Group and the inadequate fidelity of B-747 flight training simulators for slippery runway operations contributed to the cause of this accident. The captain's reapplication of forward thrust before the airplane departed the left side of the runway contributed to the severity of the runway excursion and damage to the airplane.

**NTSB Detail: NYC96WA049**

Local Date/Time: 1/3/1996 2300  
 City, State: ONTARIO  
 Injury Severity: NONE  
 Aircraft Damage: SUBS  
 Operator Name: NATIONAL JETS, INC.  
 Aircraft Make/Model: Learjet 35A-305

**Narrative**

On January 3, 1996 about 2300 eastern standard time, a Lear 35A-305, N33NJ, operated by National Jets Inc., was substantially damaged when it collided with a snow bank during an aborted takeoff at the Oro-Barrie-Orillia Airport, Ontario, Canada. The airline transport pilot, commercial pilot and two passengers were not injured. Visual meteorological conditions prevailed for the positioning flight that was destined for Ft. Lauderdale, Florida. An instrument flight rules flight plan was filed for the flight conducted under 14 CFR Part 91.

In the NTSB form 6120.1/2, the operator stated:

...The captain allowed the first officer to occupy the left seat and to fly the "dead head" leg back to Ft. Lauderdale. After going through the appropriate checklists, computations and takeoff briefing, the engine were started, checklists were reviewed, and the aircraft was taxied to the runway and lined up for takeoff, where the first officer advanced the power normally and the takeoff roll was nominal. At approximately 100 knots, the aircraft started to drift to the left of centerline. The captain, believing that the first officer was touching the brakes, told him to "get off the brakes," but was immediately told by the first officer that he was not on the brakes.

The captain stated later that it appeared for a moment that the directional stability was regained; however, the aircraft again veered to the left at which point the captain took control and executed an abort. The aircraft...was far enough to the left side of the runway that its left main landing gear was hitting snow and ice that was on the side of the runway. The aircraft then turned perpendicular to the runway, and slid sideways for some distance, turning even more counterclockwise. The right hand tip [fuel] tank struck a snow bank and ruptured. Fuel sprayed on the aircraft and there was a flash fire that continued until the aircraft came to a stop....

Additionally, the operator reported that there were no mechanical malfunctions or failures with the airplane.

**NTSB Detail: DCA94MA038**

Local Date/Time: 3/2/1994 1759  
 City, State: FLUSHING NY  
 Airport: LGA - LAGUARDIA  
 Injury Severity: MINR  
 Aircraft Damage: SUBS  
 Operator Name: CONTINENTAL AIRLINES  
 Aircraft Make/Model: MCDONNELL DOUGLAS MD-82

**Narrative**

On March 2, 1994, at 1758 eastern standard time, a McDonnell Douglas MD-80, N18835, operated by Continental Airlines as flight 795, sustained substantial damage during an aborted takeoff at La Guardia Airport in Flushing, New York (LGA). Of the 116 persons on board the airplane, two were flight crewmembers, four were cabin crewmembers, and 110 were passengers. There were seven minor injuries during the accident sequence and evacuation.

A special weather observation, made about 5 minutes after the accident, found the weather as drifting snow conditions, with an indefinite ceiling at 500 feet, obscured, with the wind out of 050 at 23 knots.

The flight was to have been from LGA to Denver Stapleton International Airport, Colorado (DEN). During the attempted takeoff on runway 13, the first officer was at the controls. The captain, seeing that the airspeed indication was not increasing normally, but remained low, elected to abort by pulling back on the

throttles, entering reverse thrust, and taking control of the airplane. The airplane came to rest pitched downward, so that the nose of the airplane rested on a mud flat of the Flushing Bay Tidal, which at the time of the accident, was above the waterline.

#### Probable Cause

THE FAILURE OF THE FLIGHTCREW TO COMPLY WITH CHECKLIST PROCEDURES TO TURN ON AN OPERABLE PITOT/STATIC HEAT SYSTEM, RESULTING IN ICE AND/OR SNOW BLOCKAGE OF THE PITOT TUBES THAT PRODUCED ERRONEOUS AIRSPEED INDICATIONS, AND THE FLIGHTCREW'S UNTIMELY RESPONSE TO ANOMALOUS AIRSPEED INDICATIONS WITH THE CONSEQUENT REJECTION OF TAKEOFF AT AN ACTUAL SPEED OF 5 KNOTS ABOVE V1. (NTSB REPORT AAR-95/01)

#### NTSB Detail: NYC97FA045

Local Date/Time: 1/10/1997 923  
 City, State: BANGOR ME  
 Airport: BGR - BANGOR INTL  
 Injury Severity: MINR  
 Aircraft Damage: SUBS  
 Operator DBA: USAIR EXPRESS  
 Operator Name: MESA AIRLINES INC.

#### Narrative

##### HISTORY OF FLIGHT

On January 10, 1997, at 0923 eastern standard time, a Beech 1900D, N139ZV, operated by Mesa Airlines, Inc., doing business as USAir Express Flight 5326, was substantially damaged during an aborted climb after takeoff at the Bangor International Airport, Bangor, Maine. The certificated airline transport captain, first officer, and seven passengers were not injured. Two passengers received minor injuries. Instrument meteorological conditions prevailed for the scheduled passenger flight, destined for Boston, Massachusetts. An instrument flight rules flight plan had been filed for the flight conducted under 14 CFR Part 135.

The airplane had been flown by the flight crew from Boston, to Bangor International (BGR), and arrived, at 0856. The airplane was fueled, passengers were boarded, and the flight crew started the engines and taxied to the de-icing area. While in the de-icing area, the engines were shut down and airplane de-icing was initiated at 0912, and completed at 0917. The engines were restarted, and the airplane was taxied to runway 33 for takeoff. At 0921, Flight 5326 was cleared for takeoff by the BGR tower controller.

The first officer (FO) stated that she was the flying pilot. The FO briefed the captain that this was to be a zero degree flap takeoff, and repeated the takeoff speeds to be used. After taxiing onto the runway, the FO applied power, began the takeoff roll, and requested that the captain set the final takeoff power. The cockpit voice recorder (CVR) transcript revealed the following: the flight crew called out the "takeoff final items," at 0921:10; which included ice protection items, at 0921:21; the propeller RPM was heard to increase, at 0921:59; and the FO called out "set takeoff power," at 0922:09. The captain then made the following callouts: "eighty knots cross checked," at 0922:12; "the wind is from the right," at 0922:17; and "V one rotate," at 0922:19.

The CVR revealed the sound of a horn, at 0922:21, which was similar to the stall warning horn. At 0922:26, the captain called out, "abort abort." The sound of the horn ceased, at 0922:28, and the captain called out, "abort Doris Doris," at 0922:29. The CVR recorded the sounds of impact and the recording ended, at 0922:31.

The FO stated that at Vr, she pulled the yoke back with both hands, raised the pitch of the airplane into the command bars, and heard the stall warning horn sound as the airplane rotated. She stated that she released "a little back pressure," observed the airspeed indicator at 120 knots, and applied more back pressure. The airplane then left the ground, but it felt sluggish. She estimated that the airplane was about 20 feet

above the runway when the captain commanded, "Abort! Abort!" The FO closed the throttles and the airplane contacted the ground approximately on the centerline of the runway. She stated that, "visibility went to zero because of the flying snow." She then brought the "throttles to Ground Fine," and felt the captain's hand on top of hers as she moved the throttles into reverse.

According to one passenger, the airplane lifted from the runway and the engines were "whining as we started to climb."

## AERODROME CONDITIONS

The Bangor International Airport (BGR) had a concrete runway, 15-33, which was 11,439 feet long, 300 feet wide, and was grooved. According to the BGR airfield maintenance supervisor on duty at the time of the accident, the BGR snow removal crews had been plowing runway 15-33, from east to west. At 0815, the FAA BGR air traffic control tower (ATCT) advised the plow crews to clear the runway, due to a Boeing 727 that was to depart in 5 minutes. The plow crews were clear of the runway, at 0855. The maintenance supervisor stated that at that time, runway 15-33 had been plowed 150 feet east, and 75 feet west of the centerline. The supervisor reported that the plowed area was covered with a light dusting of snow less than 1/4 inch high, and braking action was "fair." He also reported that the piles of snow, which were the result of wind drifts and snow plowing, were about 1 foot high and 10 feet wide.

A Notice to Airmen (NOTAM) was issued by the FAA, at 0830, which described runway 15-33 as "patchy thin layer of loose snow, braking action - fair." At 0840, BGR issued a field condition report which stated, "RWY 15/33 - plowed 150 feet east of centerline and 75 feet west of centerline full length. Light dusting of snow. Braking fair. Snow removal in progress." According to the BGR Operations Manager, the 0840 field condition report was not relayed to the FAA Flight Service Station because the airfield maintenance supervisor was waiting to finish plowing the runway. Winds were reported to be from 050 degrees at 10 knots.

Prior to the arrival of the Safety Board, the first 8,000 feet of runway 33 was plowed to its full width of 300 feet, from the approach end toward the accident site. The airport management reported that they received approval to perform the plowing from an unidentified Federal Aviation Administration person after the accident. The airport authority reported that measurements were taken before the snow plowing continued. The airplane's landing gear tracks indicated that the airplane touched down 7,200 feet from the approach end of runway 33. They also measured the right main landing gear touch down point to be about 35 feet to the left of the runway centerline.

During an interview with the FO, she stated she had received "a good 1 1/2 hours of CRM," during her recurrent training in August, 1996. The FO did not recall any winter operation or de-icing training, but did state that winter operations were "mentioned" in the Company Flight Manual and General Operations Manual.

## SERVICE DIFFICULTY REPORTS

### Stall Warning System

The NTSB Investigator-In-Charge contacted the FAA Flight Standards Service, Safety Data Analysis Section, AFS-620, Oklahoma City, Oklahoma, and requested a print-out of all Service Difficulty Reports (SDR) concerning the stall warning system of the Beech 1900, for the period from 1990, to January, 1997. A total of 20 SDR's were provided by AFS-620. Ten of the reports were a result of stall warning horn activation during the takeoff roll or in flight, and five of the activation's resulted in aborted takeoffs. Two of the five aborted takeoffs were reported to be due to "Maintenance found stall vane to be contaminated with ice." The corrective action by the maintenance personnel was, "Removed ice with stall heat vane system. Checked operation of heat system. System operationally checked satisfactory. Aircraft was returned to service. A review of SDR and NASA reports of inadvertent (false) stall warning horn activation, revealed that a majority of the events occurred on a takeoff, immediately following airplane deicing.

### Probable Cause

The inadequate flight and winter operations training provided by the operator, and the pilot's improper decision to abort the takeoff while airborne above V1, due to a false stall warning horn. Also casual was the airport operations improper decision to discontinue plowing, and their failure to remove a snow pile on the runway. Factors relating to the accident were an easterly crosswind, the narrow icy runway conditions, inadequate FAA oversight in allowing the operator to continue operations with an inadequate training program that continued over several years, and the manufacturer's checklist which delayed the activation of the stall vane heat until just prior to takeoff.

## Analysis of Contaminated Runway Takeoff Incidents

A break-down of the 46 incidents discovered in the FAA AID database indicates 41 were operating underneath an airline and 5 were operating as private business aircraft. 42 of the aircraft involved were turbojet engine, the remaining 4 were turboprop. The majority of incidents involved aircraft that had experienced ice/snow build-up or ingestion that caused the activation of anti-ice warnings or a compressor stall.

These events resulted in either an aborted takeoff or a runway excursion. One case involved an Airbus that slid off a taxiway while performing a run-up during the taxi to the active runway. In a few cases hydroplaning was cited as a factor in runway excursions during the takeoff sequence.

## Examples from the FAA Accident / Incident Database and ASRS Database

### FAA Accident/Incident Database: 19910107002969C

#### General Information

Accident Date: 01/07/1991  
 Airport: KANSAS CITY INTL  
 Total On Board: 36  
 Total Fatalities: 0  
 Total Injuries: 0

#### Operations Information

Aircraft Group: 737  
 Aircraft Damage: NONE  
 Phase of Flight: TKOF-GRND ROLL  
 Owner Name: UNITED AIR LINES INC  
 Aircraft Manufacturer: BOEING

#### Remarks

AS POWER WAS APPLIED FOR TAKEOFF ON ICE COVERED RUNWAY AIRCRAFT VEERED OFF RUNWAY. ENGINES HAD DIFFERENTIAL THRUST.

### FAA Accident/Incident Database: 19841202072719C

#### General Information

Accident Date: 12/02/1984  
 Accident State: WI  
 Accident City: MARSHFIELD  
 Airport: MUNI  
 Total On Board: 2  
 Total Fatalities: 0  
 Total Injuries: 0

#### Operations Information

Aircraft Group: 110  
 Aircraft Damage: MINR  
 Phase of Flight: TKOF-ABORTED  
 Owner Name: AMERICAN CENTRAL AIRLINES

Aircraft Manufacturer: EMB

**Remarks**

DURING TAKEOFF ON WET RUNWAY, AIRCRAFT HYDROPLANE. PILOT UNABLE TO CORRECT AIRCRAFT LEFT SIDE OF RUNWAY.

**FAA Accident/Incident Database: 20080123012859G**

**General Information**

Accident Date: 01/23/2008  
Airport: GUNNISON-CRESTED BUTTE RGNL  
Total On Board: 2  
Total Fatalities: 0  
Total Injuries: 0

**Operations Information**

Aircraft Group: P180  
Aircraft Damage: MINR  
Phase of Flight: TKOF-GRND ROLL  
Aircraft Manufacturer: PIAGIO  
Owner Name: AVANTAIR INC  
FAR Part Number: 091

**Remarks**

(-23) ON TAKEOFF OUT OF THE GUNNISON COUNTY AIRPORT THE SIC WAS FLYING THE AIRCRAFT AND LOST CONTROL DURING THE INITIAL TAKE-OFF RUN. AT AROUND 70 KNOTS THE PIC TOOK THE FLIGHT CONTROLS AND ATTEMPTED TO ABORT THE TAKE-OFF. THE AIRCRAFT HAD DRIFTED TO THE LEFT SIDE OF THE RUNWAY DURING THE OSCILLATIONS RIGHT AND LEFT OF RUNWAY CENTERLINE. THE AIRCRAFT HIT A PATCH OF ICE, ROTATED ABOUT 70 DEGREES TO THE LEFT, AND SLID OFF THE RUNWAY HITTING A RUNWAY EDGE LIGHT. THE RUNWAY EDGE LIGHT PUNCHED A SMALL IN THE UNDERSIDE OF THE AIRCRAFT.

**ASRS Detail: 539625**

**Synopsis**

AN AIRBUS 320 TAXIING ON PACKED SNOW AND ICE EXITED THE TXWY DURING A R ENG PWR RUN-UP. ACFT INCURRED NO DAMAGE.

**Narrative**

WE WERE CLRED TO TAXI OUT TO RWY 32L, INTXN 10 FOR TKOF. AFTER WE TURNED THE CORNER FROM A7 ONTO TXWY T, I PROCEEDED TO DO AN ENG RUNUP TO 50% N1, AS PER OUR AIRLINE WINTER OPS SOP'S. AS I WAS APPLYING BRAKES WHILE MOVING ON THE TXWY T, I RAN UP THE L ENG AND BACK TO IDLE. THEN I RAN UP THE R ENG, AND AS THE PWR WAS AROUND 50% N1, THE ACFT STARTED TO VEER TO THE L OFF TOWARD THE EDGE OF THE TXWY. IMMEDIATELY, I PULLED THE PWR TO IDLE AND APPLIED MAX BRAKING. THE ACFT'S NOSEWHEEL CAME TO REST ON A HARD SURFACE AREA A LITTLE BIT BEYOND THE TXWY EDGE MARKINGS AND IN THE VICINITY OF THE BLUE TXWY LIGHTS. THE MAIN GEAR WHEELS CAME TO REST WITHIN THE CONFINES OF THE TXWY AND NEVER CROSSED PAST THE TXWY EDGE MARKINGS. MAINT MET THE ACFT AND INSPECTED THE AREA. THERE WAS NO DAMAGE TO THE ACFT OR THE TXWY LIGHTS. A TUG WAS HOOKED UP AND THE ACFT WAS PUSHED ONTO TXWY T. WE THEN TAXIED BACK TO TERMINAL WHERE A FURTHER INSPECTION WAS DONE. A NEW MAINT RELEASE DOCUMENT WAS ISSUED REFLECTING THE INSPECTION, AND WE PROCEEDED TO BOS. THE SURFACE CONDITIONS ON TXWY T FROM T7 TO T10 WERE PACKED SNOW AND ICE, AND THERE WAS LIGHT SNOW FALLING AT THE ARPT. CALL

BACK CONVERSATION WITH RPTR REVEALED THE FOLLOWING INFO: THE RPTR STATED THE

BRAKES WORKED OK. THE PROB WAS THE PACKED ICE AND SNOW AND THE R ENG AT 50% N1 CAUSED THE VEERING TO THE L AND THE EXCURSION FROM THE TXWY. THE RPTR SAID THE ACFT NEVER WAS OFF THE CONCRETE EVEN WITH THE NOSE GEAR SLIGHTLY PAST THE BLUE LIGHTS. THE RPTR STATED THE AIRPLANE WAS INSPECTED AND FOUND OK FOR SVC WITH NO DAMAGE.

### Analysis of Gulfstream Accidents and Incidents

Gulfstream aircraft, models G-1 through G-V, have had 25 accidents and 136 incidents in total since February 1, 1978; None of which reported a contaminated runway as a contributing factor during takeoff. The events displayed below occurred during landing. The first involves a G-IV landing at Teterboro Airport after inadvertently engaging the autothrottle. The Second involves a G-IV which encountered foreign object damage to the nose-wheel during touchdown. Available at [http://www.faa.gov/other\\_visit/aviation\\_industry/airline\\_operators/airline\\_safety/safe](http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safe) is SAFO 06012 (Safety Alert for Operations). This document outlines recommended procedures for turbojets landing on slippery runways.

### NTSB Detail: NYC05FA026

Local Date/Time: 12/1/2004 1623  
 City, State: Teterboro NJ  
 Airport: TEB - Teterboro Airport  
 Injury Severity: NONE  
 Aircraft Damage: SUBS  
 Aircraft Make/Model: Gulfstream Aerospace G-IV

#### Narrative

##### HISTORY OF FLIGHT

On December 1, 2004, at 1623 eastern standard time, a Gulfstream Aerospace G-IV, G-GMAC, was substantially damaged while landing at Teterboro Airport (TEB), Teterboro, New Jersey. The certificated airline transport flight crew, one flight attendant, and six passengers were not injured. Visual meteorological conditions prevailed for the flight that departed from London Luton Airport (EGGW), Luton, United Kingdom. An instrument flight rules (IFR) flight plan was filed for the foreign operated charter flight.

The flight crew reported that they originally departed Farnborough Airport (EGLF), Farnborough, United Kingdom; and flew uneventfully to Luton, United Kingdom. They then boarded passengers and departed for Teterboro, New Jersey. Upon arrival in the Teterboro area, air traffic control (ATC) cleared the flight for the ILS Runway 19 approach, circle-to-land on Runway 24; a 6,013-foot-long, 150-foot-wide, asphalt runway.

The pilot stated that a strong crosswind prevailed, and the planned landing speed was  $V_{ref}$  (128 knots) plus 10 to 15 knots for wind gusts. During the last 200 feet of the approach, the pilot felt like the airplane was perfectly controllable, and not subject to any strong wind gusts. The airplane was at a normal touchdown point, on centerline, at  $V_{ref}$  to  $V_{ref}$  plus 5 knots. The pilot then attempted to apply reverse thrust, but could not lift the thrust reverser levers (piggybacks). He alerted the copilot and concentrated on braking. The pilot did not recall any cockpit crew advisory message (CAS) of incorrect spoiler operation, and felt the brakes were not working properly or achieving the desired result. The pilot subsequently applied the emergency brake and felt the right wing drop slightly, presumably from tire bursts. The airplane then veered right uncontrollably, and departed the right side of the runway.

The copilot added the airplane was fully configured for the ILS Runway 19 approach, with the autopilot on and the auto throttles engaged. At the outer marker, the flight crew disengaged the auto throttles and autopilot, and circled to Runway 24. Once the airplane was established on a final approach for Runway 24, he

confirmed the landing configuration. The airplane was in a stabilized descent, and touched down at the 1,000 foot markers, at approximately Vref plus 5 knots (133 knots). When the pilot remarked about the thrust reversers, the copilot reached over to assist, but was unsuccessful. At that time, the copilot extended the speed-brakes and assisted with the brake pedals.

The pilot then applied the emergency brakes and the airplane departed the right side of the runway about 5,500 feet beyond the approach end. The airplane traveled over a grassy area, struck trees, and came to rest upright. All nine occupants were able to egress through the forward left, number five, emergency window exit. The accident occurred during the hours of night; located about 40 degrees, 50.01 minutes north latitude, and 74 degrees, 03.65 minutes west longitude.

#### PILOT INFORMATION

The pilot held a foreign airline transport pilot certificate, with a rating for multiengine land airplanes. He also held a type rating for the Gulfstream IV. The pilot reported a total flight experience of approximately 10,000 hours; of which, about 1,000 hours were in a Gulfstream IV. In addition, the pilot had accumulated approximately 120 hours of flight time in a Gulfstream IV within the 90 days preceding the accident.

The pilot's first class medical certificate was issued on July 5, 2004.

The copilot held a foreign airline transport pilot certificate, with a rating for multiengine land airplanes. He also held a type rating for the Gulfstream IV. The copilot reported a total flight experience of approximately 8,000 hours; of which, about 2,000 hours were in a Gulfstream IV. In addition, the copilot had accumulated approximately 60 hours of flight time in a Gulfstream IV within the 90 days preceding the accident. The copilot's first class medical certificate was issued in January 2004.

#### AIRCRAFT INFORMATION

The airplane, serial number 1058, was manufactured in 1988.

The airplane was maintained under a continuous airworthiness maintenance program. The most recent phase inspection was completed on July 14, 2004. At that time, the airplane had accumulated 7,207.10 hours of operation. At the time of the accident, the airplane had accumulated 7,452.58 hours of operation.

#### METEOROLOGICAL INFORMATION

The weather reported at TEB, at 1651, was: wind from 290 degrees at 16 knots, gusting to 25 knots, with a peak wind from 300 degrees at 32 knots; visibility 10 miles; few clouds at 6,000 feet; temperature 52 degrees F.; dew point 34 degrees F.; altimeter 29.62 inches Hg.

#### FLIGHT RECORDERS

##### Cockpit Voice Recorder

The airplane was equipped with a Fairchild model A-100 cockpit voice recorder (CVR). The CVR was transported to the NTSB Office of Research and Engineering on December 6, 2004. A CVR group convened on December 8, 2004, and a transcript was prepared of 7 minutes 44 seconds of the approximate 33-minute recording. The transcript started as the aircraft was being vectored for the approach, and continued until the accident.

The CVR was not damaged during the accident. The recording consisted of two channels of "fair to good" quality audio information.

The data on the CVR was consistent with the flight crew's recollection of the approach up to the point of touchdown.

The CVR revealed that during the approach, at 1622:20, a "cavalry charge" sound was recorded, consistent with an auto throttle disconnect tone.

At 1623:17, the CVR recorded a sound consistent with aircraft touchdown.

At 1623:21, the CVR recorded a "triple chime" sound consistent with a configuration master warning. During the landing roll, the CVR recorded several "double chime" and "triple chime" sounds.

At 1623:43, the CVR recorded a sound consistent with an impact, followed by another impact at 1623:53.

##### Flight Data Recorder

The airplane was equipped with a L3-Communications (Fairchild) Model FA2100 flight data recorder (FDR). The FDR was transported to the NTSB Office of Research and Engineering on December 6, 2004, and a readout was performed.

The FDR recorded data in a digital format using solid-state Flash Memory as the recording medium.

The FDR was not damaged in the accident, and the timing of the data was correlated to air traffic control and CVR timing. A total of 127.4 hours was recorded.

The FDR data revealed that the airplane's auto throttle and autopilot were disengaged during the approach. Specifically, the auto throttle disengaged about 570 feet agl, at a calibrated airspeed of approximately 140 knots. Prior to touchdown, the auto throttle re-engaged about 38 feet agl, at a calibrated airspeed of approximately 150 knots. The auto throttle remained engaged for approximately 22 seconds. After a majority of the landing roll, the auto throttle eventually disengaged at a calibrated airspeed of approximately 110 knots. At touchdown, a red and amber configuration warning activated.

After touchdown, the engine pressure ratio (EPR) increased to about 1.3, then 1.35 during the landing roll. The ground spoilers and outboard spoilers deployed approximately 13 seconds after the weight on wheels (WOW) switches were in the ground mode. The auto-throttle disengaged about 3 seconds after the spoilers deployed.

The FDR did not record power lever angle.

#### WRECKAGE INFORMATION

During the impact, the outboard one-third of the left wing was severed, and the nose section was crushed inward approximately 7 feet. A Federal Aviation Administration (FAA) inspector followed the tire marks from the accident airplane, to the approach end of Runway 24. He observed that tire marks originated about 1,900 feet beyond the approach end of the runway, consistent with the left main gear touching down about 12 feet right of runway centerline. About 2,900 feet, the tire marks were consistent with anti-skid action. All four main gear tire marks were observed at 3,504 feet, and heavier marks at 4,550 feet. The inspector also observed wavy tire marks and metal, consistent with a blown right main tire at 4,756 feet. About 5,072 feet, the nose gear tire marks crossed the right main gear tire marks, and both main gear tire marks then veered right. The tire marks departed the right side of the runway about 5,450 feet.

Examination of the wreckage revealed that the right main gear inboard tire had partially separated, and the left main gear inboard tire completely separated. The flaps were in the full-extended position, and the emergency brake was pulled to its limit. The ground spoilers were selected to "ARM," and the speed-brake handle was near the fully extended position. Further examination of the wreckage revealed that the right side number five and six emergency window exits had been unlatched, but could not be removed.

#### TESTS AND RESEARCH

##### Airplane

Review of the aircraft system logic revealed that upon touchdown, thrust reverser and ground spoiler deployment required the power levers (throttle levers) in the idle position, and the main landing gear WOW switches to be in the ground mode.

##### Auto throttle System

The airplane was equipped with an auto throttle system controlled by an auto throttle ARM pushbutton located on the GP-820 Flight Guidance Controller. The system included two auto throttle Engage/Disengage paddle switches, located on the aft side, about 4 inches below the top of each power lever. The paddle switches were not equipped with any switch guard. The Engage/Disengage paddle switches were designed to remain in the down (resting) position. An upward force was required to move either switch up, engaging the auto throttle, and a spring would return the switch to its resting position. The switch would then have to be pushed up again to disengage the auto throttle. In addition, the system included two auto throttle Quick Disconnect switches, located on the front of each power lever handle. A Takeoff/Go-around button was located on the side of each power lever handle.

The following was required to engage the auto throttle in the air:

- Auto throttle armed
- A speed target displayed in the GP-820 speed window (for speed mode only)
- An EPR limit rating selected for display on the Display Controller
- Bleed air isolation valve must be closed
- N1 cannot be split by more than 20 percent
- No engine out condition
- A valid preselector

There were several ways to disconnect the auto throttle:

- Pressing either Quick Disconnect switch
- Pressing either Engage/Disengage paddle switch
- Moving the power levers (15 to 32 pounds of applied force)
- If a fault was detected in the auto throttle system or a system providing required inputs

Auto throttle disengagement provided an audible tone. Auto throttle engagement did not provide a tone, but displayed a CAS message.

The auto throttle system utilized two identical Honeywell PZ-800 performance auto throttle computers. Although the FDR did not record power lever angle, the auto throttle computers did. On March 24, 2005, the non-volatile memory was downloaded from both computers at a Honeywell facility in Arizona, under the supervision of two FAA inspectors. The computers recorded the last nine engagement/disengagement events (not flights). The non-volatile memory data revealed that the last auto throttle engagement occurred about 57 feet agl, and was a commanded engagement through one of the Engage/Disengage paddle switches. At the time, the airplane's speed was approximately 151 knots, with a selected target speed of 138 knots, and the power levers were near idle. The last auto throttle disengagement occurred on the ground, and was uncommanded, but possibly the result of force applied to the power levers. At the time, the airplane's speed was approximately 123 knots, with a selected target speed of 138 knots. The power levers were near the mid-range position at the time of auto throttle disengagement.

Testing of the auto throttle computers revealed that one computer had no failures, while the other computer had four separate failures. The computer with four failures was equipped with three separate batteries. The first failure was recorded as one of the three batteries was not providing power, but the batteries served no purpose when the aircraft was powered. The second failure occurred during the Monitor Valid Test. The test called for the voltage to be in the range of 2.5 volts, plus or minus .038 volts. The measured value was 2.463 volts. The value was within range, on the lower threshold limit, and could not be determined why it was identified as a failure. The third failure occurred during the D/A (digital to analog) Calibration Check. During the check, the D/A was tested at several points along a range of positive 10 volts to negative 10 volts. At two points the calibration was off by .002 volts and .0001 volts. The fourth failure occurred during the Battery Load test, as a result of the dead battery. There was no evidence that the failures affected the accident flight.

#### Thrust Reversers and Ground Spoilers

A re-examination of the wreckage was conducted on December 21, 2005. During the re-examination, the electrical continuity of the power levers, thrust reverser levers, and ground spoilers was checked with an ohmmeter. The test did not reveal any discrepancies.

A flight demonstration was conducted in a Gulfstream IV simulator on January 20, 2005. During the simulation, the auto throttles were engaged prior to touchdown, while the power levers were near idle and the airplane was approximately 150 knots. After touchdown, as the airplane decelerated, the power levers slowly advanced to maintain the pre-selected target airspeed of 138 knots. Attempts to pull up on the thrust reverser levers created an upward force on the power levers, but did not create enough rearward force (15 to 32 pounds) to move the power levers aft and disengage the auto throttle. In addition, without the power levers at the idle stop, the upward force on the thrust reverser levers did not deploy the thrust reversers.

#### Auto Throttle Switches

Further examination of the wreckage was conducted on January 21, 2005. During the examination, all cockpit pedal switches were checked, including the auto throttle switches. The check was successfully conducted with an ohmmeter and "break-outbox." One minor discrepancy was noted as the left thrust reverser switch "S4" was slightly out-of-adjustment; however, the "S4" switch controlled the thrust reverser stowing, not deploying.

During the examination, the two fault warning computers were downloaded. The data revealed that the computers had stopped recording on July 30, 2004, and September 24, 2004. The auto throttle Engage/Disengage paddle switches were then removed from the airplane and forwarded to the Safety Board's Materials Laboratory for further examination. The examination included an electrical continuity check, disassembly, and a visual inspection. The examination did not reveal any discrepancies with either of the two switches.

#### SURVIVAL ASPECTS

The airplane was equipped with four emergency window exits, with two on the right side and two on the left side. The forward window exits were located at the number five windows on each side, and the aft window exits were located at the number six windows on each side. Each window exit was designed to be released, pulled into the cabin, and allow a portal for egress.

The airplane came to rest with trees against the main cabin door. The copilot reported that he was unable to open the main door. The copilot then went aft, and attempted to open the right forward window exit. The exit release handle moved, and the exit became loose in the opening, but would not free from the airplane. The copilot attempted the aft right window exit with the same result. The exit release handle moved, and the exit became loose in the opening, but would not free from the airplane.

The copilot then went to the left forward window exit, and with the help of passengers, was able to remove the exit.

Examination of the wreckage revealed that all three remaining window exit release handles had been pulled. The three remaining windows were loose in the openings, but could not be removed. The rectangular decorative interior trim panels attached to the exit hatches, extended behind the passenger service unit (PSU) panels that ran longitudinally down the fuselage, above the window exit panels, and prevented normal operation of the three window exits. The examination did not reveal any evidence of distortion or displacement of the cabin as a result of the impact.

The accident airplane underwent various modifications to the passenger cabin, including installation of the PSU, side panels, and decorative panels on the window exits during July 2004. Savannah Air Center (SAC), an FAA-certificated repair station in Savannah, Georgia, performed the work. At the time the interior was installed, the airplane's registration was held in Bermuda, and following the refurbishment, the airplane's registration was transferred to the United Kingdom. A representative of the British Civil Aviation Authority (CAA) examined the completed airplane at SAC prior to the issuance of a CAA certificate of airworthiness.

On June 14, 2004, prior to the work being performed, FAA Form 8110-3, Statement of Compliance was issued, which approved the master drawing list (MDL) for the proposed work. On July 17, 2004, FAA Form 337, Major Repair and Alteration was completed, signifying that all work was done in accordance with the MDL, and that the airplane was approved to return to service. Savannah Air Center records indicated that on July 19, 2004, a successful operational test of the emergency windows was accomplished. On a June 9, 2005 a representative of the British CAA stated that he observed a successful operational test of the window exits during an inspection of the airplane at SAC prior to transferring the airplane to U.K. registration.

A representative of Savannah Air Center stated that the interior installed on the accident airplane was the "only one of its kind;" SAC had not installed a similar PSU/decorative panel combination on any other airplane. He stated that he knew of no guidance that specified the sizes of the decorative panels, and that he did not know whether Gulfstream provided guidance to interior shops regarding tolerances around the exits. He also said that operational tests of window exits "are always done" following installation of new interior components. He added that employees who were familiar with the operation of the exits typically performed the operational tests.

In a May 3, 2005 email message to the Survival Factors Group Chairman, the Chief of Quality at Savannah Air Center stated:

"The PSU design used on G-IV-1058 will no longer be used by Savannah Air Center."

In a June 2, 2005 email message, the SAC Chief of Quality stated:

"Savannah Air Center has implemented a policy that all emergency window release operational checks be performed by personnel unfamiliar with the procedure, using the manufactures maintenance procedures under the supervision of an A&P mechanic and Quality Control Inspector. Savannah Air Center will ensure a sufficient minimum gap of a quarter of inch (1/4") is provided between the bottom of the PSU and top of emergency window close out panel. All PSU clearance around emergency window exits will be checked on installation."

Gulfstream document GIV-GER-023, Outfitting Interface Specification, provided guidance to airplane owners and maintenance facilities regarding installation of equipment and furnishings into Gulfstream airplanes. The document stated:

"Owners who choose to have their Gulfstream IV's outfitted by a non-Gulfstream facility must ensure that the said facility achieves compliance with the requirements contained in this document when performing outfitting of the airplane. Failure to do so could adversely impact systems provided by Gulfstream with the basic airplane and affect warranty responsibility on them."

Section 8.17 of GIV-GER-023, Emergency Exit Access, stated:

"The Gulfstream IV is equipped with one forward auxiliary and four (two on each side) overwing Type IV emergency exits. It is the outfitter's responsibility to provide for access to these emergency exits that are in compliance with FAR's 25.813 and 25.815. It is also the outfitter's responsibility to install emergency exit markings, exit signs, and emergency lighting that are in compliance with FAR's 25.811, 25.812, and 25.813. The outfitter must not perform any modifications that interfere with the operation of these emergency exits from both inside and outside the airplane."

In May of 2005, Gulfstream amended Section 8.17, adding the following sentence:

"The guidelines set forth in these paragraphs must be followed to achieve ease of removal in an emergency situation for an untrained passenger."

The Gulfstream Computerized Maintenance Program (CMP), Chapter 56, Windows, calls for an operational test of the window exits to be conducted every 24 months.

#### ADDITIONAL INFORMATION

The wreckage was released to a representative of the owner on December 4, 2004.

#### Probable Cause

The flightcrew's inadvertent engagement of the autothrottle system, and their failure to recognize the engagement during landing, which resulted in a runway excursion. Factors were the lack of autothrottle switch guards, lack of an autothrottle engagement audible tone, and gusty winds.

### NTSB Detail: DEN05LA030

Local Date/Time: 11/29/2004 1236

City, State: Eagle CO

Airport: EGE - Eagle County Regional

Injury Severity: NONE

Aircraft Damage: SUBS

Operator Name: NJI, Inc.

Aircraft Make/Model: Gulfstream Aerospace G-IV

#### Narrative

On November 29, 2004, at 1236 mountain standard time, a Gulfstream Aerospace G-IV, N420QS, owned by Consolidated International Services LLC., and operated by NJI, Inc., was substantially damaged when it departed the right side of the runway and impacted terrain during landing roll at Eagle County Regional Airport (EGE), Eagle, Colorado. Visual meteorological conditions prevailed at the time of the accident. The airline transport certificated captain, the airline transport certificated first officer, and one flight attendant reported no injuries. An instrument flight rules (IFR) flight plan was filed for the positioning flight being conducted under Title 14 CFR Part 91. The flight originated at San Francisco, California, at 1040.

According to the captain, the airplane touched down on runway 25 at 1,000 feet down the runway. Shortly after the nose wheel touched down, the aircraft experienced an uncommanded divergence to the right. The captain was unable to correct the divergence through rudder input. Approximately 2,800 feet down the runway, skid/scuff marks from the airplane's nose landing gear tires appeared as the airplane began to veer to the right. At approximately 3,900 feet, the airplane departed the right side of the runway. The nose landing gear folded aft, and the airplane's nose and right wing tip struck the terrain. The airplane continued to slide, coming to a stop on the edge of the runway at 4,500 feet. The airplane's forward fuselage was substantially damaged and the outboard right wing leading edge sustained minor damage.

According to data provided by Gulfstream, a slight differential braking pressure of 200 psi was noted on the flight data recorder. The recorded brake pressures were not sufficient to provide any appreciable total or differential braking action. Gulfstream engineering analysis indicated that the aircraft would have remained on the runway had maximum differential braking been applied at the time the flight data recorder captured the brake pressure increase as indicated. Shortly after the incident, Gulfstream issued a letter to operators indicating the use of differential braking as the preferred method to counteract any uncommanded divergence of the nose wheel steering system.

On March 17, 2005, the airplane's nose wheel steering servo valve (p/n 74133-01, s/n 409), was examined on a test stand at Parker to determine if the valve was failing electrically or hydraulically. The valve

had previously been removed from another GIV for reports of a hard right turn upon landing. The valve was initially tested under room temperature conditions and it operated normally. The valve was then cold soaked to minus 70 degrees F., and tested with and without electrical input. The servo valve failed in both configurations. After the valve was warmed up to room temperature, the valve operated normally. This testing confirmed, that at minus 70 degrees F., the unit commanded a full flow output, or "hard over," from the "P" to "C2" port.

During the disassembly of the servo valve, it was noted that a small piece of Teflon lacing tape used to secure the motor lead wires was located under the o-ring seal for the torque motor cover. The cover and seal protects the torque motor cavity from the external environment. Moisture was observed under the cover and on the torque motor. Rust was evident on the torque motor frame and magnets. A white powdery substance, consistent to an aluminum corrosion product, was also found at the base of the torque motor, on the magnets and in the armature air gaps. The white powder was removed from the air gaps. The air gaps were cleaned with cleaning alcohol and dried with filtered shop air. The torque motor cover was re-installed. A second room temperature test, and cold soak tests were completed. No further "hard over" conditions were produced.

According to Parker, the hard over condition is consistent with the foreign object (white powder) contaminating the air gaps. The contamination would permit accumulation of moisture, which would freeze when subjected to minus 70 degrees F. The expansion of the ice and contaminant in the air gaps would exert a torque on the torque motor armature, which would offset the torque balance and cause the first stage jet to move, commanding the second stage spool into a hard over (P to C2) condition.

No other airplane system or component anomalies were noted. At 1235, the reported weather conditions at Eagle County Regional Airport was, wind, 000 degrees at 0 knots; visibility, 10 statute miles; sky condition, clear; temperature, -8 degrees C.; dew point, -16 degrees C.; altimeter setting, 30.13. Runway conditions were clear and dry along the center of the runway, with standing water and slush along the edges.

**Probable Cause**

Nose wheel steering system failure due to foreign material substance contamination.