May 29, 1997

Mr. Robert Hancock
Investigator-In-Charge
National Transportation Safety Board
Northeast Regional Field Office
Suite 203
2001 Route 46
Parsippany, New Jersey 07054

Dear Mr. Hancock:

In accordance with the Board's rules, the Air Line Pilots Association submits the attached comments concerning the accident involving Delta Airlines Flight 554 which occurred on October 19, 1996 at New York's LaGuardia Airport.

The flight was executing an ILS approach to Runway 13. The reported weather was 800 feet broken, 1900 feet overcast, visibility 3/4 miles in heavy rain. The winds were reported as 100° at 12 knots and the temperature was 55°. During the final portion of the approach, the aircraft descended below the glideslope and contacted the approach lighting system approximately 200 feet from the end of the runway pier.

Just prior to contact with the approach light system, full power was added and the pitch attitude of the aircraft was commanded. The main landing gear contacted the end of the Runway 13 pier and separated from the aircraft. The nose landing gear did not contact the pier and remained attached to the aircraft. The aircraft slid down the runway approximately 3670 feet, coming to rest facing the approach end of the runway. Major damage was sustained to the aft lower fuselage and the right wing. An evacuation was ordered and the passengers and crew exited the aircraft. One passenger sustained a minor injury during the accident/evacuation sequence.

The attached submission contains ALPA's analysis of the facts surrounding the accident based upon information obtained from the NTSB's investigation. ALPA's suggested Safety Recommendations are included and are also based upon these facts.

ALPA believes that this accident, like all others, was the combination of many factors. Listed below are the key factors and events that ALPA feels had a role in the cause of this accident. The body of this submission contains a more detailed analysis of each of these points.

- ✈ **METEOROLOGY**

The crew of DAL 554 was not provided the most recent SIGMETs and Urgent Center Weather Advisory that were issued, therefore the flight crews expectations of weather along the approach course were probably for weather conditions much better than they actually encountered. Referencing the current ATIS only, it would appear to a flight crew that weather conditions had improved and field conditions were fairly good.

Based upon rain values derived from WSR-88D data, the correlated RVR value was less than the actual distance from the approach end of the runway to the last VASI bar and therefore, would not have been seen.

Based upon reflectivity values from WSR88-D data, rain bands had been moving across the airport for the past few hours prior to Flight 554's arrival in the terminal area. As previously mentioned, the rain got heavier along the approach path once Flight 554 passed GARDE intersection. In-flight visibility decreased. Because of this type of weather system and its inherent variability's, it is unlikely that the aircraft preceding Flight 554 experienced the same weather conditions at the same locations along the approach course that Flight 554 did.

✈ OPERATIONS/HUMAN PERFORMANCE

The Vertical Speed Indicator (VSI), and/or the system that drives it in Delta's MD-88's is not adequate for determining sink rates in dynamic situations such as the one encountered by DAL 554. Also, the lack of an Instantaneous Vertical Speed Indicator (IVSI) denied the crew timely and accurate sink-rate information during a critical period in DAL 554's approach. This could have been compounded by a lack of training on the part of Delta Airlines that the instrument was not instantaneous. This is an important and critical instrument during the late stages of an approach.

A review of published Delta procedures shows guidance and definition relating to CAT I crew responsibilities. However, glideslope excursions, approach tolerances and stabilized approach criteria are either vague or non-existent.

The captain was wearing monovision contact lenses (MVCL) during the flight to correct for presbyopia. He had worn these lenses for six years and was well adapted. He stated he used the lenses on approximately 75% of flights in lieu of using reading glasses, which he carried on his person in compliance with the restriction on his current First Class Medical Certificate. These lenses are not authorized for use in flight as noted in the FAA Guide for Aviation Medical Examiners. The FAR's do not specifically mention MVCL, but do state distant visual acuity must be 20/20 and near visual acuity of 20/40 or better in each eye for First Class Medical privileges. The pilot was unaware of this restriction. Follow-up surveys indicated a general lack of knowledge among pilots and Aviation Medical Examiners (AME's) about this issue.

Neither the captain's optometrist nor his AME informed the captain that the use of MVCL are not authorized during flight. The optometrist was unaware of the restriction and stated that the "*captain adapted remarkably well to the use of monovision lenses*." The results of the NTSB requested ophthalmologic evaluation indicated little degradation in his distant vision with the contacts in place (right = 20/20; left = 20/30; and both = 20/15). There is some question, however, about the ability of an individual wearing monovision contacts to adequately perceive depth cues. Upon further investigation, we find a significant lack of recent data to allow us to adequately address this issue.

The only visual cues available to the flight crew after "braking out" at 100 feet above minimums were the approach lights. On final, they found themselves in heavy rain with only the area cleaned by the windshield wipers offering the limited visual stimuli. The situation was compounded by the inability to see the VASI either because it was obscured by rain or inoperative. In short, they did not have: (1) a reliable glideslope indicator (either electronic or visual); (2) any peripheral cues (side windows being distorted by heavy rain); (3) gradient information (over dark water); and (4) runway perspective information (could only see approach end at best). Several scientific studies have investigated this precise situation, commonly referred to as the "black hole" approach.

The complete absence of an overrun surface area makes the approach area of this runway extremely hazardous. Had the aircraft struck the concrete approach light piers or descended closer to the runway, the fuselage may have impacted the runway edge, possibly allowing portions to be lost in the water under the runway, with catastrophic results.

✈ LAGUARDIA AIRPORT

LaGuardia Airport (LGA) and specifically Runway 13 offers a challenging and difficult landing environment with very little margin for error. The complete absence of an overrun surface area makes the approach area of this runway extremely hazardous. Had the aircraft struck the concrete approach light piers or descended closer to the runway, the fuselage may have impacted the runway edge, possibly allowing portions to be lost in the water under the runway, with catastrophic results.

The combination of a lack of runway safety area with the positioning of several non-frangible obstacles at or beneath the desired glide path, but above the surface of the earth/water create what could best be referred to as a non-error tolerant environment. This is precisely the problem addressed by ICAO Annex 14 at paragraph 3.4.9. (*A runway end safety area should be so prepared or constructed as to reduce the risk of damage to an aeroplane undershooting or overrunning the runway and facilitate the movement of rescue and fire fighting vehicles*).

✈ AIR TRAFFIC CONTROL

It appears that the LGA tower controllers have a habit of extensive non-relevant communications on the local control frequency. This is shown by another incident which occurred approximately seventy minutes prior to the DAL 554 accident. USAir 1730 landed on Runway 13 and recommended that approaches to that runway cease. Local Control (LC) continued to inquire about the reasons for that recommendation as USAir 1730 taxied to the terminal and LC handled arriving and departing aircraft. As a result, aircraft on the LC frequency heard USAir 1730's explanation, but in subsequent transmissions to aircraft on approach, LC mistakenly reported the gain and loss of airspeed as 20 knots, not the 25 knots that USAir 1730 reported.

The flight crew of DAL 554 was concerned about their landing clearance. Although TWA 8630 was clear of the active runway, the Tower told TWA 8630 to "...just continue down the runway...", leading the crew of DAL 554 to believe that the runway they were cleared to land on was not clear. The frequency was quite congested with the tower's persistent inquiry into the reason for TWA's aborted takeoff. DAL 554, in turn, could not confirm their clearance to land until they were at minimums; a serious distraction.

The use of Local Control (Tower) frequency to gather information not directly and immediately applicable to traffic control should be discouraged. Ground Control frequency should be the appropriate place to gather details or the PIREP in order to accurately relay the details to other approaching aircraft, TRACON and Center.

ALPA offers the following Safety Recommendations in an attempt to correct the above mentioned system deficiencies. Additional recommendations are included to improve FAA and industry inadequacies.

RECOMMENDATIONS

1. All airlines review their procedures for all approaches (without consideration of the type of approach being flown) to standardize to the highest degree possible the duties of both the PF and the PNF.

2. Weather dissemination practices in the industry be reviewed to ensure that flight crews are given the most current weather advisories as soon as possible (preferably prior to entry into said conditions).

3. Review the LaGuardia Runway 13 approach from an approach visibility standpoint to determine the effects of visibility on VASI usability.

4. Raise the visibility requirements for the LGA ILS/DME Runway 13 approach to a minimum distance that would ensure both VASI bars be seen at Decision Height or that a PAPI be installed at the approach end of the runway.

5. The FAA must remind dispatch departments of 121 Air Carriers of their responsibility to pass along new weather information to flight crews as it is received. Special attention should be paid to whatever process an Air Carrier uses to see that their flight crews receive Urgent Center Weather Advisories issued after departure.

6. The FAA should remind pilots of their responsibility to report weather conditions to ATC and fellow pilots in the form of a PIREP. Reporting good weather and lack of turbulence should be stressed as well.

7. All localized weather information be provided to flight crews real time.

8. Strict guidelines be established and enforced for Air Traffic Controllers concerning the use of ATC frequencies.

9. Precision visual landing aids be installed at LaGuardia Airport which are fully visible and useable by the pilot from the decision height to threshold crossing. It should be a precondition of any use of the runway that such an aid be fully functional before issuance of a landing clearance.

10. Training be developed for flight crews as it relates to visual illusions during particular weather conditions.

11. Night approaches be designed to ensure that some form of vertical guidance information is available to the pilot to threshold crossing.

12. Human Factors research be conducted to understand the effects on visibility of monovision contacts and heavy rain on the windshield.

13. Human Factors research be conducted to understand the effects on cognitive demands concerning first leg of first rotation on first day between two crewmembers.

ALPA appreciates the opportunity to have participated as a party to the investigation and hopes the attached comments, conclusions and recommendations will be of assistance as the Board concludes its investigation.

Sincerely,

Captain Paul McCarthy
Chairman, Accident Investigation Board

PMcC/cm

I. INTRODUCTION

On October 19, 1996, at approximately 1639 local time, a McDonnell Douglas MD-88, N914DL, operating as Delta Airlines Flight 554, touched down short of the runway surface while executing an ILS approach to Runway 13 of New York's LaGuardia Airport. Major damage was sustained to the aft lower fuselage and the right wing.

The flight was executing an ILS approach to Runway 13. The reported weather was 800 feet broken, 1900 feet overcast, visibility 3/4 miles in heavy rain. The winds were reported as 100° at 12 knots and the temperature was 55°. During the final portion of the approach, the aircraft descended below the glideslope and contacted the approach lighting system approximately 200 feet from the end of the runway pier.

Just prior to contact with the approach light system, increased engine power was applied and an increased pitch attitude of the aircraft was commanded. The main landing gear contacted the end of the Runway 13 pier and separated from the aircraft. The nose landing gear did not contact the pier and remained attached to the aircraft. The aircraft slid down the runway approximately 3670 feet, coming to rest facing the approach end of the runway. An emergency evacuation was ordered and the passengers and crew exited the aircraft. One passenger sustained a minor injury during the accident/evacuation sequence.

II. METEOROLOGY

A. Dispatch and Enroute Weather Dissemination

At the time of Delta Flight 554's departure from Atlanta (ATL), the flight crew had received the 1500, 1600, and 1700Z KLGA METARs along with the KLGA Delta Terminal Forecast. SIGMET Uniform 2 was current at departure (for turbulence in areas of strong winds and rough terrain). The crew had a copy of SIGMET Uniform 2 along with a LaGuardia Airport alert for moderate to strong turbulence below 7,000 feet and likely Low Level Wind Shear (LLWS).

While enroute, SIGMETs Uniform 3 and 4 were issued. SIGMET 3 was issued for turbulence at a lower altitude than SIGMET 2 in areas of strong winds and rough terrain. SIGMET 4 was issued for turbulence in areas of strong winds. The rough terrain section in previous SIGMETs had been dropped. A new and important paragraph had also been added that was not present on previous SIGMETs for LLWS to be expected. The LaGuardia Airport was included in the area encompassed by both of these advisories. There is no evidence that the crew was updated with these latest SIGMETs by Delta's dispatch department or any enroute sectors of Air Traffic Control (ATC).

14 CFR 121.601 basically requires that prior to and during a flight, the dispatcher shall provide all available weather information that may affect the safety of flight. This can be interpreted one of two ways; one being that all weather information be provided to the flight crews and the act of determining what is necessary is up to the crew, the other

interpretation is that Dispatch sort the data themselves and provide what they feel is important to the flight crews.

Delta's current policy of disseminating weather information is the latter interpretation. Delta does not provide AIRMETs in the flight crew dispatch paperwork because AIRMETs are used only to amend area forecasts for weather situations that affect aircraft with limited capabilities.

Delta's dispatch policy is to forward SIGMETs and Convective SIGMETs after they are reviewed by the dispatcher and then only the ones that have changed are actually sent. In the case of DAL 554, SIGMET 3 was not much different than SIGMET 2 except that it lowered the ceiling of forecasted turbulence from 16,000 feet to 14,000 feet. However SIGMET 4 eliminated the requirement for rough terrain. Since the flight was approaching the airport over water, a crew may have disregarded the turbulence forecasts in 2 & 3, however, SIGMET 4 eliminated this criteria so that it applied to all surfaces. Also, SIGMET 4 was the only SIGMET that contained the words **Low Level Wind Shear**. This change was significantly different than SIGMETs 2 & 3 and the crew should have been advised of this by dispatch. Furthermore, the fact that a SIGMET had been issued will at least alert the crew that something is going on to warrant a new SIGMET even if it's not substantially different. By the fact that the crew of DAL 554 was never advised of any of the new SIGMETs, they were not alerted that weather conditions may have been changing and therefore were not afforded the opportunity to prepare for such conditions.

Delta's policy concerning Center Weather Advisories (CWA) is that they are an ATC function and issued for ATC use. Delta’s meteorology department did not forward the Urgent Center Weather Advisory to the dispatcher covering DAL 554. ALPA disagrees with this policy. Urgent Center Weather Advisories are issued for crew use and are most important because they depict current conditions. Also, if the Advisory depicts a forecast, it covers a very small time frame.

Delta felt it inappropriate to forward this advisory since Delta meteorologists had already issued an Airport Alert for LGA for moderate to strong turbulence below 7,000 feet with Low Level Wind Shear likely. This was a Delta forecast. The Urgent Center Weather Advisory stated these conditions existed now (not forecast). The Urgent Center Weather Advisory was so specific it even referenced airspeed losses/gains within 200 feet of the surface. In ALPA’s opinion, the crew of DAL 554 should have been provided this information to alert them of conditions at LGA.

ALPA also feels that Delta's current policies require the dispatcher to review each SIGMET and determine if it is different from the one previous. The meteorology department computer should be modified to search for SIGMETs and send them automatically to the flight crew via ACARS, thus freeing the dispatcher to address other operational needs. Should the flight crew find it repetitive or non-pertinent, they can then choose to disregard it. At least they would be alerted that a change has occurred meteorologically.

An Urgent Center Weather Advisory was issued by the New York Center Weather Service Unit. This type of advisory is extremely important. It is issued primarily for flight crew use to anticipate and avoid adverse weather conditions in enroute and terminal environments. Moreover, unlike SIGMETs, it reflects actual conditions at the time of issuance (or if any forecast is appropriate, it should be one of short range). The Urgent Center Weather Advisory was for the New York Metro area including LaGuardia. This advisory was very specific for strong low level windshear with 30 knots airspeed gain/loss within 200 feet of the surface; severe turbulence was also reported. This advisory was issued 38 minutes prior to the accident. There is no evidence that the crew received this advisory either from the ATC system or Delta's Dispatch department.

A frontal system passed through the New York area prior to Flight 554's arrival. At the time of dispatch, there is no evidence that the crew was provided with information about the position of the low pressure system (and associated fronts) either in graphic or text form with the gate paperwork. There is no regulation requiring a synoptic "overview" and therefore the flight crew had to use other sources for this information. The first officer reviewed the synoptic weather on the Delta weather computer located in the Atlanta pilot crew lounge. The captain reviewed the synoptic situation by watching CNN. Neither of these two briefing formats provide information about low level wind shear or turbulence near the surface.

As a result of the Simmons Airlines 4184 aircraft accident over Roselawn, Indiana on October 31, 1994, the NTSB issued the following Safety Recommendations which should be reiterated for this accident:

> A-96-48: Direct principal operations inspectors (POIs) to ensure that all 14 Code of Federal Regulations (CFR) Part 121 air carriers require their dispatchers to provide all pertinent information, including airman's meteorological information (AIRMETs) and Center Weather Advisories (CWAs), to flight crews for preflight and in-flight planning purposes. (Class II, Priority Action)

and:

> A-96-49: Require that Hazardous In-Flight Weather Advisory Service (HIWAS) broadcasts consistently include all pertinent information contained in weather reports and forecasts, including in-flight weather advisories, airman's meteorological information (AIRMETs), significant meteorological information (SIGMETs), and Center Weather Advisories (CWAs). (Class II, Priority Action)

B. LaGuardia Airport Weather Conditions

1. **Windshear**

There is no meteorological evidence which indicates that a Low Level Wind Shear was created by any type of outflow boundary from convective weather or by frontal passage. However, the reported Low Level Wind Shear was caused by a vertical shear environment which had wind velocity values of 12-14 knots at the surface increasing to 46 knots at 500 feet to approximately 60 knots at 1,000 feet. There was a horizontal wind shear in the area of LaGuardia of 10 knots per 2.5 nautical miles. The following wind velocities are derived from the NEXRAD Velocity Azimuth Display and had an easterly component (reference NTSB Meteorology Factual Report):

1,000 feet winds were approximately 60 knots.
2,000 feet winds were approximately 65 knots.
3,000 feet winds were approximately 70 knots.
4,000 feet winds were approximately 70 knots.

All lower level winds had an easterly component. This would cause an approaching aircraft to have a left crosswind component in addition to a headwind component. The net effect would cause an aircraft to drift right of runway centerline unless an appropriate crab angle to the left of runway centerline was established. Based upon the Low Level Wind Shear Alert System's northwest wind sensor (located approximately 5,468 feet northwest of the approach end of Runway 13), surface winds were from the east and varied from as low as 8 knots to values as high as 16 knots from the time period of 1 minute prior to the accident to 1 minute after the accident (at 10 second sampling intervals). No gusts were recorded. This would have caused a crosswind component (reference to runway centerline) of as little as 6 knots to as much as 12.5 knots from the left. The headwind component would have varied from 5 knots to 10 knots.

2. **Visibility.**

For this particular approach into LGA, visibility during the approach and at the field are extremely important issues. Surface observations (NTSB Meteorology Factual Report) rainfall rates were derived along the approach path to Runway 13.

As the flight approached GARDE intersection (5.2 miles from Runway 13 approach threshold) field visibility was dropping to 0.4 mile where it remained until approximately 2 minutes prior to touch down. At that time, visibility began to increase to 0.5 mile where it remained at the time of the accident. The airport visibility trend was increasing. Two minutes after the accident, airport field visibility improved to 0.8 mile (reference 1 minute AMOS engineering data NTSB Meteorology Factual Report). The worst visibility the flight crew encountered along the approach course occurred 0.6 mile (about the middle marker) from the approach end of Runway 13. Due to sensor locations, the inflight visibility would have been different from the official airport observation.

3. **Rainfall Rates.**

Again, with regards to visibility, radar reflectivity values indicate that the **inflight** visibility decreased as the flight progressed after crossing GARDE intersection toward LGA Airport. This visibility assessment is based upon increasing rainfall rates along the approach course (derived from WSR-88D data NTSB Factual Report).

Outside of GARDE Intersection, the crew encountered an area with a rainfall rate of between 0.18 to 0.29 inches per hour (which corresponds to moderate rain as defined by National Weather Service). The rainfall rates increased consistently from GARDE Intersection to approximately the middle marker (approximately 0.6 mile from touchdown). At this point, the crew encountered the heaviest rain during their approach with values between 0.93 to 1.79 inches per hour (which corresponds to heavy rain as defined by National Weather Service standards). The rainfall rate encountered at the approach end of Runway 13 was between 1.52 and 0.93 inches per hour (heavy rain).

In conclusion, Without the two additional SIGMETs and Urgent Center Weather Advisory, the flight crews' expectations of weather along the approach course were probably for weather conditions much better than they actually encountered. Referencing the current ATIS only, it would appear to a flight crew that weather conditions had improved and field conditions were fairly good.

Based upon rain values derived from WSR-88D data, the correlated RVR value was less than the actual distance from the approach end of the runway to the last VASI bar and therefore, the far VASI bar would not have been seen.

Based upon reflectivity values from WSR-88D data, rain bands had been moving across the airport for the past few hours prior to Flight 554's arrival in the terminal area. As previously mentioned, the rain got heavier along the approach path once Flight 554 passed GARDE intersection. In-flight visibility decreased. Because of this type of weather system and its inherent variability, it is unlikely that the aircraft preceding Flight 554 experienced the same weather conditions at the same locations along the approach course that Flight 554 experienced.

III. OPERATIONS / HUMAN PERFORMANCE

A. Vertical Speed Indicator / Instantaneous Vertical Speed Indicator

Delta MD-88 pilots consistently report that the aircraft's Vertical Speed Indicator (VSI) significantly lags the actual performance of the aircraft. Referencing the Operational Factors Group Factual Report dated February 15, 1997 interview with Captain Hank Vehige, Captain Vehige states that "*The VSI is electronic, not instantaneous. A sudden sink rate would not reflect immediately. I do not believe most MD-88 pilots are aware of the lag in the VSI*".

The Delta MD-88 Pilot's Reference Manual (PRM) explicitly states that the display is not instantaneous. VSI lag is most obvious when the rate of climb or descent changes rapidly. Pilots report that the VSI displays a 700 to 800 fpm rate of descent for a few seconds after leveling off. Bottom line, the MD-88 vertical speed indicator is not instantaneous and cannot and should not be used to determine the aircraft's actual rate of climb or descent in real time. In the absence of a reliable electronic or visual glide slope indicator and without an instantaneous VSI, inertial aim point reference or other aircraft indication, the crew must rely totally on external references to establish their vertical position. This then comes down to visual assessment of both vertical position and rate of change by reference to visual cues.

The MD-88 fleet was initially delivered with an analog VSI indicator which was driven by the air data computer. The ADC output was instantaneous and was accurately displayed on the cockpit instrumentation. To facilitate the installation of TCAS, Delta transitioned to an LED VSI which could display both VSI and TCAS data at the same time. While the ADC output remains instantaneous, the LED indicator is not capable of displaying the information without a lag of variable duration. (Reference Captain Vehige's interview)

The CVR shows that the F/O called the sink rate as 700 fpm ten seconds before impact. This call out was simultaneous with, or just prior to, the development of the high sink rate. At the time of the 700 fpm call out by the F/O, Flight Data Recorder (FDR) information indicates that the sink rate was between 800 fpm and 1200 fpm (based upon pressure and radar altitude respectively). Five seconds later the F/O called attention to the speed, indicating that he was monitoring the approach and was, as was required, calling out any deviation from normal values which he felt were significant. The absence of a sink rate call indicates that, at least at the time of this speed call out, the F/O did not detect any abnormal sink rate, either from the instrumentation or from external references.

Referencing the F/O's statement in the Operational Factors Group Factual Report dated February 15, 1997, the F/O stated that he was not *"...able to determine vertical guidance by looking at the approach lights in the rain. The F/O reported that the next thing he remembers seeing was a windscreen full of lights"*. However, he did ultimately detect either a high sink rate or the aircraft's low altitude. This suggests that the F/O was dividing his attention between inside and outside references. Even if the VSI did eventually display an excessive sink rate in the final seconds, it is possible that the F/O's attention was properly directed outside the cockpit. It is significant to note that, however he did it, the F/O was apparently the first to detect that something was wrong, and called "*nose up*" three seconds before impact, and one second before the Ground Proximity Warning System (GPWS) began announcing "*sink rate*".

The Vertical Speed Indicator (VSI), and/or the system that drives it in Delta's MD-88's is not adequate for determining sink rates in dynamic situations such as the one encountered by DAL 554. Also, the lack of an Instantaneous Vertical Speed Indicator (IVSI) denied the crew timely and accurate sink-rate information during a critical period in DAL 554's approach. This could have been compounded by a lack of training on the part of Delta Airlines that the instrument was not instantaneous. This is an important and critical instrument during the late stages of an approach.

B. Delta Procedures / Flight Crew Duties During Approaches

A review of published Delta procedures shows guidance and definition relating to CAT I crew responsibilities. However, glideslope excursions, approach tolerances and stabilized approach criteria are either vague or non-existent.

Referencing the interview with the Chief Pilot, Charlie Tutt, Mr. Tutt states there are no tolerances for go-arounds in normal operations, and parameters for missed approaches have not been quantified. He goes on to state that, as a result of this accident, the company is developing stabilized approach guidelines. Interviews with Dr. John Lauber, Delta Vice President for Corporate Safety and Compliance, states that company manual language in these areas should be clarified. He questions the "*go-around mindedness*" of Delta pilots, and also states that with contingency fuel at a minimum, stabilized approach guidelines will certainly be looked at.

The Delta Flight Operations Manual, Chapter 2: Normal Operations, page 50 states that on all approaches the PNF should continue to monitor the flight instruments through the flare, call out any significant deviation to minimize the effects of possible visual illusions for the PF, and monitor airspeed and sink rate through touch down. The PNF is reduced to a "random monitor of approach parameters" without formal guidance at this critical phase of flight. For CAT I approaches it adds only that he should closely monitor air speed and sink rate through touch down and adjust scan to include outside references and verbalize those observed.

Referencing the interview of Mr. Bill Dubis, FAA POI for Delta Airlines concerning the responsibilities of the PNF on a CAT I approach, Mr. Dubis stated that, *"...Delta didn't standardize the procedures on final. Once the PF says 'I've got the field,' procedures stop. The other pilot can go brain dead."* Also referencing F/O Ollie Edwards interview regarding PNF duties on an ILS approach; *"the PNF makes call outs for any deviations,* *not sure on all parameters. Will call out one dot above or below glideslope..."* This viewpoint appears consistent with FAA opinion and what guidance was published at the time.

ALPA strongly encourages the NTSB to recommend that not only Delta, but all airlines in general closely review their procedures for all approaches without consideration of the type of approach being flown to standardize to the highest degree possible the duties of both the PF and the PNF. An ad hoc approach to the monitoring function results in the possibility that the PNF may not effectively participate, rendering the PF a solo operation. Intuitively, it would seem that this is more likely when the PF flying is the captain.

Several foreign operators have adopted a system that requires all low visibility approaches be conducted by the F/O, who is tasked to continue on instruments throughout the approach to insure that a seamless go around will be executed should the captain not affirmatively identify the landing environment or if, subsequent to the captain assuming responsibility for the landing, the approach becomes somehow unstabilized. ALPA advocates research in this area to compare the various procedural approaches to the conduct of such approaches to extract maximum value out of the monitoring function.

Referencing the interview with the F/O and a review of the CVR indicates that the F/O did make the required observations and call outs. However, it is apparent that the aircraft developed a sudden and rapid sink rate as it descended into the approach lights. Without a useable glideslope as a flight instrument reference and with a VSI that provides vertical speed indications with a significant lag, whatever information the PNF could obtain was inadequate and untimely.

C. Monovision Contacts / Visual Acuity

The captain was wearing monovision contact lenses (MVCL) during the flight to correct for presbyopia. He had worn these lenses for six years and was well adapted. He stated he used the lenses on approximately 75% of flights in lieu of using reading glasses, which he carried on his person in compliance with the restriction on his current First Class medical Certificate. These lenses are not authorized for use in flight as noted in the FAA Guide for Aviation Medical Examiners. The FAR's do not specifically mention MVCL, but do state distant visual acuity must be 20/20 and near visual acuity of 20/40 or better in each eye for First Class Medical privileges.

The captain's distant visual acuity using MVCL is 20/20 in the right eye, 20/30 in the left eye and 20/15 using both eyes. His near visual acuity is 20/50 in the right eye, 20/20 in the left eye and 20/20 using both eyes. His stereoscopic visual acuity decrease one increment using MVCL compared to his measurements when not corrected and when using bifocals. He has visual fusion at distances greater than three feet indicating some preservation of stereopsis.

The pilot was unaware of this restriction. Follow-up surveys indicated a general lack of knowledge among pilots and Aviation Medical Examiners (AME's) about this issue.

The pilot's use of MVCL raises questions as to his depth perception ability. Depth perception derives from both monocular and binocular cues. The monocular cues are much stronger, but more susceptible to illusions than binocular (stereoscopic) cues. Many experts question whether stereopsis is useful beyond distances of twenty feet. The visual environment at the time of the accident compromised many monocular cues to depth perception and may have been completely devoid of any stereoscopic cues. The rain caused decreased contrast sensitivity and acuity. The over water approach removed any cues of relative size due to absence of ground references, parallax or convergence until the runway markings were in sight. The spacing of the runway lights at intervals closer than normal is known to cause a strong visual illusion of excess distance (too high). The visual height reference the pilot may have relied on through experience, the VASI's, may not have been visible in the terminal phases of the approach. Even with optimum stereopsis, this visual environment would have minimal outside height cues.

Neither the captain's optometrist nor his AME informed the captain that the use of MVCL are not authorized during flight. The optometrist was unaware of the restriction and stated that the "*captain adapted remarkably well to the use of monovision lenses*." The results of the NTSB requested ophthalmologic evaluation indicated little degradation in his distant vision with the contacts in place (right = 20/20; left = 20/30; and both = 20/15). There is some question, however, about the ability of an individual wearing monovision contacts to adequately perceive depth cues. Upon further investigation, ALPA finds a significant lack of recent data to allow us to adequately address this issue. ALPA agrees with the gist of the Armstrong Laboratory paper submitted as part of the factual report in the Human Factors section (that there were very limited cues and the use of monovision contacts may have played a role). Without solid empirical evidence, however, ALPA is guarded in its acceptance of the influence of monovision contacts in this particular case especially in light of the captain's long term use and ready adaptability to the prescription.

1. Visual Environment.

As has been addressed in Section 2.c. of this report, the Meteorology Group has established that the crew of DAL 554 experienced "heavy rain" during the final stages of their approach into LGA.

The only visual cues available to the flight crew after "braking out" at 100 feet above minimums were the approach lights. On final, they found themselves in heavy rain with only the area cleaned by the windshield wipers offering the limited visual stimuli. The situation was compounded by the inability to see the VASI either because it was obscured by rain or inoperative. In short, they did not have: (1) a reliable glideslope indicator (either electronic or visual); (2) any peripheral cues (side windows being distorted by heavy rain); (3) gradient information (over dark water);

and (4) runway perspective information (could only see approach end at best). Several scientific studies have investigated this precise situation, commonly referred to as the "black hole" approach.

One of the most notable of these studies was conducted by H. W. Mertens in 1981 while he was a researcher at the FAA's Civil Aeromedical Institute. This study added "*empirical evidence of visual illusions and the danger of reliance on visual information for judgment of approach angle in the nighttime 'black hole' situation*..." (Mertens, 1981). In the Handbook of Perception and Human Performance, it was also found that humans have very limited accuracy when asked to analyze an impact point with limited visual cues. In the classic Human Factors in Aviation (1988), Leibowitz also warns of conducting visual approaches without gradient information and acknowledges the tendency of pilots to overestimate their approach angle and fly dangerously close to the ground prior to crossing the runway threshold. In summary, the crew of DAL 554 behaved exactly as the data would have predicted.

2. NTSB Investigations Into Visual Illusion.

On December 13, 1969, an aircraft was being ferried from Boeing Field, Seattle to Renton, Washington. During an approach to landing, the aircraft struck an embankment approximately 20 feet short of the runway threshold. As a result of the NTSB's investigation, the following Safety Recommendation was made:

> A-70-052 "The NTSB recommends that the FAA ...(3) undertake quantitative research into the effect of rain on the windshield in order to determine more accurately the finite relationships between the amount of rain and the degree of displacement between the real and apparent positions of objects viewed through a water-covered windshield...".

Although classified as "Closed - Acceptable" by the NTSB, the same type of phenomenon was discussed as a causal factor in the following accident.

On November 27, 1973, a Delta Airlines DC-9-32 was involved in an accident at Chattanooga, Tennessee[1]. This accident occurred at approximately 1851 Eastern Standard Time (EST) during similar weather conditions (i.e. periods of heavy rain) into an airport with similar electronic vertical guidance limitations (i.e. glideslope unusable below 200 feet agl). The NTSB determined that the Probable Cause was "...the pilot did not recognize the need to correct an excessive rate of descent after the aircraft had passed decision height...possibly because of the influence of a visual illusion caused by the refraction of light through the heavy rain on the windshield..."

As part of the NTSB's analysis, the report states that "...another factor which could have contributed to this accident was the pilot's perception of the runway location. His perception may have been deceiving because of illusions or refraction of light through water on the

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[1] Aircraft Accident Report, Delta Air Lines, Inc., McDonnell Douglas DC-9-32, N3323L, Chattanooga Municipal Airport, Chattanooga, Tennessee, November 27, 1973, Report Number: NTSB-AAR-74-13.

windshield. Numerous studies conducted on the effects of this phenomenon have established that faulty visual perception contributes to disorientation and erroneous judgment of horizontal and vertical distance...The most serious problem associated with water on the windshield is that the objects appear farther away than they actually are.

The report goes on to state "...This bending of light rays would cause the approach and runway lights to appear lower than their actual elevation. The pilot would believe that he is higher and farther away from his planned touchdown point than he actually is...Rain can also affect the pilot's perception of distance to the approach and runway lights by diffusing their glow and thus cause them to appear less intense. This too would lead the pilot to conclude that the lights were farther away than they actually were. On occasion, rain causes lights to appear larger (but not brighter), and the pilot believes that he is closer to the light than he actually is. In either case, the pilot would be prompted to descend to an altitude comparable to the perceived runway elevation."

It would appear that further Human Factors analysis should be conducted to determine the effect of heavy rain on windshields and how it relates to visibility and visual illusions. Accidents occurring in adverse weather conditions (i.e. reduced visibility) should be reviewed as to their relationship with visual illusions. Again, Safety Recommendation A-70-052 should be reiterated and the FAA should:

"undertake quantitative research into the effect of rain on the windshield in order to determine more accurately the finite relationships between the amount of rain and the degree of displacement between the real and apparent positions of objects viewed through a water-covered windshield"

D. Runway 13 Approach

Field notes from interviews of crews arriving in proximity to Delta 554 show a number of similarities and trends. In the preceding ten minutes to Delta 554, four aircraft experienced moderate or heavy rain. The weather was deteriorating and the rain moved closer to the runway with aircraft breaking out of weather from 1000 feet to 1500 feet, eight minutes before the accident in moderate rain to 300 feet in a wall of water immediately prior to DAL 554. All aircraft went high on the glideslope except one in which the pilot made a "conscious effort to stay on glideslope" and stated he saw an airspeed excursion from 138 knots to 164 knots.

Most aircraft showed significant crab on final and some, including DAL 554, described some lateral drift and correction on breakout. Based on these observations and the Meteorological Factual Report, it is apparent that these aircraft experienced a substantial wind shift or lateral shear as they approached the runway which contributed to a disruption of their flight path. In no case did any crew report a wind shear alert. Most aircraft had earlier overheard reports of aircraft making missed approaches and had used maximum airspeed additives during the approach. The crew of Delta 554 did not report hearing these reports and set their airspeed additive to 8 knots, consistent with Delta policy for the reported winds.

The VASI was not observed by any preceding crew and was logged as inoperative due to switch flooding shortly after the accident. However, due to the location of the upwind VASI bar at 1400 feet from the Runway 13 threshold, it would not be expected to be easily visible in the approved 2400 RVR during most of the approach below the usable glideslope altitude of 200 feet. In comparing the experiences of the preceding aircraft it could be concluded that Delta 554 was in the worst of deteriorating weather with a minimum of safety margin as it left decision altitude. The results of a wind shift contributed to an approach unstable vertically and horizontally, in an area described by the Operations Group Factual Report of a simulator flight as having limited visual cues. The captain stated that he could only see out the window where the wiper cleaned. The side windows were covered with rain and he could not see out of them at all. With limited peripheral cues, the crew was open and subject to numerous visual illusions. The first officer stated that the first visual indication of being low was a "*windshield full of lights*."

Without a VASI and with little of the runway visible, the crew was deprived of visual resources to judge their approach. Without a usable glideslope or IVSI, the crew was deprived of adequate instrumentation to judge their approach. And, without clear or concise leadership in their manuals or training, they were deprived of a clear method to recognize the nature of their predicament and elect to execute a missed approach.

In reviewing aircraft and airport damage, it is clear that the potential for catastrophic damage to the aircraft was narrowly avoided. A combination of where the aircraft impacted the approach lights and a timely and aggressive reaction by the captain averted disaster. The right wing dragged over and removed sections of the approach lights and frangible catwalk well below the runway plane. The right landing gear passed between vertical concrete approach piers striking large wooden cross timbers, one of which was found protruding from the plywood face of the runway about 100 feet away. The aircraft then climbed high enough for the fuselage to clear the runway end. However, the landing gear was sheared off by the concrete runway end. This left dramatic and obvious impressions in the plywood runway face extending downwards 3 feet 9 inches. The aircraft then continued down the runway, sliding on its nose wheel and belly, coming to rest facing the approach end of the runway, about 2700 feet from the runway end.

The complete absence of an overrun surface area makes the approach area of this runway extremely hazardous. Had the aircraft struck the concrete approach light piers or descended closer to the runway, the fuselage may have impacted the runway edge, possibly allowing portions to be lost in the water under the runway, with catastrophic results.

Any shortening of the runway to increase the overrun would make the runway too short for normal air carrier use. A logical answer would be to construct an extension of the runway surface as a platform or shallow ramp, out into the Rikers Island channel to create an overrun and obstruction free safety area.

E. Crew Background

The background of the flight crew appeared exemplary. Charlie Tutt, Chief Pilot at Delta stated that he had reviewed the pilots records and they were unblemished. Captain John Vancestated that he had administered the first day of the re-qualification check rides given the crew after the accident. He said both were above average and remarked that the FAA observer also said they had performed above average.

Both pilots were highly experienced aviators and demonstrated no behavioral problems that may have been a causal factor. Their history immediately prior to the accident did not indicate that life habit patterns or major events played a role. Both pilots seemed fit and coherent as reported by all others that had come in contact with them. Both pilots reported adequate rest periods just prior to the accident and were not taking any medication.

There is very little about this crew's record and performance to differentiate them from the rest of the Delta pilot group. It would be reasonable to surmise that had the flight been flown by another Delta crew, the accident may still have occurred.

This suggests that improvements in manuals and procedures relating to CAT I approaches, missed approach procedures relating to CAT I approaches, missed approach procedures and requirements are needed. Training in these areas and in optical illusions related to weather and limited visual cues would be of benefit to the entire pilot group.

F. Emergency Evacuation

The evacuation procedures and decisions involved are of note because of the remarkable success of the abort with only one minor injury, apparently a correct result of the crew member's decision to exit through only the L-1 door. The flight attendant (F/A) in charge, Jennifer Teas, remarked in an interview that it was a hard landing, but did not feel like they had wrecked. After the aircraft stopped, an initial public address (PA) announcement was made by the captain to remain seated, remain calm and wait for instructions. A non-revenue pilot proceeded to the cockpit to inform the crew of fuel fumes. The captain then made a PA to evacuate the airplane. The F/O left his seat to assist in evacuating and removal of an elderly passenger who resisted evacuation and had to be carried to the door. All passengers exited through the L-1 door. The F/O said he believes that he made the decision to use only the L-1 door based on fuel fumes and passenger load.

Examination of the airplane subsequent to the accident showed that there was fuel spillage in the area of the right wing. There was also substantial damage to both inboard flap areas creating a lot of large, torn metal edges. This could have caused injuries and impairment of egress had the overwing exits been used. The actions and orders given by the flight attendants were assertive and clear. The F/A in charge said, when she heard the evacuation order, she stood up, got her flashlight, yelled 6-10 times "*release seat belts,* *get up, get out*." She opened the L-1 door and deployed the slide and stood at the exit yelling "*sit and slide*." She described the evacuation as orderly and that only a few passengers tried to retrieve carry-on luggage and that none brought their luggage for evacuation.

Remarks from members of the CVR group are that the comments and discussion of the flight attendant during the evacuation sequence were captured by the CVR and might be useful in constructing a training document or aid.

G. Cognitive Demands.

A recent NTSB report suggests that accidents are more likely to occur on the first day of the first rotation that two pilots fly together, especially on the first leg. DAL 554 represents such a case. This phenomenon has not been empirically explored, but a possible explanation may lie in the cognitive capacity of the pilots being diminished by social exploration. As with other resource intensive tasks, social investigation and attributional judgments take cognitive resources away from other flight related activities. Armed with less resources, the possibility of the pilot making an error is increased. This is, of course, only one explanation.

A more useful approach to explain the cognitive demands experienced by these pilots might be to investigate some of the psychological aspects of the situation during short final. These are motivation, capacity, diagnosticity, accessibility, and automaticity.

Motivation: The key concern seems to be related to the pilot's decision to continue with the approach. Diversion is a difficult situation. There is pressure on the pilot to complete the "mission" and be rewarded by a thankful group of passengers, co-workers, and company representatives.

Capacity: In this situation, the pilots were faced with a very high workload. The weather was much worse than communicated, there were social pressures associated with flying with a new crew member, and the approach was poorly designed. These are just a few of the factors that added to the pilot's workload and, therefore, decreased the cognitive resources available to address other decisions, such as "should we go around?"

Diagnosticity: This term refers to the usefulness of the information available to the pilot. In this situation, the weather information was incorrect, the glideslope information was unusable, there was no VASI and the research supports that the visual cues present were inadequate to determine a proper glide path.

Accessibility: This refers to the ease with which a particular thought is brought to the forefront of consciousness. It is doubtful that the possibility of a visual illusion occurring was accessible to either of the pilots since they had never been trained on the concept.

Automaticity: People are typically parsimonious with their cognitive resources. With highly practiced psychomotor and social events, less cognitive resources are required than when a novel situation is presented. These automatic processes are everywhere and allow us to function in the modern world. In layman's terms, we are creatures of habit because it is easier (does not require as much thought). Suppose the captain routinely "ducked under" during the final phase on the approach. His view of a normal glide path would be much less than three degrees. As the Mertens study shows this would exacerbate the tendency for the pilot to fly lower than normal when attempting a night visual approach.

Perhaps a more in-depth Human Performance study is warranted in the area of cognitive demands as it relates to the accident and the role it plays in day-to-day line flying.

IV. LAGUARDIA AIRPORT ISSUES

A. Runway 13 Configuration

LaGuardia (LGA) Airport and specifically Runway 13 offers a challenging and difficult landing environment with very little margin for error. Runway 13 has been extended into the Rikers Island Channel by using piers to support it above the waters' surface. Most of the runways surface is dedicated to operational use with approximately 98 feet providing an unusable portion dedicated to a runway overrun. This short area ends abruptly at the vertical face of the concrete runway surface which has been covered vertically with red painted plywood to increase visibility. The approach lights extend out into the bay. The system is supported by concrete piers connected by a frangible bridge. The vertical concrete approach light support is connected by two large timber structures. The approach lights and bridge are constructed of frangible materials. The concrete and timber light supports and the blunt concrete runway end create substantial solid obstructions in the approach area.

The combination of a lack of runway safety area with the positioning of several non frangible obstacles at or beneath the desired glide path but above the surface of the earth/water create what could best be referred to as a " **Non Error Tolerant**" environment. This is precisely the problem addressed by ICAO Annex 14 at paragraph 3.4.9. (*A runway end safety area should be so prepared or constructed as to reduce the risk of damage to an aeroplane undershooting or overrunning the runway and facilitate the movement of rescue and fire fighting vehicles*).
Any undershoot of even minor angular degree will in all probability result in contact with these obstacles, with the resultant undesirable effects on the path of the aircraft and it's structural integrity. Where no error can be tolerated in the final landing maneuver, every

effort must be made to both reduce the hazard to the greatest extent practical and insure the flight crews have aids which might be provided to insure the accurate transition from the instrument to the visual environment and the precise control of vertical position during the visual landing maneuver. At a minimum, this must include a precision visual landing aid which is fully visible and usable by the pilot from the decision height to the threshold crossing. It should be a precondition of any use of the runway that such an aid be fully functional before issuance of a landing clearance.

The runway environment contains numerous unusual installations. The approach lights are closer than usual and runway light spacing is approximately 3/4 of the normal 200 feet. The VASI lights are located approximately 500 feet and 1400 feet from the runway threshold. The transmissometer for touchdown is shared with Runway 22. The localizer antenna is placed northeast of the runway resulting in a 3^{o} alignment offset. The final approach course crosses the runway centerline 2745 feet from the threshold. Although the rationale is unclear, the Jeppesen Approach plate for the ILS DME Runway 13 approach indicates that the glide slope for this particular runway is unusable below 200 feet MSL. Aircraft may receive glideslope information below this altitude, however there is no guarantee that it is valid.

The VASI is so located as to be functionally unusable during periods of reduced visibility, both from its distance and its location within the runway lights for Runway 22. A PAPI would not suffer either infirmity and would dramatically lessen the impact of the unusual approach and runway light configurations on pilot perception ability.

B. Offset Localizer

The localizer for Runway 13 is aligned on a 132° magnetic course and the runway centerline is on a 135° magnetic orientation. The localizer beam crosses the extended runway centerline 2745 feet before the runway threshold. The current minimums for this approach are 263 feet (250 feet) and RVR 24 (2400 feet) or 1/2 mile.

An aircraft on this approach in weather conditions that provide the minimum requirements will close on the extended runway centerline from the right, cross the extended runway centerline and be approximately 38 feet left of center when the runway threshold is first seen. The aircraft would still be going further left of the runway centerline when the required correction would be initiated. A normal alignment maneuver would require a right turn to a heading to regain the centerline and a left turn to align the aircraft with the runway.

This challenging approach is further complicated by a glideslope that is unusable below 200 feet. The VASI system is not visible until the aircraft has progressed another 1400 feet toward the threshold. This implies that a pilot must judge his approach angle by visual cues within 2400 feet of his position while turning right, then left.

The vertical wall at the approach end of the runway structure and the concrete pilings supporting the approach lights are extremely hazardous in the event of an undershoot or overrun. In this accident, the aircraft lost its main landing gear and a portion of the right engine as a result of the impact with this particular area of the runway. For this runway, the autopilot cannot be utilized to touchdown when there is an offset localizer or an unusable glideslope.

It is ALPA's understanding that the offset localizer situation has been, or is in the process of being corrected for Runway 13 at LGA. While relevant to the perception problems of the pilots in the accident aircraft, the decision to replace the transmitter with one which will eliminate the offset will lessen the need for a recommendation in this area. However, this approach should have visibility minima that are high enough to see the VASI system at minimums (4000 feet RVR, 3/4 mile).

V. AIR TRAFFIC CONTROL

A. Interval Between Takeoff and Landing

LGA was using a single runway for takeoffs and landings, reducing the time that the runway was clear before an aircraft landed. The significance of such an operation will effectively increase the amount of communications on that particular frequency and delay the issuance of the landing clearances. This type of operation will also increase the amount of time spent in maneuvering on approach to accommodate the need for increased spacing. While not particularly significant under normal conditions, it became very significant when TWA 8630 executed their abort, introducing a great distraction to the flight deck of the DAL 554. Normally, an aborted takeoff would not impact the issuance of a landing clearance at LGA.

B. Air Traffic Control Frequency Usage

DAL 554 had been cleared to land while TWA 8630 was beginning its takeoff on Runway 13. However, TWA 8630 aborted almost immediately. DAL 554 was aware of the single runway operation at LGA and based upon TWA 8630's discussions with ATC on the Local Control frequency, it was fairly obvious to DAL 554 that the runway may be occupied and unavailable for an immediate landing. TWA 8630 turned off Runway 13 onto Runway 4/22 and the tower continued to direct them to "*just continue down the runway, make the first right turn* ...." To a pilot on approach, it might sound as though TWA 8630 was still on the active runway, a significant distraction. Referencing the DAL 554 Captains interview: *"Rushed, I did not feel at all rushed on the approach, only felt rushed when TWA took the runway and aborted...At some point, they announced they were clear."* Also referencing the First Officer's interview; *"The TWA was a bigger concern than the weather. Our landing clearance was in jeopardy. I was concerned with whether TWA was clear."* The tower re-affirmed DAL 554's clearance to land about 10 seconds before the accident -- about the time they were at minimums.

As it relates to this accident, the tower's initial persistent inquiry into the reason for the abort and the non-clarity as to TWA's route of taxi subsequent to the abort made it difficult for DAL 554 to ascertain the availability of Runway 13 for landing. When TWA 8630 cleared the active runway, Local Control might have been better served if TWA 8630 had been instructed to contact Ground Control and explained the reason for his abort on that frequency. The use of the Local Control (Tower) frequency to gather information not directly and immediately applicable to traffic control should be discouraged.

It seems that the LGA tower controllers have a habit of extensive non relevant communications on the local control frequency. This is shown by another incident which occurred approximately seventy minutes prior to the DAL 554 accident. USAir 1730 landed on Runway 13 and recommended that approaches to that runway cease. Local Control continued to inquire about the reasons for that recommendation as USAir 1730 taxied to the terminal and Local Control (LC) handled arriving and departing aircraft. As a result, aircraft on the LC frequency heard USAir 1730's explanation, but in subsequent transmissions to aircraft on approach, LC mistakenly reported the gain and loss of airspeed as 20 knots, not the 25 knots that USAir 1730 reported.

The flight crew of DAL 554 were concerned about their landing clearance. Although TWA 8630 was clear of the active runway, the Tower told them to "...just continue down the runway...", leading the crew of DAL 554 to believe that the runway they were cleared to land on was not clear. The frequency was quite congested with the tower's persistent inquiry into the reason for TWA's aborted takeoff. DAL 554, in turn, could not confirm their clearance to land until they were at minimums; a serious distraction.

The use of Local Control (Tower) frequency to gather information not directly and immediately applicable to traffic control should be discouraged. Ground Control frequency should be the appropriate place to gather details or the PIREP in order to accurately relay the details to other approaching aircraft, TRACON and Center.

VI. AIRCRAFT PERFORMANCE

A. Flight Data Recorder (FDR) Analysis

Analysis of the accident FDR information as well as some of the ancillary FDR data provides additional evidence of the significant meteorological conditions present during this particular approach that resulted in aircraft deviating from ILS parameters (glideslope and localizer).

FDR information for DAL 554 shows a glideslope deviation beginning approximately 35 seconds prior to ground contact. This deviation increased to approximately 1.8 dots above glideslope with no appreciable changes in elevator; with only minor corrections evident (+/- 4° centered around a neutral -8°). Vertical, Lateral and Longitudinal accelerations remained relatively constant during this phase of the approach, with minor perturbations appearing in vertical acceleration. Airspeed remained constant at approximately 130 kts and the aircraft was in a constant descent.

Heading during the final 35 seconds remained at approximately 129° for the first 12 seconds of this 35 second period. During the period from 23 seconds prior to initial ground contact to ground contact, heading corrections were evident with heading varying from 131° to approximately 124° at impact. These heading corrections are occurring from what appears to be minor aileron inputs. Left heading corrections appear to be influenced by momentary left wing down aileron inputs, however neutral aileron inputs (~0°) result in heading values deviating to the right. The relationship between roll angle and heading indicate a slight lag of heading angle to roll angle. It appears that as aileron inputs are relaxed from the left wing down position, roll also begin a trend toward the right wing down direction, or a right heading.

Aircraft right of localizer deviations began approximately 30 seconds prior to initial ground impact. The deviation rate remained constant during the entire 30 seconds with corrections back toward (but never reaching) "0-deviation" beginning approximately 7 seconds prior to ground impact. Although the heading was being corrected to the left, the localizer deviation continued to deviate to the right.

The magnetic heading of Runway 13 at LaGuardia is 135°. The final heading recorded for the accident flight was 123.59°. Due to a lack of recorded radar data below 500 feet MSL, a valid assessment of the relative winds was not possible by the Aircraft Performance Group. Several analysis were conducted by Honeywell in conjunction with the Performance Group resulting in varying wind profiles. The Honeywell simulation resulted in no evidence of windshear, nor did the output from the Honeywell windshear computer.

Wind studies conducted by the Performance Group did indicate the presence of a headwind/crosswind during DAL 554's approach. Wind speeds varied on the approach between 7 to 17 knots and wind directions varied between 120° to 50°. Average wind speed and direction being approximately 12 kts and 80° respectively. A review of the ancillary FDR data from other aircraft on approach into LGA with wind speed / direction readout capability indicate similar wind profile data.

These averages would equate to an 8 kt crosswind and a 9 kt headwind at touchdown for an aircraft heading of 123.59°. On the approach, during the period where a localizer deviation was present, the aircraft heading varied between 131° and 123.59°. However, at the time where the localizer deviation was most pronounced, the aircraft heading had just been corrected back to approximately 126°. Performance Group calculations indicate that at this time, the wind speed and direction was 10 kts and 70° respectively. This would equate to an 8.3 kt crosswind and a 5.6 kt headwind.

Referencing several flight crew interviews (See Operations Group Factual Report, DAL 1215, CAL 1614, AAA 212, AAA 184, UAL 1576, & AAA Shuttle 6491), all flight crews indicated some degree of "crab" angle during their approach. Crab angles varied anywhere from 20° to "*...quite a bit...*" to "*...strong crosswind...*". Several flight crews stated that they went high on the approach.

The aircraft experienced a greater than normal descent rate during the final seconds of their approach. Wind profiles taken from the ancillary FDRs show very minor wind velocities at the surface, thus equating to minor headwind/crosswind components.

As the aircraft was "crabbed" for the approach, to compensate for the crosswind components present, and the crosswind decreased to negliable amounts, the aircraft experienced a higher than expected descent rate. During the final seconds of the approach, being at relatively low altitude, this increased descent rate nearly resulted in catastrophe.

VII. CONCLUSIONS

The crew of DAL 554 was asked to accomplish a task that very few pilots would be able to complete successfully. The captain was never informed about the possible implications of wearing monovision contacts. Although the effect of wearing monovision contacts may have been a contributing factor, it is unlikely because the first officer (who had normal vision) did not perceive an unusual situation. In fact, it appears that the captain and first officer recognized their predicament simultaneously. Why then would two experienced, professional crewmembers make the same mistake? It is our belief that a visual illusion of some type was present. Either the rain interacted with the windshield giving the pilots the perception that they were higher than they actually were, or these pilots fell victim to the "black hole" approach phenomenon.

In the case of the DAL 554 crew, there was simply insufficient information available to accurately assess aircraft position or performance on this approach. While it is certainly valid to argue that the crew should have executed a missed approach, this assumes that they were capable of detecting an abnormality sooner than they did. The factors leading to the misperception included the time of day, the weather conditions, the visual illusions due to the heavy rain on the windshield, the unusual approach light configuration, the offset localizer and the use of monocular contact lenses. Also contributing to the misperception were the shifting and variable winds, the external distractions, the prejudice over runway length and the risk of overrun, the lack of procedural guidance and the lack of electronic, visual or internal guidance concerning vertical position or rate of change. With all of these potentials for error, it should not be surprising that the crew varied from the optimum approach angle. When the Non Error Tolerant runway is added to the equation, the accident becomes very predictable. If it is predictable, it should be preventable.

ALPA strongly encourages the NTSB to recommend that not only Delta Airlines but all airlines closely review their procedures for all approaches without consideration of the type of approach being flown to standardize to the highest degree possible the duties of both the PF and the PNF. An ad hoc approach to the monitoring function results in the possibility that the PNF may not effectively participate, rendering the PF a solo operation. Intuitively, it would seem that this is more likely when the PF flying aids the captain.

Several foreign operators have adopted a system that requires all low visibility approaches be conducted by the F/O, who is tasked to continue on instruments throughout the approach to insure that a seamless go around will be executed should the captain not affirmatively identify the landing environment or if, subsequent to the captain assuming responsibility for the landing, the approach becomes somehow unstabilized. ALPA advocates research in this area to compare the various procedural approaches to the conduct of such approaches to extract maximum value out of the monitoring function.

Training and education will not prevent a re-occurrence of this accident. The particular runway configuration is fatally flawed and must be corrected by, at an absolute minimum, insuring immediately that there is always precision vertical guidance available from decision height to touchdown. The monocular contact issue is easily corrected by inclusion of a question concerning use on the medical questionnaire used during FAA physical examination. Procedures directed to the duties of PNF and consideration of the entire issue of responsibility for a low visibility approach should be recommended. As is frequently the case, the dissemination of real time critical weather information is still inadequate within our domestic system. The NTSB should point out to the FAA the number of times this issue has come up without effective remediation taking place.

Finally, the issue of "landing mindedness" needs to be addressed to the commercial pilot population. Reference is made to the remarks of Captain Colby in his memo of Nov. 14, 1996 where he states that "*we must change our culture so that we plan for and accept mentally the possibility of go around on every approach*." ALPA strongly endorses that statement and calls upon the NTSB to include it as a strong recommendation to the entire industry. It can be accomplished by a change in attitude of management and a modification of the training which we accomplish. It is not simply a "Delta" problem, and it won't go away without a change in attitudes from the top down.

VIII. RECOMMENDATIONS

1. All airlines review their procedures for all approaches (without consideration of the type of approach being flown) to standardize to the highest degree possible the duties of both the PF and the PNF.

2. Weather dissemination practices in the industry be reviewed to ensure that flight crews are given the most current weather advisories as soon as possible (preferably prior to entry into said conditions).

3. Review the LaGuardia Runway 13 approach from an approach visibility standpoint to determine the effects of visibility on VASI usability.

4. Raise the visibility requirements for the LGA ILS/DME Runway 13 approach to a minimum distance that would ensure both VASI bars be seen at Decision Height or that a PAPI be installed at the approach end of the runway.

5. The FAA must remind dispatch departments of 121 Air Carriers of their responsibility to pass along new weather information to flight crews as it is received. Special attention should be paid to whatever process an Air Carrier uses to see that their flight crews receive Urgent Center Weather Advisories issued after departure.

6. The FAA should remind pilots of their responsibility to report weather conditions to ATC and fellow pilots in the form of a PIREP. Reporting good weather and lack of turbulence should be stressed as well.

7. All localized weather information be provided to flight crews real time.

8. Strict guidelines be established and enforced for Air Traffic Controllers concerning the use of ATC frequencies.

9. Precision visual landing aids be installed at LaGuardia Airport which are fully visible and useable by the pilot from the decision height to threshold crossing. It should be a precondition of any use of the runway that such an aid be fully functional before issuance of a landing clearance.

10. Training be developed for flight crews as it relates to visual illusions during particular weather conditions.

11. Night approaches be designed to ensure that some form of vertical guidance information is available to the pilot to threshold crossing.

12. Human Factors research be conducted to understand the effects on visibility of monovision contacts and heavy rain on the windshield.

13. Human Factors research be conducted to understand the effects on cognitive demands concerning first leg of first rotation on first day between two crewmembers.

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