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| **Accident Rpt# CEN16LA291 07/28/2016 1530 CDT** | **Regis# N2033N** | **David City, NE** | **Apt: N/a** | |
| **Acft Mk/Mdl AIR TRACTOR AT602** | **Acft SN 602-1208** | **Acft Dmg: SUBSTANTIAL** | **Rpt Status: Factual** | **Prob Caus: Pending** |
| **Eng Mk/Mdl PRATT & WHITNEY PT6A-65AG** | **Acft TT 1932** | **Fatal 1 Ser Inj 0** | **Flt Conducted Under: FAR 137** | |
| **Opr Name: EMRICH AERIAL SPRAYING, LLC** | **Opr dba:** | | **Aircraft Fire: NONE** | |
| | | | **AW Cert: SPR** | |

## Events

1. Maneuvering - Loss of control in flight

## Narrative

On July 28, 2016, about 1530 central daylight time (CDT), an Air Tractor AT-602, N2033N, impacted A corn field 3 miles northeast of David City, Nebraska. The pilot, the sole occupant on board, was fatally injured. The airplane was destroyed. The airplane was registered to Rayne Aviation, LLC, and operated by Emrich Aerial Spraying, LLC, both of Dorchester, Nebraska, under the provisions of 14 Code of Federal Regulations (CFR) Part 137 as an aerial application flight. Visual meteorological conditions (VMC) prevailed at the time, and no flight plan had been filed. The flight originated from Columbus Municipal Airport (OLU), Columbus, Nebraska, about 1430.

According to Federal Aviation Administration (FAA) inspectors who were on-scene, the airplane had been spraying Headliner Fungicide (pyraclostrobin - a Group 11 fungicide) on a corn field. The accident site was located 200 feet north of County Road 38 and west of County Road O. There was no fire and there were no witnesses to the accident.

The on-scene evidence was consistent with the airplane striking the ground in a right wing slightly low, 60ø nose-down attitude. The airplane rebounded about 20 feet from the initial impact point and came to rest upright facing south. Witness marks in the field were consistent with a large sweep of the right wing through the corn crop, consistent with some right wing-down rolling motion at impact. All impact signatures and crop damage were in a northerly direction, and the debris field was small.

The aft cockpit wall immediately behind the pilot's seat was deformed. Elevator and rudder control continuity was confirmed. Aileron controls were found to be continuous except for fractures at both wing roots. All hardware was found to be properly installed. The Hobbs Meter was destroyed. The airplane was equipped with an inflatable restraint system, and it had deployed. The airplane was equipped with an inflatable restraint system and it had deployed. The flap actuator was found extended 3-7/8". According to Air Tractor, this setting correlated to a flap deflection of 28ø to 30ø. Examination of the engine revealed the fuel control unit (FCU) low pressure fuel filter had dark colored debris on the filter and in the bottom of the filter bowl. The FCU high pressure fuel filter had a chalky gray sediment in the housing. The propeller assembly had fractured off the engine propeller shaft on impact. Two blades remained attached. The other three blades had broken off the hub. One blade was found near the propeller assembly, a second blade was found in front of the fuselage, and the third blades was found several weeks later in a corn field some distance from the main wreckage.

On August 18, 2016, FAA and Pratt & Whitney examined the airplane, engine, propeller, and fuel system at the facilities of Dodson International in Rantoul. Kansas. According to Pratt & Whitney, the engine displayed contact signatures to its internal components, characteristic of the engine making significant power at impact. Engine components displayed no indications of malfunction or pre-impact failure. Examination of the recovered propeller blades and propeller hub bore no indications that the propeller may have been in Beta mode or reverse pitch.

On December 1, 2016, the propeller assembly was further re-examined under the auspices of two FAA inspectors at the facilities of Stallings Aircraft Propeller in Wynne, Arkansas. Representatives from Hartzell Propellers and Air Tractor were in attendance. According to Hartzell's report, blade butt, piston, cylinder, and rod impact marks indicated the propeller was operating at a blade angle range of approximately 16ø to 19ø at impact. The beta ring low pitch for this propeller is 13.9ø and the "hydraulic" (aka "running") low pitch is approximately 7.9ø. The estimated blade angle at impact was above the low pitch stop and in the normal operating range. The report concluded, "There were no discrepancies noted that would prevent or degrade normal propeller operation prior to impact. All damage was consistent with high impact forces with objects and/or terrain."

A SATLOC (an aerial guidance system that allows aerial applicators to view flight information, such as spray and waypoints, and companies to track the position of their aircraft) was recovered from the wreckage and sent to NTSB's Vehicle Recorder Division for download and readout. According to the GPS Specialist's factual report, the airplane had made six previous aerial applications that morning, and was engaged in a seventh application when the accident occurred. During this last application, the airplane made four passes followed by shallow turns in the opposite direction. During these turns, the altitude increased until the airplane reached 90ø abeam the direction of application and descended as it completed the turn on the opposite heading. The last data point

was captured at 15:03:57 as the aircraft was turning to complete its fifth pass. The recorded altitude showed the aircraft was at 1,841 feet msl and at a groundspeed of 96 miles per hour. The spray condition was off. The measured diameter of the airplane's last turn, from the impact point to a point abeam the impact point, was measured to be approximately 750 feet. The diameter of the previous turns throughout the entire accident flight ranged from 600 feet in diameter to over 1,000 feet in diameter. Based on the recorded data, the characteristics of the airplane's last turn prior to impacting the field did not greatly vary from other turns the airplane performed during the accident flight. According to the SATLOC manufacturer, up to six seconds of data may be lost in the volatile memory during a high impact.

According to an Arkansas Air Tractor pilot familiar with this accident, agricultural pilots often make turns with flaps extended to give the airplane greater stability. He said, "Most all the Air Tractors need flaps in turns when carrying a load. There are 3 notches of flaps in the AT-602: 15, 30 and 45ø. Most Air Tractor pilots use 30ø of flaps and keep their speed above 100 knots. There are some pilots who use 45ø but let the airspeed get down to 80 to 90 knots in turns. There are other pilots who do wing-over turns. Some pilots pull their stall warning circuit breaker on the panel to keep it from annunciating during the turn. This 'on the edge' kind of flying is just a bad combination that gets worse as the weather warms up and the density altitude climbs."

The pilot's autopsy report attributed death to "massive blunt trauma secondary to a plane crash." His toxicology report revealed no evidence of carbon monoxide, ethanol, or drugs. Cyanide testing was not performed.

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| **Accident Rpt# WPR17LA177 07/31/2017 1140 PDT** | **Regis# N70LA** | **Wells, NV** | **Apt: Wells Muni/harriet Field LWL** |
| **Acft Mk/Mdl AIR TRACTOR INC AT 802A** | **Acft SN 802A-0102** | **Acft Dmg: SUBSTANTIAL** | **Rpt Status: Factual Prob Caus: Pending** |
| **Eng Mk/Mdl PRATT AND WHITNEY PT6A-67AG** | **Acft TT 3653** | **Fatal 0 Ser Inj 0** | **Flt Conducted Under: FAR PUBU** |
| **Opr Name: HENRY'S AERIAL SERVICE, INC.** | **Opr dba:** | | **Aircraft Fire: NONE** |
| | | | **AW Cert: SPR** |

## Events

1. Landing-landing roll - Loss of control on ground
2. Landing-landing roll - Loss of control on ground

## Narrative

On July 31, 2017, about 1140 Pacific daylight time, an Air Tractor AT-802A, N70LA, was substantially damaged during a landing roll at Wells Municipal Airport/Harriet Field (LWL), Wells, Nevada. The commercial pilot was not injured. The airplane was registered to Custom Air, Inc., operated by Henry's Aerial Service, Inc., and under contract with the Department of the Interior to provide aerial firefighting services. Visual meteorological conditions prevailed and a company flight plan was filed for the cross-country flight that departed Battle Mountain, Nevada, about 1042 as a Public Aircraft flight.

According to the pilot, after an uneventful flight he entered the airport through the left downwind leg of the traffic pattern for runway 26, which was the active runway at the time of the accident. He observed winds from the north about 10 mph based on the position of the midfield windsock and configured the airplane for a wheel landing. The airplane touched down on the main landing gear at approximately 85 mph on the runway centerline. As the airspeed bled off and the tailwheel began to settle down to the runway surface, the pilot lost all rudder and aileron authority. After the airplane entered a hard right turn and began to depart the right side of the runway, the pilot unlocked the tailwheel to regain directional control. Runway tire marks show the airplane begin to slowly veer to the right of the runway centerline, followed by a rapid departure to the right side of the runway. The left main landing gear collided with an imperfection in the asphalt surface and separated. The left wing then impacted the ground and the airplane rotated 180 degrees before it came to rest on the north side of the runway. The pilot reported that he had never experienced a loss of rudder and aileron control in his 3,787 total flight hours of experience in the airplane make and model.

In a subsequent statement, the pilot reported that he did not encounter any mechanical anomalies with the powerplant or control system that could have precluded normal operation during the entire flight, except for the landing phase of flight when he lost rudder and aileron authority. The pilot further stated that he confirmed continuity and function of the rudder and part of the aileron control after the airplane came to rest.

A representative of the Department of the Interior reported that he observed a build-up of fire retardant inside the porthole of the tailwheel lock. He further stated that he confirmed function of the rudder, elevator and partial movement of the aileron, which had been damaged at the accident site.

The airplane manufacturer reported that landing with the tailwheel unlocked can manifest as a noticeable shimmy, but is not likely to result in a loss of directional control. Additionally, the pilot is not likely to observe any unusual flying characteristics or vibrations if the tailwheel remains unlocked during flight. If the airplane touches down with the tailwheel in the "unlocked" position, the pilot's attempt to move the lock lever to the "locked" position may or may not successfully lock the tailwheel.

An NTSB weather study did not show any surface frontal boundaries near the accident site around the time of the accident. In addition, a 500-hectopascal (hPa) chart, around 18,000 feet msl, showed a large ridge of high pressure over the western United States at 0500 PDT on the accident day. These two charts indicated that with no strong surface, mid-, or upper-level features, the daily valley/mountain breezes and thermals would be the main weather interactions on the accident day. These daily circulations include variable winds during the morning hours, with a more consistent wind around lunchtime through sunset. Visible imagery from 1830 UTC and 1845 UTC showed isolated cumulus clouds around the accident site, likely indicating that the thermals were the biggest driver in up and down motions around the terrain of the accident site. The upper air sounding using a weather model for the accident site for 1100 PDT did not indicate any low-level wind shear or turbulence below 10,000 feet msl, with an east to northeast wind around 5 to 10 knots from the surface through 10,000 feet msl.

According to the LWL airport manager, the airport is equipped with two windsocks; both located south of runway 26 about midfield. She further remarked that in the summertime the area is occupied with thermals and other weather phenomena. Each year she receives reports from pilots who experience unforeseen rapid yaw moments, and losses of directional control, both in the airport traffic pattern and on the ground, sometimes accompanied by an impact with a runway light. These sudden changes in flight performance are reported during times of wind circulation and thermal activity.

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| **Accident Rpt# DCA17CA123** | **05/21/2017 1930 CDT** | **Regis# N512NK** | **South Toledo Be, TX** | **Apt: N/a** |
| **Acft Mk/Mdl AIRBUS A319 132-132** | | **Acft SN 2673** | **Acft Dmg: NONE** | **Rpt Status: Prelim** **Prob Caus: Pending** |
| | | | **Fatal 0** **Ser Inj 1** | **Flt Conducted Under: FAR 121** |
| **Opr Name: SPIRIT AIRLINES, INC.** | | **Opr dba:** | | **Aircraft Fire: NONE** |



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| **Incident Rpt# DCA17IA020** | **10/27/2016 1942 EDT** | **Regis# N278EA** | **New York, NY** | **Apt: New Yor La Guardia LGA** |
| **Acft Mk/Mdl BOEING 737 7L9-7L9** | | **Acft SN 28006** | **Acft Dmg: MINOR** | **Rpt Status: Factual Prob Caus: Pending** |
| **Eng Mk/Mdl CFM INTL. CFM56-7B** | | **Acft TT 48179** | **Fatal 0 Ser Inj 0** | **Flt Conducted Under: FAR 121** |
| **Opr Name: EASTERN AIRLINES GROUP, INC.,** | | **Opr dba:** | | **Aircraft Fire: NONE** |
| | | | | **AW Cert: STT** |


**Summary**

Automatic terminal information service (ATIS) "Bravo" was current when the first officer, who was the pilot flying, began to brief the instrument landing system approach for runway 22. The ATIS indicated visibility 3 miles in rain, ceiling 1,500 ft broken, overcast at 2,200 ft, wind from 130§ at 9 knots, and that braking action advisories were in effect. The approach briefing included the decision altitude and visibility for the approach and manual deployment of the speed brakes by the captain, with the captain stating "you're gonna do these. I'm gonna do this" to which the first officer replied "[that] is correct." (The airplane's automatic speed brake module had been deactivated 2 days before the incident and deferred in accordance with the operator's minimum equipment list, which was appropriate).

The flight crew completed the approach briefing after descending through 18,000 ft mean sea level and completed the landing checklist when the airplane was near the final approach fix. The airplane was configured for landing with the autobrake set to 3 and the flaps set to 30§. ATIS information "Charlie" was current at that time and indicated visibility 3 miles in rain, ceiling 900 ft broken, overcast at 1,500 ft, and wind from 120§ at 9 knots.

Flight data recorder (FDR) data and postincident flight crew statements indicate that the airplane was stabilized on the approach in accordance with the operator's procedures until the flare. The airplane crossed the runway threshold at 66 ft radio altitude at a descent rate of 750 ft per minute. When the airplane had traveled about 2,500 ft beyond the runway threshold, its descent rate decreased to near zero, and it floated during the flare. Its pitch attitude started to increase in the flare from 2.8ø at a radio altitude of about 38 ft, which is high compared to the 20 ft recommended by the Boeing 737 Flight Crew Training Manual. Further, the first officer didn't fully reduce the throttles to idle until about 16 seconds after the flare was initiated and after the airplane had touched down. The initiation of the flare at a relatively high altitude above the runway and the significant delay in the reduction of thrust resulted in the airplane floating down the runway, prompting the captain to tell the first officer to get the airplane on the ground, stating "down down down down you're three thousand feet remaining."

The airplane eventually touched down 4,242 ft beyond the runway threshold. According to the operator's procedures, the touchdown zone for runway 22 was the first third of the 7,001-ft-long runway beginning at the threshold, or 2,334 ft. Touchdown zone markers and lights (the latter of which extended to 3,000 ft beyond the threshold) should have provided the flight crew a visual indication of the airplane's distance beyond the threshold and prompted either pilot to call for a go-around but neither did. The point at which the airplane touched down left only about 2,759 ft remaining runway to stop. The airplane's groundspeed at touchdown was 130 knots.

The captain manually deployed the speed brakes about 4.5 seconds after touchdown and after the airplane had traveled about 1,250 ft down the runway. Maximum reverse thrust was commanded about 3.5 seconds after the speed brakes were deployed, and, with fully extended speed brakes and maximum wheel brakes (which were applied at main gear touchdown) the airplane achieved increasingly effective deceleration. Its groundspeed was about 35 knots when it entered the EMAS. With the effective deceleration provided by the fully extended speed brakes, maximum wheel brakes, and reverse thrust, the flight crew would have been able to safely stop the airplane if it had touched down within the touchdown zone.

The captain later stated that he had considered calling for a go-around before touchdown but the "moment had slipped past and it was too late." He said that "there was little time to verbalize it" and that he instructed the first officer to get the airplane on the ground rather than call for a go-around. He reported that, in hindsight, he should have called for a go-around the moment that he recognized the airplane was floating in the flare. The first officer said that he did not consider a go-around because he did not think that the situation was abnormal at that time.

Training and practice improve human performance and response time when completing complex tasks. In this case, the operator's go-around training did not include any scenarios that addressed performing go-arounds in which pilots must decide to perform the maneuver rather than being instructed or prompted to do so. Thus, the incident flight crew lacked the training and practice making go-around decisions, which contributed to the captain's and first officer's failure to call for a go-around.

Following the incident, the operator incorporated go-around training scenarios in which flight crews must decide to go around rather than being instructed to do so. The company's director of operations also stated that the company has incorporated scenarios in which go-arounds are initiated from idle power and

rejected landings are performed after touchdown with the automatic speed brake inoperative. It also added a training module emphasizing that "if touchdown is predicted to be outside of the [touchdown zone], go around" and intended to require a go-around if landing outside of the touchdown zone were predicted. The operator also intended to incorporate go-around planning into the approach briefing. Flight crews would determine the cues for the touchdown zone using the airport diagram and decide at which point they would initiate a go-around if the airplane had not touched down.

Given the known wet runway conditions and airplane manufacturer and operator guidance concerning "immediate" manual deployment of the speed brakes upon landing, the captain's manual deployment of the speed brakes was not timely. NTSB analysis of FDR data for previous landings in the incident airplane determined an average of 0.5 second for manual deployment of the speed brakes. Using the same touchdown point as in the incident, postincident simulations suggest that, if the speed brakes had been deployed 1 second after touchdown followed by maximum reverse thrust commanded within 2 seconds, the airplane would have remained on the runway surface. Therefore, the captain's delay in manually deploying the speed brake contributed to the airplane's runway departure into the EMAS.

During the landing roll, the captain did not announce that he was assuming airplane control, contrary to the operator's procedures, and commanded directional control inputs that countered those commanded by the first officer. The captain later reported that he had forgotten that an EMAS was installed at the end of runway 22 and attempted to avoid the road beyond the runway's end by applying right rudder because he thought it would be better to veer to the right. However, the first officer applied left rudder to maintain alignment with the runway centerline and to counter the airplane pulling "really hard" to the right because of the captain's inputs. The breakdown of crew resource management during the landing roll and the captain's failure to call for a go-around demonstrated his lack of command authority, which contributed to the incident.

At the time of the incident, EMAS training was not part of the operator's pilot training program, but such training was added after the incident. The circumstances of this event suggest that the safety benefit of EMASs could be undermined if flight crews are not aware of their presence or purpose.

## Cause Narrative

THE NATIONAL TRANSPORTATION SAFETY BOARD DETERMINED THAT THE CAUSE OF THIS OCCURRENCE WAS: The first officer's failure to attain the proper touchdown point and the flight crew's failure to call for a go-around, which resulted in the airplane landing more than halfway down the runway. Contributing to the incident were, the first officer's initiation of the landing flare at a relatively high altitude and his delay in reducing the throttles to idle, the captain's delay in manually deploying the speed brakes after touchdown, the captain's lack of command authority, and a lack of robust training provided by the operator to support the flight crew's decision-making concerning when to call for a go-around.

## Events

1. Landing-flare/touchdown - Landing area overshoot
2. Landing-landing roll - Runway excursion

## Findings - Cause/Factor

1. Personnel issues-Task performance-Use of equip/info-Use of policy/procedure-Copilot - C
2. Personnel issues-Task performance-Use of equip/info-Use of policy/procedure-Flight crew - C
3. Personnel issues-Action/decision-Action-Lack of action-Flight crew - C
4. Aircraft-Aircraft oper/perf/capability-Performance/control parameters-Landing flare-Not specified - F
5. Personnel issues-Action/decision-Action-Delayed action-Copilot - F
6. Personnel issues-Action/decision-Action-Delayed action-Pilot - F
7. Personnel issues-Action/decision-Info processing/decision-Decision making/judgment-Pilot - F
8. Organizational issues-Support/oversight/monitoring-Training-Recurrent training-Operator - F

## Narrative

HISTORY OF FLIGHT

**This report was modified on September 18, 2017. Please see the docket for this accident to view the original report.**

On October 27, 2016, about 1942 eastern daylight time, Eastern Air Lines flight 3452, a Boeing 737-700, N923CL, overran runway 22 during the landing roll at LaGuardia Airport (KLGA), Flushing, Queens, New York. The airplane traveled through the right forward corner of the engineered materials arresting system (EMAS) at the departure end of the runway and came to rest off the right side of the EMAS. The 2 certificated airline transport pilots, 7 cabin crewmembers, and 39 passengers were not injured and evacuated the airplane via airstairs. The airplane sustained minor damage. The charter flight was operating under the provisions of 14 Code of Federal Regulations Part 121. Night instrument flight rules conditions prevailed at the airport at the time of the incident, and an instrument flight rules flight plan was filed for the flight, which originated at Fort Dodge Regional Airport (KFOD), Fort Dodge, Iowa, about 1623 central daylight

time.

The first leg of the trip began on October 14, 2016, and the captain and first officer were paired from then to the incident. In postincident statements, the flight crew indicated that the captain was the pilot monitoring (PM) for the incident flight, and the first officer was the pilot flying (PF). The first officer reported that the autopilot and autothrottles were engaged beginning about 2,500 ft after their takeoff from KFOD. Both pilots stated that the en route portion of the flight and the descent into the terminal area were uneventful but they encountered moderate-to-heavy rain during the final 15 minutes of the flight.

According to information from the airplane's cockpit voice recorder (CVR), the first officer partially briefed the instrument landing system (ILS) approach for runway 13 beginning about 1848, indicating an autobrake setting of 3 and a 30§ flap setting. ATIS information "Bravo" was current at that time and indicated visibility 3 miles in rain, ceiling 1,500 ft broken, overcast at 2,200 ft, wind from 130§ at 9 knots, and that braking action advisories were in effect. About 1852, the first officer began briefing the ILS approach for runway 22 after the captain clarified, based on the ATIS recording, that runway 13 was being used for departures.

About 1902, as the airplane descended through 18,000 ft msl, the flight crew completed the approach briefing for runway 22, with the same autobrake and flap setting as indicated earlier, as well as the decision altitude and visibility required for the approach, the touchdown zone elevation, and a reference speed (Vref) of 137 knots. ATIS information "Charlie" was current at that time and indicated visibility 3 miles in rain, ceiling 900 ft broken, overcast at 1,500 ft, and wind from 120§ at 9 knots.

The flight crew also discussed the captain manually deploying the speed brakes (the airplane's automatic speed brake module had been deactivated 2 days before the incident and deferred in accordance with the company's minimum equipment list (MEL), with corrective action scheduled for November 4, 2016). In reference to the manual deployment of the speed brakes, the captain stated at 1902:44.5 "you're gonna do these. I'm gonna do this" to which the first officer replied "[that] is correct."

About 1927, the flight was provided vectors to the final approach course for the ILS approach to runway 22. About 1936, the flight was cleared for the approach. The first officer then called for the landing gear to be extended and the flaps set at 15§. About 1937, the captain stated that the localizer and glideslope were captured. About 1938, as the airplane neared the final approach fix, the flight crew completed the landing checklist and configured the airplane for landing, with flaps set to 30§.

The CVR indicates that the captain pointed out the approach lights about 1939. The first officer reported, and flight data recorder (FDR) data indicate, that about 1940:12, he disconnected the autopilot when the airplane's altitude was about 300 ft radio altitude, as required by Eastern Air Lines standard operating procedure. FDR data indicate that the first officer disconnected the autothrottles about 1940:19.

FDR data indicate that, shortly after the first officer disconnected the autopilot and autothrottles (about 300 ft radio altitude), the airplane began to increasingly deviate above the glideslope beam and crossed the threshold at a height consistent with the threshold crossing height of the VGSI, which was not coincident with the glide slope beam. CVR data indicate that between 1940:35 and 1940:46, the enhanced ground proximity warning system alerted the decreasing altitude in increments of 10, beginning at 50 ft. The pitch attitude started to increase in the flare from 2.8ø at a radio altitude of about 38 ft. After the 20-ft alert, the captain stated "down" at 1940:43.3. After the 10-ft alert, the captain stated, "down down down down you're three thousand feet remaining" at 1940:46.6. There was no callout of spoilers or thrust reversers during the rollout on the CVR.

FDR data and performance calculations indicate that the airplane crossed the runway threshold at a radio altitude of 66 ft, with an increasing glideslope deviation and a descent rate of about 750 ft per minute. When the airplane had traveled about 2,500 ft beyond the runway threshold, its descent rate decreased to near zero, and it floated before touching down. The captain later reported that the descent to the touchdown zone was normal until the flare. He stated that the airplane floated initially in the flare, which prompted the captain to tell the first officer to "get it down."

The first officer recalled hearing the captain's instruction to "put [the airplane] down" during the flare but was not certain how far down the runway the airplane touched down. FDR data indicate that, at 1940:51.8, the airplane's main landing gear touched down; maximum manual wheel brakes were applied at main gear touchdown. The throttles were not fully reduced to idle until about 16 seconds after the flare was initiated, and after the airplane had touched down. The touch down point was about 4,242 ft beyond the threshold of the 7,001-ft-long runway. The nose gear initially touched down about 2 seconds after the main landing gear but rebounded into the air due to aft control column input. The nose gear touched down a second and final time at 1940:56.8.

The captain reported that, as briefed, he manually deployed the speed brakes, which FDR data indicate were manually extended to full at 1940:56.3, about 4.5 seconds after the main landing gear touched down and the airplane had traveled about 1,250 ft farther down the runway from the touchdown point. At 1940:59.8, when the airplane had traveled about 1,650 ft down the runway from the touchdown point (and 5,892 ft from the threshold), maximum reverse thrust was commanded. The captain reported that he saw the end of the runway approaching and began to apply maximum braking, as well as right rudder because he thought it would be better to veer to the right rather than continue straight to the road beyond the end of the runway.

The first officer reported that the captain did not, as required in the operator's procedures, tell him that he was attempting to brake and steer the airplane during the landing rollout, and no such callout is recorded on the CVR. The first officer stated that the airplane was pulling to the right "really hard," which prompted him to apply left rudder. He reported that the left rudder input was counter to his expectation due to a 9-knot crosswind from the left, which he expected to counteract with right rudder input. He attempted to maintain alignment with the runway centerline by applying left rudder and overriding the autobrakes with pressure on the brake pedal.

At 1941:08.3, the CVR recorded the sound of rumbling, consistent with the airplane exiting the runway. The airplane then entered the EMAS about 35 knots groundspeed and came to rest 172 ft beyond the end of the runway and to the right of the EMAS. Review of the CVR recording revealed that, after the airplane came to a stop, the first officer twice remarked that they should have conducted a go-around, and the captain agreed. The first officer later reported that he did not believe the approach or landing were abnormal at the time. The captain later stated that he should have called for a go-around when the airplane floated during the flare.

PERSONNEL INFORMATION

The Captain

The captain, age 58, held an airline transport pilot (ATP) certificate with a rating for airplane single- and multiengine land with commercial privileges, with type ratings on the Boeing 737, DC-10, DC-8, and MD-11, Bombardier CL-65, BAE Systems HS-114, and Lockheed Martin L-188. He also held a Federal Aviation Administration (FAA) first-class medical certificate dated July 20, 2016, with a limitation for glasses or corrective lenses for near and intermediate vision. He was hired by Eastern Air Lines in June 2015 as a first officer and upgraded to captain in February 2016, when he received captain leadership training. At the time of the incident, he was based in Miami, Florida.

Before joining Eastern Air Lines, the captain was a pilot at Centurion Cargo, where he was hired as a first officer on the DC-10 in 2005 and subsequently upgraded to captain on the MD-11 in 2010. According to Eastern Airlines personnel records, the captain had 20,638 hours of flight experience, 14,767 hours pilot-in-command (PIC) time, with 3,000 hours on 737s and 202 hours as PIC on 737s. He flew 75 hours, 28 hours, and 11 hours during the 90-, 30-, and 7-day periods, respectively, preceding the incident. He also reported flying 1.5 hours during the 24-hour period before the incident.

His most recent 737 proficiency check occurred March 16, 2016. A review of FAA records found no prior accident, incident, or enforcement actions.

72-Hour History

On Monday, October 24, the captain flew from Indianapolis, Indiana, to Charlotte, North Carolina; Charlotte to Greensboro, North Carolina; and Greensboro to Indianapolis, arriving at 2119 EDT. He went to bed about 0030 EDT and slept until 1100 EDT.

On Tuesday, October 25, he and the first officer flew commercially to Salt Lake City, Utah, via Minneapolis, Minnesota. After arriving about 1700 mountain daylight time (MDT), he went to dinner with his son. He watched television for about an hour and went to sleep about 2230 MDT.

On Wednesday, October 26, he slept until 0800 MDT and went to breakfast about 1000 MDT. He met his son briefly in the morning and flew from Salt Lake City to Colorado Springs, Colorado, then Colorado Springs to Omaha, Nebraska. He was off duty at 2356 CDT and went to bed about 0130 CDT on October 27.

On Thursday, October 27, he awoke about 0830 CDT. He reported having no difficulties sleeping that night and stated that, when he awoke, he felt as rested as could be expected with "normal flying" 14 days into a trip (the first leg of the captain's trip began on October 14). He took a shuttle to the airport about 1000 CDT. He flew to KFOD from which he departed for the incident flight to KLGA.

The First Officer

The first officer, age 49, held an ATP certificate with a rating for airplane single- and multiengine land with commercial privileges and with type ratings on the Boeing 737, Cessna Citation CE-500, and Embraer ERJ-170 and ERJ-190. He also had an FAA first-class medical certificate dated October 11, 2016, with a limitation for glasses for near vision. His date of hire with Eastern Air Lines was December 1, 2015. At the time of the incident, he was based in Miami, Florida.

Prior to Eastern Air Lines, he was employed by Republic Airlines as a pilot flying the ERJ-170. In 2007, he began working as a flight instructor, which he did for about 5 years. He began flight training in 2002. According to Eastern Airlines personnel and FAA records, the first officer had 6,200 hours of flight experience, 3,137 hours PIC time, and 225 hours on 737s. He flew 57 hours, 35 hours, and 11 hours during the 90-, 30-, and 7-day periods, respectively, preceding the incident. He also reported flying 1.5 hours during the 24-hour period before the incident.

The first officer's most recent 737 proficiency check occurred February 2, 2016. A review of FAA records found no prior accident, incident, or enforcement actions.

72-Hour History

On Monday, October 24, the first officer had a 31-hour rest period in Indianapolis that ended at 1530 EDT. He flew from Indianapolis to Charlotte, Charlotte to Greensboro, and Greensboro to Indianapolis. He reported sleeping well that night but did not indicate when he went to bed.

He awoke between 0815 to 0830 EDT on Tuesday, October 25. He flew from Indianapolis to Salt Lake City arriving about 1641 MDT. He estimated he went to bed between 0130 and 0200 MDT on October 26.

On Wednesday, October 26, he had a report time of 1540 MDT and flew from Salt Lake City to Colorado Springs then to Omaha. He went to bed around 0100 CDT on October 27.

He estimated that he awoke between 0815 to 0830 CDT on Thursday, October 27, and ate breakfast. He could not recall the quality of his rest the night before the incident. He remained in the hotel after breakfast and went to the gym, worked out, and did laundry. He then showered and departed for the airport. He operated the flight to KFOD then departed on the incident flight to KLGA.

AIRCRAFT INFORMATION

The Boeing 737-700 airplane, serial number 28006, was manufactured May 15, 1998, and equipped with two CFM International CFM56-7B22 engines. At the time of the incident, the airplane had accumulated 48,179 hours of operation, the No. 1 (left) engine had 34, 671 hours, and the No 2. (right) engine had 20,456 hours.

The airplane was equipped with an auto speed brake system that, when armed, automatically deployed the spoilers after touchdown to reduce the airplane's lift and increase the effectiveness of the wheel brakes. Alternatively, the flight crew could use the speed brake lever to deploy the spoilers manually. As previously mentioned, the system's automatic mode was inoperative; maintenance records indicate that a ground spoiler did not automatically deploy during a previous landing. The status of the automatic mode was indicated by a paper sticker wrapped around the base of the speed brake handle. In addition, the amber SPEED BRAKE DO NOT ARM light above the captain's right display unit illuminated when the automatic mode was unavailable. The flight crew's paperwork for the flight contained the procedures for the MEL item (see Organization and Management Information for more information).

Each engine was equipped with a hydraulically operated thrust reverser, which consisted of left and right translating sleeves. Reverse thrust was produced by aft movement of the reverser sleeves, which caused blocker doors to deflect fan discharge air forward through fixed cascade vanes. According to manufacturer guidance, thrust reversers are manually deployed after touchdown to slow the airplane, reducing stopping distance and brake wear.

The autobrake system, which is part of the airplane's hydraulic brake system, monitored the airplane's deceleration after landing and metered hydraulic pressure (via the antiskid/autobrake control unit) to the brakes to achieve the level of deceleration selected by the autobrake select switch. The switch on the incident airplane was found positioned at "3." A manual brake application by either flight crewmember would override and disarm the autobrake system.

The airplane's antiskid system controlled the brakes to prevent the wheels from skidding during braking action. An antiskid transducer was located in each main landing gear axle to provide the system with rotational wheel speed. The system monitored the speed and metered hydraulic pressure to each brake to prevent skidding (see the Tests and Research section for additional information on this system).

Weight and Balance

Eastern Air Lines used the Jeppesen JetPlanner and a nomograph as the primary means of producing weight and balance and performance data for each flight. In accordance with the operator's procedures, following the calculations, flight crews loaded weight and balance information into the airplane's flight management system. Flight 3452 landed with a gross weight of about 116,560 pounds and a center of gravity (CG) of about 21.5 inches. According to operator and manufacturer guidance, the maximum landing weight as 129,000 pounds and the CG range was 10 to 28 inches.

METEOROLOGICAL INFORMATION

At 1851 EDT, (ASOS) at KLGA reported the wind from 090ø true at 9 knots, visibility of 3 statute miles (sm), moderate rain, ceiling broken at 900 ft agl, overcast clouds at 1,500 ft agl, temperature of 13øC and a dew point temperature of 11øC, and altimeter setting of 30.14 inches of mercury. Remarks included: surface visibility of 4 sm, precipitation accumulation of 0.14 inch since 1751 EDT.

At 1951 EDT, KLGA ASOS reported the wind from 100ø true at 10 knots with gusts to 15 knots, visibility of 3 sm, moderate rain, mist, ceiling overcast at 1,000 ft agl, temperature of 13øC and a dew point temperature of 12øC, and an altimeter setting of 30.10 inches of mercury. Remarks included: surface visibility of 4 sm, precipitation accumulation of 0.32 inch since 1851 EDT, precipitation accumulation of 0.61 inch during previous 3 hours.

COMMUNICATIONS

No problems with communications equipment were reported.

AIRPORT INFORMATION

KLGA is located about 8 miles east of Manhattan in the borough of Queens and is operated by the Port Authority of New York and New Jersey. The airport has an elevation of 22 ft and borders Flushing Bay and Bowery Bay. KLGA has two intersecting runways, 4/22 and 13/31, which were extended over water to their present length and width in 1966. Runway 22 was 7,001 ft long and 150 ft wide with a touchdown zone elevation of 12.4 ft mean sea level and a grooved paved surface constructed of asphalt and concrete. The runway had 7,001 ft of landing distance available. The ILS glideslope beam intersected the runway 1,022 ft from the threshold, leaving 5,979 ft of runway remaining.

Touchdown zone markers on runway 22 were positioned 500; 1,200; 2,000; and 2,500 ft from the threshold. Touchdown zone lights-two rows of steady burning white transverse light bars-ran symmetrically about the runway centerline from 100 ft beyond the threshold to 3,000 ft beyond the threshold, and lighted signs indicating remaining runway distance were placed at 1,000-foot increments from the runway end. The runway was also equipped with edge lights, centerline lights (which were out of service at the time of the incident), runway end identifier lights, and a four-light PAPI located on the right side of the runway with an ILS glideslope of 3.0§ and a threshold crossing height of 52 ft. The visual glideslope indicator angle was 3.0§ with a threshold crossing height of 67 ft (as mentioned previously, the visual glideslope indicator and the ILS were not coincident).

A 272-ft-long by 170-ft-wide EMAS was set back about 30 ft from the end of runway 22; it was originally installed in 2005 and replaced in 2014. The EMAS used crushable material designed to decelerate and stop an aircraft, traveling up to 80 mph (about 69.5 knots), that overruns the runway. This technology was developed and implemented to improve safety at airports where the full 1,000-ft runway safety area beyond a runway's end could not be obtained due to a lack of available land or obstacles, such as bodies of water, highways, railroads, populated areas, or terrain with a severe dropoff.

According to an FAA fact sheet (https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=13754; accessed June 6, 2017), as of November 2016, there have been 11 incidents in the United States-in addition to the event involving flight 3452-in which an EMAS has safely stopped an overrunning aircraft, with a total 247 passengers and crewmembers on board.

FLIGHT RECORDERS

The airplane was equipped with a cockpit voice recorder (CVR) and a flight data recorder (FDR). Both recorders were removed from the airplane and retained by the NTSB for further examination and readout at the NTSB's Recorder Laboratory in Washington, DC. The recorders showed no signs of damage.

Cockpit Voice Recorder

The CVR, a Honeywell 6022, serial number 3452, was a solid-state CVR that recorded 120 minutes of digital audio. It was played back normally without difficulty and contained excellent quality audio information. The recording was transcribed in two parts focusing on the en route approach briefing and the approach, landing, and events thereafter until the end of the recording. Part one began at 18:48:06 EDT, when flight 3452 was en route at FL390, and continued until 1902:52 EDT. Part two began at 1918:01 EDT and ended at 1948:32 EDT (the end of the recording). The transcript and additional information about the recording are included in the CVR Group Chairman's Factual Report.

Flight Data Recorder

The FDR, a Honeywell 4700, serial number SSFDR-16936, recorded airplane flight information in digital format using solid-state flash memory as the recording medium. The FDR could record a minimum of 25 hours of flight data and was configured to record 256 12-bit words of digital information every second. The FDR was designed to meet the crash-survivability requirements of Technical Standard Order C-124.

Data from the FDR were extracted normally. The event flight was the last flight of the recording, and its duration was about 2 hours and 19 minutes. Details of the FDR evaluation are available in the FDR Specialist's Factual Report.

WRECKAGE AND IMPACT

As a result of the airplane's travel through the EMAS, pulverized EMAS material (a gray, powdery residue) was noted on portions of the airplane's exterior during postincident examination. The lower and forward portions of the airplane-fuselage, landing gear, and antennas-were coated with a dried residue resulting from the mixture of the EMAS material and rainwater. In addition, pieces of a matting material used in the EMAS were found in various locations on the airplane.

No damage or anomalies were noted during the visual examination of the nosewheel landing gear and associated assemblies. A preliminary visual examination of the main landing gear strut, doors, assemblies, associated hydraulic lines, and antiskid components did not reveal evidence of physical damage. However, after the airplane was cleaned of EMAS debris and the main landing gears were retracted, damage was noted on the underside of each gear strut. The operator indicated that the lower wire bundle support brackets for the left and right main landing gear were both damaged, as well as the wire conduit sleeve on the left main landing gear.

Each of the four main wheel tires showed cut damage in addition to normal wear. None of the observed cuts were deep enough to reach the tire treads. No flat spots or other evidence of hydroplaning was noted on any of the tires. Examination of the four brake assemblies found no evidence of damage or hydraulic leaks. No evidence of a hydraulic power malfunction or damage to any of the visible hydraulic lines was noted.

Both engines showed evidence of EMAS material and matting on the engine inlet and internal components. The No. 1 engine sustained fan blade damage, including four blades bent in the direction opposite of rotation, at the tip corner. No visible blade damage was noted on the No. 2 engine. Visual examination of the thrust reversers found no preincident anomalies. The operator later reported that, after cleaning and deploying the thrust reversers, damage was found on the inboard thrust reverser sleeves and blocker doors for both engines.

Examination of the speed brake control components on the incident airplane noted the speed brake handle positioned full forward. All spoiler panels, including the ground spoilers, were found in the down or retracted position. No damage was noted to any of the ground spoilers.

MEDICAL AND PATHOLOGICAL INFORMATION

Eastern Air Lines conducted drug and alcohol testing for both pilots about 6 hours after the incident. Test results were negative for alcohol and major drugs of abuse.

TESTS AND RESEARCH

An analysis of the FDR data performed by Boeing and reviewed by the NTSB showed that the airplane was in a turbulent atmosphere with an increasing tailwind as it approached runway 22. At touchdown, the tailwind was about 10 knots (which is the maximum specified in the Boeing 737 Flight Crew Operations Manual), and the airplane's airspeed was 123 knots, its groundspeed was 130 knots, and its sink rate was 3.3 ft per second. Boeing's analysis indicated that (the eventual) full deflection of the speed brakes, maximum wheel brakes, and maximum reverse thrust provided effective deceleration. From the time the nose gear touched down to the time the airplane entered the EMAS, the airplane's braking coefficient varied between 0.2 and 0.4. The increasing left control wheel input, which reached 50§ by 1941:09, reduced the spoiler deflections on the right wing, in accordance with the airplane's design.

Boeing conducted a simulation of the airplane's stopping performance at the request of the NTSB. The simulation revealed that, had the speed brakes been manually deployed within 1 second of touchdown (the criteria for automatic deployment), followed by thrust reverser deployment 7 seconds later, the airplane's CG would have remained on the runway surface and only the nose of the airplane would have exited the runway surface. If, in addition to the prompt deployment of the speed brakes, the thrust reversers had been deployed about 2 seconds (instead of 7 seconds) after manual speed brake deployment, the entire airplane would have remained on the runway surface. NTSB review of FDR data for previous landings of the incident airplane determined an average of 0.5 second for manual deployment of the speed brake.

The autobrake and antiskid systems were tested and no faults were found. In addition, no pre-existing faults were recorded.

ORGANIZATIONAL AND MANAGEMENT INFORMATION

Company Overview and Management Organization

Eastern Air Lines, Inc., received certification to operate as a Part 121 supplemental carrier on May 15, 2015. Subsequently, Eastern Air Lines began scheduled charter services to Havana and four other cities in Cuba. Before the incident, the airline also launched charter service to other Latin American and Caribbean destinations. The airline's sole base of operations was at Miami International Airport, Miami, Florida, at the time of the incident. It employed 64 pilots and had a fleet of five Boeing 737 airplanes, including the incident airplane; the other four airplanes were Boeing 737-800 series.

The airline's vice president of flight operations was responsible for the flying operations of the airline, flight crew training, the operations control center (OCC), and ground operations. The chief pilot, manager of flight operations training, director of inflight, OCC director, manager of flight standards, and manager of charter operations all reported to the vice president of flight operations.

At the time of the incident, Eastern Air Lines' director of safety and security reported directly to the chief executive officer and was the only staffed position in the safety department. The director of safety and security had been hired about 2 weeks before the incident and was in the process of being trained by his predecessor, who had held the position from 2013 until September 2016. While he was being trained, the vice president of regulatory compliance served as the acting director of safety and security.

According to the vice president of flight operations and the manager of flight operations training, the Boeing 737 Flight Crew Training Manual and the Boeing 737 Flight Crew Operations Manual were used as the airline's systems training material and procedures manual, respectively.

Safety Management

The FAA approved Eastern Air Lines' safety management system (SMS) implementation plan in February 2016. The first segment of implementation included administering the SMS implementation plan and developing a tool (Aviation Resource Management Solutions) that was designed to help the company with safety risk assessment, assurance, and risk management. The former director of safety and security stated that, at the time of the incident, the first segment of the implementation was not fully realized and they were working toward an October 30, 2016, full implementation date.

Crew Resource Management (CRM) and EMAS Training

The manager of flight operations training at the time of the incident was also a check airman. He had been manager of training for about 1.5 years and had

been with the company for 2 years.

The airline provided three courses on CRM: new hire, captain's upgrade, and recurrent. The new hire CRM course consisted of a 2-hour segment covering CRM background, communications processes and decision behavior, team building and leadership, workload management and situational awareness, individual factors and stress reduction, and error management. The upgrade training included 1 day of ground school in which 1 hour was dedicated to CRM. Upgrade training also incorporated a captain's leadership course that included content on the captain's authority, briefings, workload management, and sterile cockpit procedures in accordance with 14 CFR 121.542, "Flight Crewmember Duties." The recurrent training included a 3.5-day ground school for captains and first officers in which 1 hour was devoted to CRM training. All courses were taught using presentation slides, open discussion, and videos created by contracted training organizations.

The captain reported after the incident that he believed he and the first officer were working well as a crew during the trip. He stated that he did not call for a transfer of controls during the landing rollout and that, in hindsight, he should have. He further mentioned that he thought it was "OK" for both crewmembers to be applying brakes. The first officer reported a "lack of communication" during the landing rollout because the captain did not say that he was taking control of the airplane. Another Eastern Air Lines first officer who had flown with the captain before the incident described the captain's CRM as "good."

At the time of the incident, EMAS training was not part of Eastern Air Lines' pilot training program. The captain stated during postincident interviews that he had forgotten that an EMAS was installed at the end of runway 22, that he had read about the systems, but had not had any training on them.

FAA Oversight

The former FAA principal operations inspector (POI) stated that he had been assigned to Eastern Air Lines before the company received its operating certificate. He stated that his duties included, most critically, surveillance and reviewing the airline's manuals, including any changes to the manuals. He traveled to the airline's headquarters about once or twice a week. He also stated that he interacted most with the operations management, director of safety and security, and the CEO.

The former director of safety and security stated that during his time at Eastern Air Lines, he "seldom" interacted with the FAA POI or other FAA personnel. Other management personnel stated they interacted with the FAA daily or multiple times per week, via telephone, e-mail, or in person at the FAA's office or at Eastern Air Lines' office. The manager of flight operations training stated that he did not directly interact with the POI and usually went through the vice president of flight operations or the chief pilot. The vice president of flight operations stated that they had been assigned a new POI 5 months before the incident and that the interaction with the new POI was "really great."

The FAA POI at the time of the incident reported that he mostly communicated with Eastern Air Lines' director of flight operations and chief pilot but had also communicated with the director of flight training. He categorized the communication as "very good." He added that Eastern Air Lines was the only certificate he managed and that FAA resources were limited such that they only had one person in the office who was able to conduct checkrides in the Boeing 737. He estimated that he was at Eastern Air Lines' operations a "couple of times a week;" however, he had not taken part in Eastern Air Lines' pilot training. He also stated that the training in the manual for a go-around was similar to the syllabus used by other airlines, and he "assumed" that they did some go-around training in the flare and some training in low visibility. The POI stated that, following the incident, he and Eastern Air Lines management had discussed training go-arounds once the airplane was on the ground and that further discussion was needed.

Operational Procedures and Guidance

Missed Approach/Go-Around, Rejected Landing Guidance

Stabilized Approach Procedures. Stabilized approach criteria for precision approaches in IMC are defined in chapter 9, "Flight Policies-Phase of Flight" of the Eastern Air Lines Flight Operations Manual (FOM) and are described as follows: WARNING: DO NOT ATTEMPT TO LAND FROM AN UNSTABILIZED APPROACH. THE DECISION TO GO AROUND IS NOT AN INDICATION OF POOR JUDGMENT, BUT RATHER GOOD JUDGMENT.

Precision Approaches in IMC

The aircraft should be stabilized no lower than 1000' above touch down zone elevation (TDZE).

Flight Parameters

To be stabilized, all of the following conditions must be achieved prior to, or upon, reaching this stabilization height:

- The aircraft is on the correct lateral flight plan.
- The aircraft is in the desired landing configuration.
- The thrust is stabilized above idle, to maintain the target speed on the desired glidepath.
- No excessive flight parameter deviation.

If the aircraft is not stabilized on the approach path in landing configuration, at 1000 feet (above TDZE) in instrument conditions, or at 500 feet (above TDZE) in visual conditions, a go-around must be initiated.

If an aircraft is not stabilized as described in Stabilized Approach or Flight Parameters, a go around should be initiated.

Missed Approach Procedures. In postincident interviews, Eastern Air Lines management stated that go-arounds were trained as missed approaches and that training for rejected landings included scenarios such as an aircraft or vehicle still being on the runway. At the time of the incident, pilots were trained to initiate rejected landings around 50 ft agl and were prompted by a simulated ATC instruction. At the time of the incident, Eastern Air Lines did not teach go-arounds being initiated after the airplane contacted the runway.

The Eastern Air Lines FOM, Section 9.11 "Landing or Go-Around" stated in part:

Execute a missed approach when:

- Arrival at the MAP or DH and visual reference to the runway environment is insufficient to complete the landing
- A safe landing is not possible.
- Instructed by ATC

During interviews with other Eastern Air Lines pilots, a few stated that they had conducted go-arounds while line flying. One stated that it was due to low visibility and another pilot stated that he had performed the maneuver after being instructed by ATC to go around due to insufficient distance from a preceding aircraft.

Rejected Landing Procedures. The FOM 9.11.5 provided the following table for conducting a rejected landing:

Speed Brakes

The Boeing 737 Flight Crew Training Manual, Chapter 6, "Landing" provided the following information on the use of speed brakes:

Unless speed brakes are raised after touchdown, braking effectiveness may be reduced initially as much as 60%, since very little weight is on the wheels and brake application may cause rapid antiskid modulation.

Normally, speed brakes are armed to extend automatically. Both pilots should monitor speed brake extension after touchdown. In the event auto extension fails, the speed brakes should be manually extended immediately.

Minimum Equipment List Operations Procedure

The operations procedure on the MEL for the inoperative automatic speed brake module stated the following:

Prior to takeoff, make sure that the speed brake lever is in the full down detent.

Base landing performance on manual speed brakes.

Extend speed brakes manually for rejected takeoff or landing. .

For landing, use the SPEED BRAKE DO NOT ARM non-normal checklist.

The SPEED BRAKE DO NOT ARM non-normal checklist in the Eastern Air Lines QRH states, in part, the following:

Do not [emphasis in original] arm the speed brakes for landing. Manually deploy the speed brakes immediately upon landing. Increased force may be needed to move the SPEED BRAKE lever to the UP position.

Autobrake Setting

The Boeing 737 Flight Crew Training Manual, Chapter 6 "Landing" provided the following information on the autobrake system:

Use of the autobrake system is recommended whenever the runway is limited, when using higher than normal approach speeds, landing on slippery runways, or landing in a crosswind.

For normal operation of the autobrake system select a deceleration setting. Settings include:

- MAX: Used when minimum stopping distance is required. Deceleration rate is less than that produced by full manual braking
- 3: Should be used for wet or slippery runways or when landing rollout distance is limited. If adequate rollout distance is available, autobrake setting 2 may be appropriate
- 1 or 2: These settings provide a moderate deceleration suitable for all routine operations.

Experience with various runway conditions and the related airplane handling characteristics provide initial guidance for the level of deceleration to be selected.

Immediate initiation of reverse thrust at main gear touchdown and full reverse thrust allow the autobrake system to reduce brake pressure to the minimum level. Since the autobrake system senses deceleration and modulates brake pressure accordingly, the proper application of reverse thrust results in reduced braking for a large portion of the landing roll.

The importance of establishing the desired reverse thrust level as soon as possible after touchdown cannot be overemphasized. This minimizes brake temperatures and tire and brake wear and reduces stopping distance on very slippery runways.

The use of minimum reverse thrust as compared to maximum reverse thrust can double the brake energy requirements and result in brake temperatures much higher than normal.

After touchdown, crewmembers should be alert for autobrake disengagement annunciations. The PM should notify the PF anytime the autobrakes disengage.

If stopping distance is not assured with autobrakes engaged, the PF should immediately apply manual braking sufficient to assure deceleration to a safe taxi speed within the remaining runway.

The incident flight crew set the autobrakes at 3 for the landing because of the reported weather conditions; they stated in postincident interviews that Eastern Air Lines preferred the autobrake selection be set at 2. However, other personnel interviewed at Eastern Air Lines indicated that there was no guidance provided by the operator on the preferred autobrake setting and that pilots would reference the performance chart when selecting the autobrake setting. A review of Eastern Air Lines manuals and performance charts found no specific recommended setting and no performance numbers for the four available autobrake settings.

Transfer of Aircraft Control

Section 8.11.6 of the FOM stated "The captain shall ensure that one flight crewmember is at all times charged with the primary task of flying the aircraft.

Change of control of the aircraft is always accomplished verbally. The flight crewmember transferring controls should say...'you have the controls.' .The flight crewmember accepting the controls . says, 'I have the controls' and takes over."

Landing Performance and Factors Affecting Landing Distance

The Boeing 737 Boeing 737 Flight Crew Operations Manual, Performance Inflight, Chapter PI, Section 32, "Advisory Information" contained a "Normal Configuration Landing Distance, Flaps 30" table that provided the following guidance concerning manual speed brakes:

For autobrake and manual speed brakes, increase reference landing distance by 45 meters [148 feet].

The Boeing 737 Flight Crew Training Manual, Chapter 6 "Landing" provided the following guidance regarding factors that affect landing distance:

Advisory information for normal and non-normal configuration landing distances is contained in the [Performance Inflight] chapter of the [Quick Reference Handbook]. Actual stopping distances for a maximum effort stop are approximately 60% of the dry runway field length requirement. Factors that affect stopping distance include: height and speed over the threshold, glide slope angle, landing flare, lowering the nose to the runway, use of reverse thrust, speed brakes, wheel brakes and surface conditions of the runway.

Note: Reverse thrust and speed brake drag are most effective during the high speed portion of the landing. Deploy the speed brake lever and activate reverse thrust with as little time delay as possible.

Note: Speed brakes fully deployed, in conjunction with maximum reverse thrust and maximum manual antiskid braking provides the minimum stopping distance.

Floating above the runway before touchdown must be avoided because it uses a large portion of the available runway. The airplane should be landed as near the normal touchdown point as possible. Deceleration rate on the runway is approximately three times greater than in the air.

Height of the airplane over the runway threshold also has a significant effect on total landing distance. For example, on a 3ø glide path, passing over the runway threshold at 100 feet altitude rather than 50 feet could increase the total landing distance by approximately 950 feet. This is due to the length of runway used up before the airplane actually touches down.

Concerning the touchdown zone, the Boeing 737 Flight Crew Training Manual stated in part:

Fly the airplane onto the runway at the recommended touchdown point. Flare only enough to achieve an acceptable reduction in the rate of descent. Do not allow the airplane to float. Floating just above the runway surface to deplete additional speed wastes available runway and increases the possibility of a tail strike. Do not risk touchdown beyond the normal touchdown zone in an effort to achieve a smooth landing.

As the airplane crosses the runway threshold it should be:

- Stabilized on approach airspeed to within +10 knots until arresting descent rate at flare
- On a stabilized flightpath using normal maneuvering
- Positioned to make a normal landing in the touchdown zone (the first 3,000 feet or first third of the runway, whichever is less).

The Boeing 737 Flight Crew Training Manual describes the technique to be used to flare the airplane for landing as follows:

Initiate the flare when the main gear is approximately 20 feet above the runway by increasing pitch attitude approximately 2ø-3ø. This slows the rate of descent.

After the flare is initiated, smoothly retard the thrust levers to idle, and make small pitch attitude adjustments to maintain the desired descent rate to the runway.

The Aeronautical Information Manual also defines the touchdown zone as "the first 3,000 feet of the runway beginning at the threshold."

The Eastern Air Lines FOM defined the touchdown zone as "the first 3,000 feet of the runway past the threshold or the first 1/3 of the usable runway length, whichever is shorter."

Postincident Changes to Training and Guidance

Following the incident, Eastern Air Lines incorporated go-around scenarios into its training in which flight crews must decide to go around rather than being instructed to do so and at least one scenario that involves manually flying an ILS approach. The operator's director of operations also stated that the company has incorporated scenarios in which go-arounds are initiated from idle power and rejected landings are performed after touchdown with the automatic speed brake inoperative. During this scenario, the instructor adds a side or tailwind gust of wind to destabilize the landing and prompt pilots' decision to go around.

The operator also added a training module emphasizing that "if touchdown is predicted to be outside of the [touchdown zone], go around." Further, the vice president of operations stated that they intend to make go-arounds mandatory if touchdown is not predicted within the touchdown zone.

The operator also intended to incorporate go-around planning into the approach briefing. Flight crews would determine the cues for the touchdown zone using the airport diagram and decide at which point they would initiate a go-around if the airplane had not touched down.

The operator also added EMAS training to the short runway module of its pilot training program.

ADDITIONAL INFORMATION

Sterile Cockpit Regulations

The CVR also contained conversation between the flight crew during the descent and approach below 10,000 ft that was not pertinent to the flight. Title 14 CFR 121.542, "Flight Crewmember Duties" states, in part, the following:

No flight crewmember may engage in, nor may any pilot in command permit, any activity during a critical phase of flight which could distract any flight crewmember from the performance of his or her duties or which could interfere in any way with the proper conduct of those duties. Activities such as.engaging in nonessential conversations within the cockpit and nonessential communications between the cabin and cockpit crews.are not required for the safe operation of the aircraft.

.critical phases of flight include all ground operations involving taxi, takeoff and landing, and all other flight operations conducted below 10,000 feet, except cruise flight.

Runway Condition Reports from Other KLGA Arrivals

Flight crews from four flights that landed on runway 22 within 10 minutes of the incident flight reported braking as "good" or "fair." One crew reported noticing their airplane's antiskid brake system pulsating during the landing rollout. Others reported that there was no hydroplaning or decrease in braking performance.

| | | | |
|---|---|---|---|
| **Accident Rpt# CEN17LA350 09/12/2017 2045** | **Regis# N121CZ** | **Greeley, CO** | **Apt: Greeley-weld County Airport KGXY** |
| **Acft Mk/Mdl EMBRAER EMB 120ER-RT** | **Acft SN 120350** | **Acft Dmg: SUBSTANTIAL** | **Rpt Status: Prelim Prob Caus: Pending** |
| **Eng Mk/Mdl PRATT & WHITNEY PW118B** | **Acft TT 33531** | **Fatal 0 Ser Inj 0** | **Flt Conducted Under: FAR 135** |
| **Opr Name: FREIGHT RUNNERS EXPRESS INC** | **Opr dba:** | | **Aircraft Fire: NONE** |
| | | | **AW Cert: STT** |

## Events

1. Standing - Aircraft loading event

## Narrative

On September 12, 2017, about 2045 mountain daylight time, an Embraer EMB 120 airplane, N121CZ, while standing on a ramp at the Greeley-Weld County Airport (GXY), near Greeley, Colorado, was struck by a bus. The airline transport pilot and two crewmembers on board the airplane were uninjured and the bus driver and 23 passengers on board the bus were uninjured. The airplane sustained substantial damage to its left aileron. The airplane was registered to and operated by Freight Runners Express, Inc. as a 14 Code of Federal Regulations Part 135 non-scheduled domestic passenger flight. Night visual meteorological conditions prevailed in the area about the time of the accident, and an unactivated instrument flight rules flight plan was on file. The flight was originating from GXY and was destined for the University-Oxford Airport, near Oxford, Mississippi.

According to preliminary information, the airplane was standing on a ramp, waiting for passenger arrival with the intent for flight. A bus transporting the passengers was driven onto the ramp and it impacted the airplane's left aileron.

| | | | | |
|---|---|---|---|---|
| **Accident Rpt# ERA17FA316** | **09/08/2017 1120 EDT** | **Regis# N146DU** | **Hertford, NC** | **Apt: N/a** |
| **Acft Mk/Mdl EUROCOPTER DEUTSCHLAND GMBH** | | **Acft SN 9474** | **Acft Dmg: DESTROYED** | **Rpt Status: Prelim** **Prob Caus: Pending** |
| **Eng Mk/Mdl TURBOMECA ARRIEL 1E2** | | | **Fatal 4** **Ser Inj 0** | **Flt Conducted Under: FAR 135** |
| **Opr Name: AIR METHODS CORPORATION** | | **Opr dba:** | | **Aircraft Fire: BOTH** |
| | | | | **AW Cert: STT** |

## Events

1. Enroute - Unknown or undetermined

## Narrative

On September 8, 2017, about 1120 eastern daylight time, a Eurocopter Deutschland GMBH MBB BK117-C2 helicopter, N146DU, was destroyed when it crashed on a wind turbine farm in Hertford, North Carolina. The commercial pilot, two flight nurses, and one patient were fatally injured. Day visual meteorological conditions prevailed at the time, and a company flight plan was filed for flight that departed the Sentara Albemarle Regional Medical Center Heliport (NC98) about 1108. The flight was destined for the Duke University North Heliport (NC92). The helicopter was operated by Air Methods Corporation under the provisions of 14 Code of Federal Regulations Part 135.

According to the operator, on the morning of the accident, the pilot and both medical crew flew from their base at the Johnston Regional Airport (JNX), Smithfield, North Carolina to the Elizabeth City Regional Airport (ECG), Elizabeth City, North Carolina for refueling. They arrived at ECG about 0924, and loaded 70 gallons of fuel. About 1011, the crew radioed the company operations center and advised they were departing for NC98, and had 2 hours of fuel on board. They arrived at NC98 about 1022. At 1108, the pilot radioed the company operations center and advised that that they were departing for NC92 with 2 hours of fuel and four people on board. There were no further communications with the helicopter.

Preliminary data transmitted from the helicopter showed that it departed NC98 to the northwest, climbed to about 1,000 ft mean sea level (msl) and then turned west. The helicopter climbed to about 2,500 ft msl and continued on a westerly track at a groundspeed of about 120 knots. About 8 minutes after takeoff, the helicopter began a turn toward the south. About 1 minute later, the transmitted data ended at an altitude of about 1,200 ft msl and a groundspeed of 75 knots, while the helicopter was on a southeasterly track.

Several witnesses reported observing smoke trailing behind the helicopter while it was in flight. The smoke was described by some witnesses as "heavy" or "dark", while others reported the color as "black", "dark blue" or "blue." One witness reported that the helicopter was "hovering" and "not travelling forward" while it was a "couple of hundred feet" above the wind turbine farm. Another witness reported hearing a "popping noise," he then observed the helicopter turn left, then right. It then descended quickly and appeared "in control" with the rotors turning before he lost sight of it.

The helicopter impacted a shallow turf drainage pathway, about 30 ft wide and 2,000 ft long, located between two fields of 8 ft tall grass, on a wind turbine farm. The fuselage came to rest in a 7 ft wide ditch in the center of the pathway, and was oriented on a heading of 261ø magnetic. No ground scars were present leading toward or away from the main wreckage.

Examination of the wreckage revealed that all the major components of the helicopter were present at the accident site. The cabin had collapsed downward and was partially consumed by a postcrash fire. The tailboom remained largely intact. Flight control continuity was established from the cockpit area to the rotor systems and engines. All main and tail rotor blades remained attached to the rotor hubs. The No. 4 (red) main rotor blade was found rotated about 180ø in the hub with its pitch links fractured and partially melted. None of the main or tail rotor blades exhibited leading edge damage, chordwise scratches, or other evidence of rotation. The outboard 4 ft of No. 1 (yellow) blade came to rest in the 8 ft tall grass adjacent to the drainage path. The grass on either side of the blade was undisturbed. The tail rotor shaft remained attached to the transmission. The transmission could not be rotated by hand.

No foreign object damage was found on the axial compressor blades of either engine. No damage was observed on the visible portions of the turbine blades at the rear of either engine. The gas generator of the No. 1 engine moved freely when rotated by hand, the No. 2 engine gas generator would not rotate. The No. 1 engine fuel shutoff valve was found in the open position. The No. 2 engine fuel shutoff valve was damaged and its position could not be determined during the field examination. The No. 2 engine rear turbine shaft bearing exhibited discoloration consistent with overheating and lack of lubrication. The bearing roller pins were worn down to the surface of the bearing race. The end of the turbine shaft aft of the nut exhibited rotational nonuniform damage.

The helicopter was equipped with an on-board audio and video recording system. The unit was thermally damaged; however, the memory device remained intact. The unit was sent to the NTSB vehicle recorder laboratory for examination.

According to Federal Aviation Administration (FAA) airworthiness records and helicopter maintenance records, the helicopter was manufactured in 2011. The helicopter's most recent 30-hour engine inspection was completed on August 15, 2017. At that time, the helicopter and both engines had accrued 2,673 total hours of operation. Several additional inspections were completed during scheduled maintenance on September 1, 2017. At that time, the helicopter had accrued 2,710 total hours of operation. According to the operator, a daily airworthiness check is performed by a mechanic.

According to FAA airman records, the pilot held a commercial pilot certificate with ratings for rotorcraft-helicopter and instrument-helicopter. His most recent second class medical certificate was issued on October 6, 2016, at which time he reported 4,362 total hours of flight experience. According to the operator, the pilot had accrued 1,027 hours of flight time in the same make and model as the accident helicopter, and had been employed with Air Methods Corporation since August 2009.

The helicopter was retained for further examination.

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| **Accident Rpt# NYC79AA106 09/17/1979 1212 EDT** | **Regis# CFTLU** | **Boston, MA** | **Apt: N/a** | |
| **Acft Mk/Mdl MCDONNELL DOUGLAS DC9-32** | **Acft SN 47196** | **Acft Dmg: SUBSTANTIAL** | **Rpt Status: Factual** | **Prob Caus: Pending** |
| **Eng Mk/Mdl PRATT & WHITNEY JT8D-7** | **Acft TT 28425** | **Fatal 0 Ser Inj 0** | **Flt Conducted Under: FAR 129** | |
| **Opr Name: AIR CANADA** | **Opr dba:** | | **Aircraft Fire: NONE** | |
| | | | **AW Cert: STT** | |


## Summary

The Safety Board's full report is available at http://www.ntsb.gov/investigations/AccidentReports/Pages/aviation.aspx. The Aircraft Accident Report number is NTSB/AAR-80-13.

At 1212 EDT, on September 17, 1979, Air Canada Flight 680, a scheduled passenger flight to Yarmouth, Nova Scotia, Canada, departed Logan International Airport, Boston, Massachusetts. About 14 min after takeoff, at an altitude of about 25,000 ft msl, the tailcone along with the aft cabin pressure access door and a portion of the aft cabin pressure bulkhead separated from the aircraft causing rapid decompression of the passenger and flightcrew compartments. The aircraft was landed safely at Logan International Airport about 38 min after takeoff. Of the 45 persons aboard, one flight attendant received minor injuries during the decompression. The aircraft's oxygen system and its elevator control and engine control systems were damaged.


## Cause Narrative

THE NATIONAL TRANSPORTATION SAFETY BOARD DETERMINED THAT THE CAUSE OF THIS OCCURRENCE WAS: a fatigue fracture of the aft cabin pressure bulkhead which resulted in a rapid decompression of the aircraft's cabin area. This fracture initiated from a crack below the aft bulkhead access door which was discernible on the X-rays taken during the aircraft's last maintenance inspection but was not detected by the inspectors.

## Events

1. Enroute-climb to cruise - Sys/Comp malf/fail (non-power)

## Findings - Cause/Factor

1. Aircraft-Aircraft structures-Fuselage-Bulkheads (main fuselage)-Fatigue/wear/corrosion - C

## Sequence of Events

**Type of Occurrence - Phase of Flight**
**Cause/Factor - Text**

DECOMPRESSION - CLIMB - TO CRUISE

| | |
|---|---|
| ----- | FUSELAGE, BULKHEAD - FATIGUE - |
| ----- | FUSELAGE, BULKHEAD - FRACTURED - |
| ----- | MAINTENANCE, INSPECTION - NOT RECOGNIZED - COMPANY MAINTENANCE PERSONNEL |

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