BAE SYSTEMS

AWP/JS32/05078

National Transportation Safety Board
490 L'Enfant plaza East, S.W.
Washington, DC
20594
United States of America

9th September 2005

For the attention of : Mr R. Rodriguez

Dear Sirs,

Re. Submission to NTSB regarding fatal accident on Jetstream 3200; Corporate Airlines Flight 5966 on the 19th October

On behalf of BAE Systems – Regional Aircraft (trading as BAE Systems (Operations) Ltd) please find enclosed our company's submission relating to the accident involving a Jetstream 3200, N875JX, operated by Corporate airlines (now known as Regions Air) at Kirksville Missouri on the 19th October 2004.

Our submission is intended to analyse the facts previously reported, draw conclusions and provide associated safety recommendations which we hope will help prevent such similar accidents in the future.

We would like to express our appreciation of the NTSB in the co-ordination and co-operation between the parties during the investigation. We would also like to acknowledge the NTSB's patience in allowing BAE Systems an extended deadline to complete our submission.

If you have any questions relating to this submission please direct them to Alistair Scott, Head of Flight Safety +44 1292 675075 who acted as the BAE Systems Party co-ordinator for the investigation team.

Yours Faithfully
For and Behalf of
BAE Systems (Operations) Ltd.

[redacted]

Alistair Scott
Head of Flight Safety and Chief Airworthiness Engineer

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BAE SYSTEMS SUBMISSION TO THE NTSB

Corporate Airlines J32, Accident, Kirksville, 18 October 2004

PREPARED BY (Author)	Delete as Applicable ~~VERIFIED /~~ APPROVED BY (Non-Cert'n Report)	AUTHORISED BY (external distribution only)
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Fatal Accident to Corporate Airlines, Jetstream 3200 series, registration N875JX, at Kirksville, 18 October 2004

Synopsis

On October 19, 2004, at 7.37 p.m. central daylight time (CDT), a British Aerospace Jetstream 32, N875JX, operated by Corporate Airlines, crashed on approach to the Kirksville Regional Airport, Missouri. The flight, designated flight number 5966, was operating in accordance with 14 CFR Part 121.

According to the NTSB preliminary report, the NTSB was first notified by the FAA Communication Centre shortly after the accident. The investigation was led by the NTSB with support from the AAIB as accredited representatives for the state of manufacture. BAE SYSTEMS Regional Aircraft assisted both the NTSB and AAIB directly during the course of investigation.

Corporate Airlines flight 5966 was conducting a non-precision LOC/DME approach into Runway 36 at Kirksville during the hours of darkness with weather at the time of the accident reported as mist, with an overcast ceiling at 300 feet.

Following vectoring by the Kansas City Air Route Traffic Control Centre (ZKC) for the LOC/DME approach to Runway 36 at Kirksville, the aircraft was noted on radar to cross the outer marker correctly aligned with the runway and at approximately the correct altitude.

The aircraft continued to descend through the minimum descent altitude and crashed approximately 1.2 nautical miles from the runway during the approach. Eleven of the 13 passengers and both flight crew members were fatally injured. The two surviving passengers received serious injuries. The aircraft was destroyed by impact forces and post-impact fire.

NTSB Group Factual Reports, following thorough investigation of this accident, determine that there were no aircraft or systems malfunctions that may have been causal in this accident.

1. FACTUAL INFORMATION

1.1 *History of the flight*

On 19 October 2004 at 1842 (CDT) Corporate Airlines flight 5966, departed St Louis for Kirksville, Missouri (IRK). The flight was operated in accordance with 14 CFR Part 121. The accident flight was the sixth flight of the day for the crew. At the time of the accident, the crew had, following a rest period of nine hours and fourteen minutes, been on duty for fourteen hours and thirty one minutes and had flown for six hours and fourteen minutes.

The captain was the flying pilot (FP) during the accident flight. The flight climbed to and cruised at an altitude of 12,000 feet mean sea level (MSL) en-route to IRK. Both flight crew members were familiar with the approach into Kirksville. Indeed, they had flown the same route earlier that day.

During the flight to Kirksville, a radar service was provided by the Kansas City Air Route Traffic Control Centre (ZKC), which included radar vectoring for a LOC/DME approach to Runway 36 at Kirksville and a clearance to carry out that approach. Prior to issuing the crew with an initial descent clearance, the ZKC radar controller verified that they had the current IRK weather and asked which approach the pilot was requesting.

The LOC/DME approach to Runway 36 at Kirksville requires the aircraft, once established on the localiser, to cross the Final Approach Fix (FAF), defined by the 'Kemmy' Outer Marker, located at 5.2 DME from the 'I-IRK' navigational facility. The aircraft should cross the FAF at an altitude of 2500 feet, and begin descent to the Minimum Descent Altitude (MDA) of 1320 feet. According to the NTSB Operational Factors Group Report, the aircraft was seen on ZKC radar to cross the FAF at 2400 feet and then begin the descent.

The aircraft continued descent after passing the FAF at an average descent rate of about 1,200 feet per minute.

The aircraft continued its descent through the Minimum Descent Altitude (MDA) until impacting trees approximately 1.2 nautical miles from the runway or at approximately 2.3 DME on the localiser centreline.

1.2 ***Injuries to persons***

Fatal	*2:2 Crew*	*11:13 Passengers*
Serious	2 surviving passengers	
Minor/None	N/A	

1.3 ***Damage to aircraft***
The airframe and both powerplants were destroyed by impact forces and post impact fire. According to the NTSB Systems and Structures Group Factual Reports there is no evidence to suggest any pre-impact structural failure or mechanical or electrical failure of the airframe, aircraft systems and powerplants.

1.4 ***Other damage***
During the initial contact with tree tops, many branches sustained damage indicating the roll attitude of the aircraft, at the initial impact. Following post impact fire, trees and surrounding bushes were destroyed.

1.5 ***Personnel information***
As extracted from the NTSB Operational Factors Report:

Captain
Age: 48
Relevant Qualifications and Checks
AIRLINE TRANSPORT PILOT (issued August 26, 2003)
AIRPLANE MULTI-ENGINE LAND BA-3100 COMMERCIAL PRIVILEGES AIRPLANE SINGLE ENGINE LAND (no limitations) [* This rating included the BA-3201 airplane.]*
Medical Certificate: First Class (issued June 22, 2004) Limitations: SHALL HAVE AVAILABLE LENSES FOR NEAR VISION
Training and Proficiency Checks:
Corporate Airlines Initial New Hire training completed on May 3, 2001 Initial Type Rating Jetstream 3201: August 26, 2003 Upgraded to captain on BAE 3201 on September 17, 2003
Last Recurrent training: June 13 and 15, 2004
Last recurrent ground training: July 7, 2004 Corporate Airlines
Last Proficiency check on BAE 3201 on July 16, 2004
Last Line Check: September 28, 2004 On June 28, 1991

Flight times (from Corporate Airlines through NTSB factual report)

Total pilot flying time	*4,234 hours*
Total Pilot-In-Command (PIC) time	*3,277 hours*
Total Jetstream 3201 flying time	*2,510 hours*
Total Jetstream 3201 PIC time	*719 hours*

First Officer
Age: 29
Relevant Qualifications and Checks
COMMERCIAL PILOT (issued September 13, 2004)
AIRPLANE SINGLE ENGINE LAND/ COMMERCIAL PILOT
AIRPLANE MULTIENGINE LAND/COMMERCIAL PILOT
INSTRUMENT AIRPLANE/COMMERCIAL PILOT
Medical Certificate: First Class (issued February 17, 2004) Limitations: HOLDER SHALL WEAR CORRECTIVE LENSES
Training and Proficiency Checks: Corporate Airlines Proficiency check on a BAE 3201: passed on August 12, 2004

Total pilot flying time	*2,856 hours*
Total Pilot-In-Command (PIC) time	*2,698 hours*
Total second-in-command (SIC) time	*192 hours*
Total time in Jetstream-3201	*106 hours*

Although both the Captain's and First Officer's medical certificates contained limitations regarding the use of corrective lenses, it is not clear from the factual reports whether corrective lenses were worn during the accident flight by either crew member.

1.6 ***Aircraft information***

It is reported that the aircraft had a valid Certificate of Airworthiness (C of A) at the time of the accident and maintenance had been conducted by Corporate Airlines in accordance with their maintenance programme.

The take off Centre of Gravity (C of G) for the accident flight was within the approved limits of the envelope in accordance with Corporate Airlines Centre of Gravity Calculator as stated in the Operational Factors Report.

Similarly, the concluding paragraph within the NTSB Performance Study states "The airplane was within its angle of attack envelope until just prior to the impact." There was no evidence from the NTSB Performance Group Study to suggest that the aircraft performance was in any way degraded leading up to the time of the accident.

1.6.1 ***Aircraft Systems***

As stated in section 1.3 Damage to aircraft, there is no evidence to suggest that there was any pre-impact structural failure, mechanical or electrical failure of the airframe, aircraft systems and powerplants that may have been causal in the accident.

Furthermore, seconds before impact, there is evidence from the NTSB Cockpit Voice Recorder Transcript, of two aural systems warnings, which for clarification purposes will be discussed in the following sub sections.

1.6.1.1 ***'MINIMUMS MINIMUMS' and ' SINK RATE' Callouts***

The Cockpit Voice Recorder transcript, at *1936:37.2, shows that the 'MINIMUMS-MINIMUMS' call out was made and,* at 1936:52.2, details that the "SINK RATE" warning also sounded. These are functions of the Ground Proximity Warning System (GPWS). The GPWS on this aircraft was introduced via a Learjet Inc. Supplementary Type Certificate (STC) and therefore the modes, as described below, may not be wholly representative.

Extract taken from the BAE Systems Aircraft Maintenance Manual (34-45-00 001 - GROUND PROXIMITY WARNING SYSTEM - SUNDSTRAND MK VI - DESCRIPTION AND OPERATION - BAe Jetstream 32).

Mode 1 - excessive descent rate

Mode 1 provides data and warnings for excessive descent rates with respect to radio altitude during the descent and approach phases of flight. There is an outer alert boundary and an inner warning boundary. Penetration of either boundary results in illumination of the GPWS alert lamps on the indication unit and the CAP. In addition, the outer alert boundary provides an aural warning of 'sink rate' every three seconds, and the inner warning boundary provides a continuous aural warning of 'pull up' with increased emphasis.

Penetration of the inner warning boundary is designed to produce an urgent continuous aural warning of 'pull up' at ten seconds before ground impact.

Appendix 1 illustrates approximately where the flight entered the outer boundary resulting in the SINK RATE call out, thus demonstrating that the system worked as predicted.

The sink rate warning occurred approximately one second before "trees" was noted on the cockpit voice recorder transcript and it is therefore debatable whether the flight crew would have been able to react in time to prevent the subsequent impact with the trees.

Mode 6 - Decision Height (DH) and bank angle

Mode 6 provides the following aural warnings:

Single 'minimums-minimums' aural warning during an approach as the aircraft descends below the DH. Repeat 'bank angle' aural warning at three second intervals (when the bank angle is greater than 15° or the roll rate is excessive).

1.6.1.2 ***Sound Similar to Stall Warning Horn***

At *1936:54.0 [sound similar to stall warning horn]* is noted in the Cockpit Voice Recorder transcript report. The stall protection system is described in following text.

Extract taken from the BAE Systems Aircraft Maintenance Manual (27-35-00 001 - STALL PROTECTION SYSTEM - DESCRIPTION AND OPERATION - BAe Jetstream 32)

The vane operated lift transducer in each wing provides continuous output signals to its related Signal Summing Unit (SSU). The computed sum of the signals is proportional to the lift coefficient (C_L / (C_L max.) of the wing. Since the amount of lift produced by each aircraft wing depends on its angle of attack, the angle defines the point of the wing at which the airflow divides (stagnation point). As the angle of attack increases, the stagnation point moves rearwards under the wing leading edge. This reduces the airflow pressure on the lift transducer vane, allowing it to move forward under spring pressure.

Forward movement of the vane to the STALL WARNING position causes the SSU to generate a shaker output signal. This signal initiates operation of the related stick shaker and dual warning unit [warning horn], alerting the pilots to a developing stall condition.

The above conditions apply to either left or right sub-systems.

1.6.1.3 ***Autopilot***

This aircraft was not installed with an autopilot at the time of delivery as per operator request nor was the aircraft retrofitted with an autopilot by any subsequent operators. The aircraft, therefore, could only be flown manually.

1.7 ***Meteorological information***

The following extract is taken from the NTSB Group Meteorological Factual Report:

The station models on the regional surface analysis chart for 0000Z over northern Missouri, obtained from the National Weather Service (NWS), indicated winds from the north to northeast at 10 knots or less, visibility obscured in mist, overcast skies, temperatures in the upper 40's to low 50's (degrees Fahrenheit (F)), and temperature dew point spreads of 2 degrees or less.

The NWS does not issue a Terminal Aerodrome Forecast (TAF) for Kirksville Regional Airport (KIRK) and as an operational requirement Corporate Airlines contracted for meteorological services from Meteorlogix, an Enhanced Weather Information System (EWINS) provider. The Meteorlogix's forecast, commonly called a "RAMTAF", current at the time the flight was dispatched, was as follows:

KIRK RAMTAF issued at 2121Z and valid from 2100Z [19 October] to 1700Z on October 20, 2004. From 2100Z, wind from 040 degrees at 5 knots, visibility 4 miles in mist, ceiling overcast at 800 feet. From 0300Z, wind from 040 degrees at 5 knots, visibility 2 miles in mist, ceiling overcast at 500 feet. From 0900Z, wind from 040 degrees at 5 knots, visibility 2 miles in mist, ceiling overcast at 400 feet, temporarily between 0900Z and 1400Z visibility 1/2 mile in fog, ceiling overcast at 200 feet. From 1400Z, wind from 060 degrees at 5 knots, visibility 4 miles in *mist, ceiling overcast at 1,000 feet. From 1600Z, wind from 060 degrees at 5 knots, visibility 5 miles in mist, ceiling overcast at 1,500 feet.*

Kirksville Regional Airport has an Automated Surface Observation System (ASOS) and has NWS certified observers located at the station to augment the system as necessary.

The 5-minute ASOS data from KIRK was downloaded and obtained from the NWS Regional Forecast Office located in Kansas City/Pleasant Hill, Missouri. The observation at the time of the accident indicated the following:

KIRK 5-minute automated ASOS observation at 0045Z, wind from 020 degrees at 6 knots, visibility 5 statute miles in mist, ceiling overcast at 300 feet, temperature and dew point 9 degrees C, altimeter 29.96 inches of Hg, pressure altitude 930 feet, relative humidity 96 percent, density altitude 500 feet, wind 020 degrees magnetic at 6 knots. Remarks: automated system, ceiling 200 variable 600 feet, thunderstorm sensor not operating.

The weather report issued to the flight crew at dispatch can be seen in Appendix 2. This documents defines what weather information was issued to the flight prior to departure from St Louis.

1.8 ***Aids to navigation***
There was a Localiser and Distance Measuring Equipment installed at Kirksville aerodrome. There is no instrument landing system installed at this airport. See section 1.10 Aerodrome Information for further details of navigation aids.

1.9 ***Communications***
An approach control service for Kirksville Regional Airport was supplied by Kansas City Air Route Traffic Control.

1.10 ***Aerodrome information.***
As stated in the operations factual report, Kirksville Regional Airport is 966 feet above mean sea level (MSL), and is located in Kirksville, Missouri.
Runway 18 has medium intensity runway lights (MIRL) and runway end identification lights (REIL). Runway 36 had medium intensity runway lights (MIRL) and a medium intensity approach lighting system (MALS). Runway 18 and runway 36 both have visual approach slope indicator (VASI-L) located on the left hand side of the runway.

Kirksville was not equipped with an Instrument Landing System, therefore all flights into the airfield were non precision approaches.

1.11 Flight Recorders

Details on the installation of Cockpit Voice Recorder and Flight Data Recorder and evidence from the recordings are discussed below, including observations on the correlation of both data sets.

1.11.1 ***Cockpit Voice Recorder (CVR)***

According to the NTSB Cockpit Voice Recorder Factual Report, the aircraft was installed with a Fairchild A-100A, thirty minute, Cockpit Voice Recorder (CVR). The recorder was installed in the tail cone of the aircraft.

The exterior of the CVR showed significant evidence of structural damage and the recorder was compressed at both ends. The interior of the recorder and the tape sustained no apparent heat or impact damage and approximately 30 minutes of recordings, including run up to accident, were successfully recovered.

Communications of interest on the CVR transcript are noted in appendix 3 and will be discussed in greater detail in the analysis section of the report including observations on crew interaction and performance.

Observations include comments on:
The relationship of the crew.
Potential evidence of fatigue.
Crew's perception of the 'runway environment'.

Examination of the CVR transcript did not reveal any facts to indicate that the crew had been faced with any in flight failure which may have caused them to be alerted or alarmed sufficiently to take specific action in response to an abnormal or emergency situation. In fact, the CVR transcript suggests that the crew were unaware of the impending accident until moments before the initial impact.

There is a note on the transcript as follows:
1936:50.5
CAM [sound similar to increase in engine RPM]

For clarification purposes BAE SYSTEMS would like to highlight that in normal flight operation, there are only two approved engine/prop RPM settings, 97 and 100%, with 100% (equivalent to 1591 RPM - propeller) being required for take off and landing. In discussions at the NTSB technical review, it was stated that 'increase in engine RPM' was a generic term used to describe a change in engine sound or tone. To that extent, it is not possible for BAE SYSTEMS to comment whether this was a normal RPM increase associated with final landing configuration without further analysis of this particular sound recording being conducted.

1.11.2 ***Flight Data Recorder (FDR)***
According to the NTSB Flight Data Recorder Group Report, the aircraft was installed with an L3 Fairchild F1000 Flight Data Recorder. The FDR was located in the rear of aircraft, aft of the main passenger door. The recorder sustained thermal damage to the outer sleeve but overall was in good condition. All recorded parameters were downloaded successfully.

According to the NTSB Flight Data Recorder Report there is no evidence to suggest that the aircraft levelled off, or that the rate of descent was reduced at MDA (1,320ft).

The FDR data presented suggests that from 2500 feet the aircraft rate of descent was approximately 1,200 fpm and the flight continued to descend at this rate through the minimum decision altitude and did not appear to deviate in flight path angle or heading until just before the initial tree strike as identified in the NTSB Performance Study. This is also corroborated by the conclusion within the NTSB Performance Study.

1.11.3 ***CVR/FDR Correlation***
From the CVR/FDR overlay, at MDA, the comment is noted HOT 1 "I can see ground there." whilst the aircraft maintained a constant rate of descent as described in section 1.11.2. The subsequent discussion between the crew, on whether the 'runway environment' was actually in sight or not, continued approximately for another 10 seconds whilst the aircraft continued to maintain a constant rate of descent.

From the NTSB Addendum to Performance Study and CVR Overlay, it is unclear whether the area microphone recording of initial impact was an actual tree strike or initial contact with the tree branches, as evidenced by photographs within the NTSB Performance Study Group Report.

At the technical review, NTSB Operational Factors group advised that the initial tree impact recorded on the CVR was most likely a significant tree strike whereas the evidence recovered at the "initial tree strike", defined in the NTSB Performance Group study, was only tree top branches causing the removal of wing tip lights and wing vortex generators. This is not consistent with a significant tree strike.

1.12 ***Wreckage and impact information***
Photographic evidence of the damaged tree branches, including that from the NTSB Performance Study show that the tree branches were broken in a horizontal manner.

A brief summary of the general wreckage and impact information is included below, in the extract from the NTSB Systems Group Factual Report. A more extensive record of the damage and wreckage path is recorded in the NTSB Structures Group Report.

"Items found along the debris path (in order of passage) included a belly strobe light reflector piece, landing light lens pieces, strobe light piece, landing and/or taxi light reflector pieces, a piece of the propeller heater mat boot , and static wick, all of which were found near the beginning of the tree line, along with several vortex generators. Farther along the debris path the #2 comm antenna was found near the left wing piece. The instruments were all found in the main wreckage field."

1.13 ***Medical and pathological information***
See survivability aspects section 1.15

1.14 ***Fire***
Post impact fire occurred and caused extensive damage to the aircraft, powerplants and surrounding trees and scrub.

Local fire services were in attendance shortly after the accident and managed to restrict further spread of fire.

1.15 ***Survival aspects***
According to the NTSB Survival Factual Report, the Adair County Medical Examiner conducted post-mortem of the fatally injured occupants and determined that the cause of deaths was multiple blunt force trauma.

The survivors were both seated on emergency exit row 4 (seats A and C). Both survivors evacuated the aircraft either through a hole in the fuselage or an emergency exit, neither can recall exact details. The attending rescue services discovered the survivors and took them to hospital for treatment.

1.16 ***Tests and research***
BAE SYSTEMS research conducted during this investigation primarily involved human factors studies and reference to Flight Safety Foundation and FAA publications. This research, primarily into fatigue and approach and landing/controlled flight into terrain accidents, is discussed in later sections.

1.17 ***Organisational and management information***
Corporate Airlines started operations in 1996 and was a privately held Part 121 air carrier with headquarters in Smyrna, Tennessee. At the time of the accident, Corporate Airlines operated 11 British Aerospace Jetstream 3201 aircraft from pilot bases in St. Louis, Missouri and Nashville, Tennessee. 62 pilots were employed by the company, including 32 captains and 30 first officers.

1.17.1 Company Guidance and Training

To date, BAE SYSTEMS have seen only limited information on company training other than the Crew Resource Management Curriculum from Corporate Airlines and some descriptive detail taken from crew interviews in the Operations Report and associated appendices.

The NTSB Operational Factors report and associated appendices indicate the practices and call outs expected on a non precision approach. However, there is some inconsistency in the interview summaries as to the extent to which standard call outs are actually trained, although the flight crew should have been aware of the company procedures for approach into Kirksville.

A brief summary of callouts extracted from Corporate Airlines Flight Manual can be seen below. However, as previously stated it is not clear how consistently such callouts were trained.

At 3-4 miles prior to FAF Flying Pilot calls
"Gear Down, Flaps 20, Before Landing checklist"

In the event that visual contact is attained that will allow descent to 100' above touch down zone, the non flying pilot calls
"Approach lights in sight, continue"

In the event that contact is made, non flying pilot calls
"Runway in sight"

However, if upon reaching missed approach point, the runway is not in sight the flying pilot calls
"Missed approach"

The full text from Non Precision Approach Profile Notes within Corporate Airlines Flight Manual can be seen in Appendix 5, which details all of the standard call outs and procedures that should be adopted on a non precision approach.

In terms of stabilised approach criteria, the Corporate Airlines Flight Manual, according to the NTSB Operational Factors report reads as follows:

Stabilized Approach Criteria

A. When any approach fails to meet the following stabilized approach criteria during IMC [instrument meteorological conditions], an immediate missed approach (or go around, as appropriate) is mandatory.

[Note: there is no B.]

C. Phase 1 *1) 2,000 Feet AFL to 1,000 AFL.*
2) Maximum Descent Rate: 2,000 FPM.

D. Phase 2 *1) 1,000 Feet to 300 Feet AFL.*
2) Maximum Descent Rate: 1,200 FPM.

E. Phase 3 *1) 300 Feet to 50 Feet AFL*

2) Maximum Descent Rate: 900 FPM

We understand that Corporate Airlines crew are generally trained within the guidelines of FAA regulations but we are unable to comment on the standard, effectiveness and frequency of training conducted, specifically in relation to the above stabilised approach criteria and this accident.

It is understood that Corporate Airlines conducts Controlled Flight Into Terrain (CFIT) avoidance training. Again, it is not clear to BAE SYSTEMS, to what level CFIT training was conducted and how far risk reduction of Approach and Landing Accidents (ALA), particularly of non precision approaches, was discussed. Evidence from the NTSB Operational Factors Report (and attachments) suggest that although CFIT training was conducted the Flight Safety Foundation CFIT Risk Checklist/ALA Risk Awareness Tool was not used to assess risks.

In terms of general CRM training, the Corporate Airlines curriculum lists crew member personality types, crew co-ordination, discipline, conflict resolution and team building amongst other teaching points.

1.17.2 ***Company Culture: reporting and trend monitoring***

The NTSB Operational Factors Group Report and appendices contain evidence to suggest that crews were encouraged to "speak up" about any potential concerns. However, it is unclear what level of safety management systems was operational within Corporate at the time of the accident.

Throughout the Operational Factors Group Report and associated appendices, there is evidence indicating that Corporate Airlines had a 'don't fly if tired' policy and according to the interview summaries, at least one First Officer stated that he was aware of crew who had called in tired with no repercussions.

In terms of the reporting culture, the Assistant Chief Pilot suggests that there was a Safety Report Form that pilots could use to report any safety concern to the Director of Safety. However, there was no indication of how far filing reports was encouraged and how these forms were processed either internally or as part of an FAA safety analysis programme for trend monitoring and potential accident prevention purposes.

The assistant chief pilot stated, according to the NTSB Interview Summaries, that he was aware of some safety report forms and named examples of bird strikes and a collision with a deer on the runway. He stated that he did not recall any serious safety concerns that were reported on the safety report form. However, the night before the accident flight, according to other Corporate Airline crew interviews, there had been an event on approach into Kirksville, where the crew climbed as they felt they were too close to the trees. This crew were using the same approach procedures as that of the accident flight. It is unclear whether this or any previous similar incidents would have been reported within Corporate Airlines.

1.17.3 ***FAA oversight***

The NTSB Operational Factors Report stated that there was a valid FAA Air Carrier Certificate for Corporate Airlines and that Corporate Airlines operated under the FAA Surveillance and Evaluation Program (SEP) which guided oversight of the company.

The FAA oversight programme in section 9 of the operations report details FAA inspections conducted over a number of years prior to the accident. However, the operations factors report does not discuss the level of findings and detail of any actions arising from these audits.

In the NTSB Interview Summaries (appendix to the Operational Factors Group Report), the interview with the FAA Principal Operations Inspector raises a concern that he felt his new office duties were detrimental to Corporate Airlines "In light of this accident he said it was especially troubling."

The interview (summary) with the assistant FAA inspector covered a range of aspects on Corporate Airlines operation including the suggestion that he was unaware of the incident where the crew manoeuvred to avoid collision with trees on approach to Kirksville.

1.17.3.1 ***FAA Material***

The operations report details FAA guidance material, such as the FAA handbook, which discusses the stabilised approach concept and constant descent rates on non precision approaches. This information is generally intended to minimise accidents but the report does not disclose how far the guidance was incorporated into Corporate Airlines' standard operating procedures or training.

Of greatest significance is the guidance material from the FAA handbook on stabilised approaches and Constant Angle Non Precision Approaches (CANPA).
"To the greatest extent practical, on final approach and within 500 feet AGL, the airplane should be on speed, in trim configured for landing, tracking the extended centreline of the runway and established in a constant angle of descent towards an aim point in the touchdown zone"
"A constant rate descent has many advantages over the traditional method of descent on non precision approaches…."

The Corporate Airlines stabilised approach criteria are detailed in section 1.17.1 Company Guidance and Training. However, there is evidence both from the interview summaries and the operational factors report, on how the approach into Kirksville should have been flown, to indicate that Corporate Airlines were not operating a CANPA policy at the time of the accident. Although this is recommended FAA practice, it is not enforced and there is no evidence, within the NTSB reports, to suggest that the FAA inspectors assigned to Corporate Airlines encouraged the use of the CANPA technique.

1.18 ***Additional Information.***

The following sections include relevant information not already included in section 1.1.

1.18.1 ***Flight Crew Duty Times***

Inspection of the limited information on flight crew duty times for the period prior to the accident indicates that, at the time of the accident, the crew had been on duty for 14 hours and 31 minutes. Prior to commencing duty on the day of the accident, the crew had had a rest period of 9 hours and 14 minutes (this rest period appears in the Operational Factors Factual Report as 9 hours and 5 minutes, but the difference is not considered to be significant). Actual flight time for 6 sectors flown is quoted as 6 hours and 14 minutes, although scheduled flight time is not shown. It should also be noted that two scheduled sectors had been cancelled. Given the operator's typical sector lengths, it is reasonable to assume that the scheduled flight time for the day of the accident would have been in excess of 8 hours.

FAR 121.471 (b) (3) requires that a flight crew member be given at least 10 consecutive hours of rest for 8 or more but less than 9 hours of scheduled flight time. This rest may be reduced (FAR121.471 (c) (2)) to a minimum of 8 hours if the flight crew member is given a rest period of at least 11 hours that must begin no later than 24 hours after the commencement of the reduced rest period. It is difficult to establish, given that the crew were on the third day of a four day operating cycle, whether the FAA scheduling requirements were likely to have been met. This suggests that the FAA requirements can be ambiguous or could be misinterpreted. In addition, the complexity of the regulations may lead to difficulties in establishing a compliant crew roster.

For information, it is understood that the flight crew duty times and hence crew rostering would not have met UK Civil Aviation Authority (CAA) regulations.

With respect to crew duty times, we feel that the following extracts, taken from the interview summaries, are of significance.

FAA Principal "Inspector said the biggest problem he faced was that the FAA position on crew duty times was poorly defined. He noted there were so many different legal interpretations of the appropriate FARs that it was very difficult to challenge the air carrier's crew time policies. The problem was compounded by the fact the airline was short of crewmembers and needed the most availability possible from them...... He added that he gets at least one call a month from pilots concerned about the crew duty days. He felt the crew duty days "fell within" the FARs."

"Assistant FAA Operations Inspector "had heard some Corporate Airlines pilots complain about being tired. The FAA regulations allowed long days. He said he had not heard of any pilot say they were too fatigued to fly. He replied that he had known of pilots calling in sick, but was not

aware of anyone ever calling in too fatigued to fly. He said he did not think the company would ever force a pilot to fly fatigued or sick."

Corporate Airlines Captain "There were some line pilots that "sometimes" complained about the duty times, but he thought most of the complaints occurred on bad weather days."

There was limited evidence from the NTSB Factual Reports to indicate whether the level of reporting of crew fatigue to the FAA was similar to that reported within the airline or vice versa.

As part of the human performance investigation, interviews were conducted and the pertinent points with respect to crew duty times and rest facilities are included below:

"...characterised the schedules as efficient, sometimes reaching the maximum hours allowed by regulations."

"...they also agreed that the long duty days involved in company schedules could be tiring. This was especially true when visibility was low (which tended to occur throughout the entire route structure at the same time and add to pilot workload on a long duty day). "

"Jon mentioned that Tuesday (the accident day) was a really long day."

1.18.2 ***Flight Safety Foundation Approach and Landing Reduction (ALAR)/Controlled Flight Into Terrain (CFIT) Toolkit***

The Flight Safety Foundation (FSF) Approach and Landing Toolkit is a comprehensive training and awareness aid to actively promote accident reduction.

The toolkit provides guidance on recommended standard operating procedures and elements of stabilised approach which contains relevant points:

All flights must be stabilised by 1000 feet above airport elevation in IMC and by 500 feet above airport elevation in VMC.

... Sink rate is no greater than 1000 feet per minute; if an approach requires a sink rate greater than 1000 feet per minute a special briefing should be conducted...

An approach that becomes unstabilised below 1000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

According to the Flight Safety Foundation's controlled flight into terrain/approach and landing accident research, the risk of an accident is increased if a non precision approach is required. Risk is further increased within the hours of darkness. Specifically, the ALAR toolkit contains an approach and landing risk reduction guide questionnaire to be used by chief pilots, schedulers and flight crew to highlight potential risks (see Appendix 4). Additionally, the approach and landing risk awareness tool which is designed to improve crew recognition of the risks is also contained in Appendix 4.

Above all, the guidance from CFIT and ALAR training aids recommend operators and crews to be go-around ready, that is, plan for a go-around unless the required landing criteria are met.

1.18.3 ***Terrain Awareness and Warning System (TAWS)***

Honeywell Enhanced Ground Proximity Warning System (EGPWS) was originally certificated on the J31/32 but was not specified by the majority of operators. BAE SYSTEMS also supported Cascade Aviation Services' supplementary type certificate of Sandel Avionics ST3400 TAWS as an alternative modification.

The FAA compliance date for installation of TAWS was March 29th 2005 for all US registered aircraft with over 6 seats. Although TAWS was not installed in the accident aircraft, we understand that all of the Corporate Airlines fleet are now compliant.

To date, there has not been a single controlled flight into terrain accident involving an aircraft with operational TAWS installed.

1.18.4 ***Fatigue Management***

Human factors research suggests that fatigue increases with altered sleep cycles, early starts and long duty days. Increased levels of fatigue have been proven to affect human performance. The flight crew of the accident flight had been on duty for almost 15 hours after an early start. Fatigue countermeasures are briefly discussed in the section below and current NTSB thinking is then detailed.

1.18.4.1 ***Rest Breaks***

Research indicates that the effects of fatigue can be reduced by utilising the period of ground time that occurs between flight sectors. According to a variety of studies a nap of 20–30 minutes can promote alertness and performance for several hours[1].

Relevant extracts from the performance study with respect to the crew room at St Louis are detailed below:

"All four pilots agreed that the rest facilities available to pilots at STL were not ideal."

"The sleep facilities in the crew room were fair to poor. It was dark, dirty, and small. The furniture was old, and most furniture was supplied by pilots rather than the company. Fatigue could be an issue on the schedules, as with any airline."

Although the Captain appeared to have been trying to rest in between sectors at St Louis it is not clear how effective this rest period was.

1. Fatigue and Sleep in Australian Short Haul Operations, Loh, University of South Australia (2005)

18.4.1.2 ***Previous NTSB Duty Time Statements***

The following recommendation for all modes of transport (intermodal) was taken from the 'NTSB most wanted' safety list 2004-2005 and addressed to the U.S. Department of Transportation, Federal Aviation Administration, U.S. Coast Guard and Pipeline and Hazardous Materials Safety Administration:

"Update Hours-of-Service Regulations in Aviation, Marine and Pipeline Industries
• Set working hour limits for flight crews, aviation mechanics, pipeline controllers, mariners and other transportation operators, and provide predictable work and rest schedules based on current fatigue research, circadian rhythms, sleep and rest requirements"

The summary of action to date, on this recommendation, is detailed below and has been extracted directly from the 'NTSB most wanted' web page.

"Intermodal

DOT (Department of Transport) Operator Fatigue Management Program

In 1998, the DOT launched the "ONEDOT" effort to coordinate resources among DOT agencies. One of the goals of this effort was to reduce the number of accidents and injuries related to operator fatigue. This led to the development of the DOT Operator Fatigue Management (OFM) Program, which is managed by the DOT's Human Factors Coordinating Committee (HFCC), a group comprising representatives from each of the DOT administrations and other agencies with a transportation role.

During its tenure, the OFM program has worked with government, industry, and labor to create tools to aid in understanding and managing operator fatigue. Four public–private partnerships have been formed under the auspices of the OFM program to develop non-prescriptive tools for operator fatigue management, with the intent that these tools are to be used by industry. Products of the OFM program include a software tool to aid in the design of work schedules and a "Fatigue Management Reference Guide" completed in January 2004.

Aviation

Flight Crews

The FAA issued a notice of proposed rulemaking (NPRM) in December 1995 to update the flight and duty regulations for airline pilots; however, in the intervening 9 years, the regulations have not been revised. The FAA has attempted on three occasions to reach consensus with the industry on a proposed rule but has not succeeded.

The FAA indicated that it had planned to issue a supplemental NPRM (SNPRM) in spring 2001 that would take into consideration the technical and operational concerns that were raised during the NPRM comment period. The SNPRM would prescribe a maximum duty period linked to a maximum flight time restriction that is associated with a minimum rest period based on the number of pilots….

In January 2003, FAA staff advised Safety Board staff that the SNPRM was being reviewed by the Office of the Secretary of Transportation prior to submission to the Office of Management and Budget and then publication in the Federal Register. To date, the SNPRM has not been published…."

1.19 ***Useful or effective investigation techniques***
BAE SYSTEMS attempted to complete a FSF CFIT Checklist to evaluate the CFIT risk for the accident flight, however, not all of the information was readily available to do so. The CFIT Checklist is primarily used to assess specific aspects of flight operations to enhance crew awareness of risks, however, the checklist is also a useful post accident tool. Tools such as the CFIT checklist are also of benefit in flight scheduling planning to assess the risks in advance. A blank CFIT Checklist can be found in Appendix 4.

During the investigation, the UK Air Accidents Investigation Branch (AAIB) forwarded a copy of a Qinetiq crew fatigue analysis tool to the NTSB for use in this investigation. It is recommended that the NTSB use this tool to ascertain the effect of duty times on human performance for comparison with previous studies on this subject. A new approach may potentially add further weight to previous conclusions and safety recommendations, particularly in light of this accident.

2. ANALYSIS DISCUSSION
In the following sections, BAE SYSTEMS have attempted to analyse the factual information contained in this report and have in part, aimed to concentrate on areas where potential future improvements could be made. We would, therefore, like to stress that the areas of discussion should not be used for apportion of any blame but to further promote flight safety.

2.1 ***Aircraft State and Flight Crew Qualifications***
From all of the supporting NTSB documents reviewed and referenced in the factual information sections of this report, it is apparent that the aircraft was appropriately certificated and maintained and was within the Centre of Gravity limits at the time of the accident. Equally, there is no evidence of an in-flight malfunction of systems or powerplants that may have led to an in-flight abnormality and or emergency which may have led to the crash. Photographic evidence suggests that the aircraft was wings level during the initial tree strike as tree branches were broken in a horizontal plane during the final stages of descent. Similarly, the aircraft was described as being within the angle of attack envelope until just prior to the impact indicating that the stick shaker warning was spurious or triggered by impact. Systems such as GPWS appeared to function as designed and provided 'minimums - minimums' and 'sink rate' warnings appropriate to the aircraft rate of descent prior to the accident.

On the basis that the aircraft was described to be within the angle of attack envelope just prior to impact, it is probable that the stick shaker warning was spurious.

Information obtained from the NTSB as discussed in earlier sections, highlights that the flight crew were appropriately qualified and medically fit to conduct the flight.

2.2 ***Kirksville Aerodrome***

There was no ILS installed at Kirksville aerodrome, at the time of the accident, the aircraft was therefore flying a non precision approach. According to the Flight Safety Foundation, "Greater risk is associated with conducting a non precision approach in darkness and in IMC".

2.3 ***Flight Crew Relationship***

Evidence from the Cockpit Voice Recorder transcript suggests that the flight crew were comfortable in each other's company and enjoyed flying together to the extent that this was voiced by the flight crew early in the flight. "..have a good time flying with you."

Commonly, when a relationship between colleagues is very relaxed, there may be tendencies for professionalism to be compromised and individual crew responsibilities to be adversely affected; this is perhaps evidenced by the kind of language, recorded on the CVR, including swearing and joking throughout the flight. Similarly, in a more relaxed relationship there can also be a tendency for over confidence "cause we know our #" and over-reliance on the other party. The crew resource management on this flight was probably degraded because of the relationship between the crew and their relaxed behaviour. Similarly, the relationship of the crew was such that their conversations served as a distraction and as such may have detracted from company standard practices and call outs as described in Appendix 5.

BAE SYSTEMS experience of standard CRM training is that the majority of taught CRM is based upon lessons from previous incidents and accidents where cross cockpit authority gradient, difficult relationships and lack of sufficient communication have created issues. Standard training will then take these case studies and discuss ways in which communications can be improved, conflicts can be avoided and so forth. A comparatively small percentage of crew resource management training seems to focus on problems that may arise when a crew relationship is relaxed and friendly. Potential problems such as over-reliance and degraded professionalism can detract from a safe operation and there would be merit in highlighting this risk to crews.

Without further detail of the CRM modules instructed within Corporate Airlines and the frequency with which principles of CRM were trained, it is difficult to state whether CRM training was effective within the company and whether improved CRM training could have prevented the accident.

2.4 ***Crew Perception of Runway Environment***

The Captain's statement that "I can see ground there" at minimum descent altitude (MDA), suggests that the Captain had made some level of assessment of the ground environment, which, to him at the time may have seemed to constitute sufficient visual reference for the descent to continue.

According to the FDR/CVR, after passing MDA, for approximately the next 10 seconds, the aircraft continued to descend at a constant rate (this equates to approx 200 feet height loss with only 300 feet available) whilst both crew members discussed their assessment of the visual references. This suggests that there was some confusion between the crew as to whether the 'runway environment' was actually in sight.

In a high percentage of approach and landing accidents, particularly those involving non precision approaches, there is evidence to suggest that inadequate flight crew assessment of the minimum required visual references was causal.

Providing that the minimum required visual reference is clearly defined, a yes/no check of the minimum required visual reference would be a faster and less complicated mental process than an assessment. This is because an assessment is a more complicated cognitive process than a simple yes/no check. A check is clear-cut: minimising ambiguity or variation between pilots.

When defining the required visual reference, a picture may also be beneficial to show the crew what they should see. By use of appropriate text with pictures, the approach decision is then formulated on the ground, thus helping crews to avoid forming a judgment based on their own ideas of visual reference or how confident they are on the day.

2.5 ***Crew Fatigue***

There is circumstantial evidence to suggest that the crew were probably tired, based on recordings on the CVR transcript. From Appendix 3, there are a number of yawns and an even higher number of sighs noted on the transcript. This coupled with dialogue such as *"All I'm thinking of is a Philly # cheese steak and an iced tea"* suggests that the crew were perhaps tired and were looking forward to the end of the day. At the point of the above noted comment, the crew had already been on duty for over 14 hours.

Later in the transcript, after the crew had expressed doubt about continuing to Kirksville due to the weather, it appears that the crew may have become somewhat irritated with the passenger noise from the cabin. Irritability may also be an indication that the crew were feeling the effects of fatigue.

With poor weather, for the majority of that day, and having to manually fly the aircraft, this would in turn result in an increased work load for the crew which could contribute to the crew's level of fatigue. Fatigue, in turn has been shown to be detrimental to the conduct of normal procedures.

As discussed in the company culture section of this report, there was evidence to suggest that Corporate Airlines promoted a 'don't fly if tired' policy. However, on the last flight of the day, with enjoyable company it is a moot point whether either of the flight crew would have actually acknowledged how tired they may have felt, especially with the perception that their duty hours were in accordance with the regulatory requirements.

The NTSB have previously made several recommendations to the FAA to review and revise the flight crew duty hours based on scientific research into crew fatigue; none of which have been implemented to date. It is worth re-iterating here that other regulatory bodies such as the CAA would not permit operators to schedule such duty times.

2.6 ***The Approach***

Much is documented by FAA, CAA and Flight Safety Foundation etc. about promoting use of Constant Angle Non Precision Approaches (CANPA). The approach into Kirksville as flown by Corporate Airlines was not a Constant Angle Non Precision Approach.

The sink rate specified in the stabilised approach criteria from the Corporate Airlines Flight Manual is higher than the recommended values suggested by the Flight Safety Foundation. As discussed in section 1.18.2, the Flight Safety Foundation recommends "sink rate no greater than 1000 feet per minute" in their stabilised approach criteria. Tools, such as, CFIT checklist and or ALA risk awareness list are designed to highlight potential risks of individual approaches to the crew.

The night before the accident, another Corporate Airlines crew, flying into Kirksville, in similar conditions, stated that they seemed to be too close to trees and manoeuvred accordingly. This suggests that prior to the accident there may have been concerns with respect to this approach. However, it is not obvious from any of the NTSB Factual Reports whether there had been other similar occurrences, particularly involving this approach, and or whether such occurrences were reported and analysed by Corporate Airlines.

2.7 ***Visual Scene Including Weather***

Comments recorded on the CVR transcript suggest that the crew at first doubted whether they would be able to continue approach into Kirksville. The crew stated "We're not getting in" due to the weather conditions. As the crew elected to continue their approach to 3100 feet, they expressed unease with the weather conditions 'we're going into the crap' and stated that the conditions felt 'eerie' and 'suffocating'. Comments such as these indicate a certain level of discomfort with the visual conditions.

Evidence suggests that the weather conditions on initial approach to Kirksville did not preclude the commencement of the LOC/DME approach. However, approximately 10 minutes prior to the accident the radio transmission from Kirksville Automated Weather Observation System (AWOS) stated that the temperature and dew point were both 9 degrees Celsius as recorded on the Cockpit Voice Recorder. The Captain then stated "temp 'n dew point's right where you don't want it." as an equal outside air temperature and dew point results in fog/misty conditions.

2.8 ***FAA Supervision***

The FAA inspectors were clearly concerned that their level of supervision of Corporate Airlines had been negatively affected by their increased office duties, particularly in light of this accident.

There is no obvious detail in the NTSB reports to indicate the level of reporting culture that existed between Corporate Airlines and the FAA. Equally, it is not clear how far the FAA were involved in any trend monitoring of Corporate Airlines events. It is therefore difficult to comment on how far an increased level of FAA oversight would have influenced the events leading to this accident.

3. CONCLUSIONS

The aircraft systems and powerplants were functional at the time of the accident.

The flight crew were appropriately licensed and medically fit to conduct the flight.

The aircraft was appropriately maintained and certificated in accordance with FAA regulations.

FAA operational supervision of Corporate Airlines had been reduced by increased office duties at the FAA.

Kirksville aerodrome does not have an Instrument Landing System.

The aircraft was on a non precision approach.

The flight crew relationship was very relaxed, to the extent that professionalism and standard operating practices may have been compromised.

Crew Resource Management training throughout the industry (according to BAE SYSTEMS experience) does not highlight the potential hazards of a relaxed and friendly flight crew relationship.

The Captain and First Officer conducted a level of assessment of the approach environment but there was some confusion between the crew members as to whether the actual 'runway environment' was in sight.

The crew had been on duty for 14 hours and 31 minutes at the time of the accident.

Evidence from the CVR suggests that the crew were tired.

BAE SYSTEMS could not establish that the crew's flight duty time was within FAA regulations as the requirements are ambiguous.

Evidence suggests that the crew were not fully aware of the risks involved as they continued their approach.

4. **PROBABLE CAUSES**

BAE SYSTEMS feel that the conclusions above and the corresponding recommendations should be sufficient to assist the NTSB in determining probable causes. It would be inappropriate for BAE SYSTEMS to state probable causes without a more in depth knowledge of the operational and human factors elements of this investigation.

5. **SAFETY RECOMMENDATIONS**

- It is recommended that operators should actively promote the lessons from the FSF CFIT/ALAR toolkit as a training aid to increase risk awareness and accident prevention as an integral part of their safety management system.

- It is recommended that operators should assess the potential benefits of improving CRM training to include the potential safety implications of an overly 'comfortable' flight crew relationship.

- It is recommended that operators should review their minimum visual requirements definitions with a view to introducing a 'check of the predetermined visual requirements' (rather than an assessment).

- It is recommended that the FAA should further promote the use of CANPA with a view to have their Operations Inspectors assist in the introduction of this approach technique.

- It is recommended that the NTSB review the effectiveness of previous fatigue/flight crew duty related recommendations to the FAA in light of this specific accident

Previous NTSB recommendations relevant to this accident are listed as follows:
Taken from the 'NTSB most wanted' List 2004-2005:

"A-95-113 (FAA)
Issued November 14, 1995
Added to the Most Wanted List: 1996
Status: Open—Unacceptable Response
Finalize the review of current flight and duty time regulations and revise the regulations, as necessary, within 1 year to ensure that flight and duty time limitations take into consideration research findings in fatigue and sleep issues.....
(Source: An Uncontrolled Collision with Terrain Accident, Air Transport International, DC-8-63, at Kansas City, Missouri, February 16, 1995 [NTSB/AAR-95-06])

A-99-45 (FAA)
Issued June 1, 1999
Added to the Most Wanted List: 1999
Status: Open—Unacceptable Response
Establish within 2 years scientifically based hours-of-service regulations that set limits on hours of service, provide predictable work and rest schedules, and consider circadian rhythms and human sleep and rest requirements. (Source: A 1999 Intermodal Safety Study on Fatigue in Transportation [NTSB/SR-99-01])

The above recommendations are actively being pursued under the general recommendation below as stated previously in section 18.4.1.2 Previous NTSB Duty Time Statements:

INTERMODAL
The U.S. Department of Transportation, Federal Aviation Administration, U.S. Coast Guard and Pipeline and Hazardous Materials Safety Administration should act to:
Update Hours-of-Service Regulations in Aviation, Marine and Pipeline Industries
• Set working hour limits for flight crews, aviation mechanics, pipeline controllers, mariners and other transportation operators, and provide predictable work and rest schedules based on current fatigue research, circadian rhythms, sleep and rest requirements."

- It is recommended that the FAA use their continuing oversight of flight operations to ensure that previous safety recommendations such as the above and any recommendations arising from this accident are implemented.

6. **APPENDICES**
Appendix 1: Mark VI GPWS Functional description – sink rate warning
Appendix 2: Weather
Appendix 3: CVR transcript (relevant sections)
Appendix 4: FSF ALAR/CFIT Material
Appendix 5: Normal Non Precision Approach Profile Notes

Appendix 1 – GPWS Mode 1 Description

Extract from Sundstrand GPWS Mark VI Report 965-0686-601

6 MK-VI FUNCTIONAL DESCRIPTION

6.1 EXCESSIVE DESCENT RATE ALERT/WARNING (Mode 1)

Mode 1 provides the pilots with alerts and warnings for high descent rates into terrain. When the outer Alert envelope is penetrated, the message "SINKRATE" will annunciate every three seconds and the GPWS lamp(s) will illuminate. An 'urgent' "PULL-UP!" message with increased emphasis will occur continuously when the inner Warning envelope is penetrated, as the upper slope of this envelope is set to produce the warning at 10 seconds before ground impact.

For Glideslope deviations *above* the beam centerline, the envelopes are shifted to the right, requiring additional Descent Rate for a GPWC output, and reducing possible nuisance outputs.

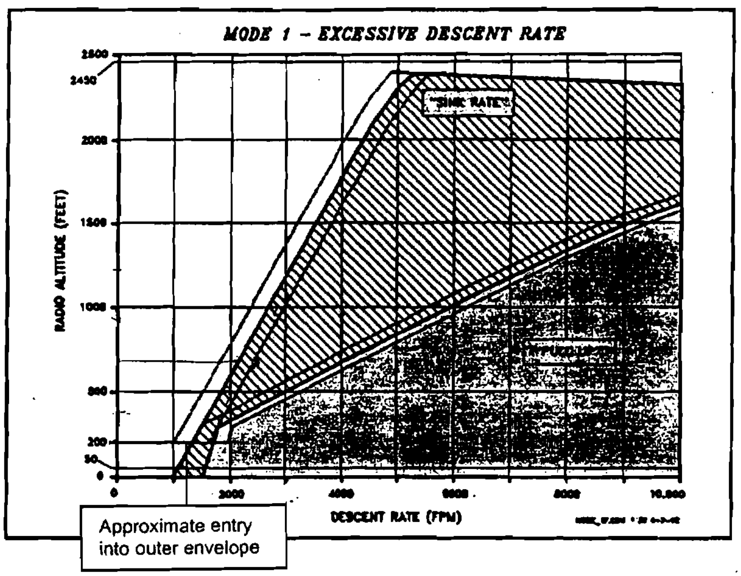
For Glideslope deviations *below* the beam centerline, the envelopes are shifted to the left, requiring less Descent Rate for a GPWC output, and increasing the GPWC sensitivity. See Figure 6.1-1 below.

Both envelopes are shifted 150 FPM for each dot of Glideslope deviation, up to a maximum of 300 FPM at 2.0 or more dots of Glideslope deviation, but only when above 200 feet Radio Altitude.

A maximum shift of 300 FPM to the right is also provided to both envelopes when the GPWS DESENS is selected.

Figure 6.1-1 below shows the nominal alert, and warning envelopes for a stabilized descent from 3000 feet over flat terrain. The effects of nuisance reducing signal filtering, time delays, and the maximum envelope shift, are shown. The top slope of the "SINKRATE" envelope is due to a fixed value nuisance reducing time delay that results in an increasing alert altitude reduction with increasing Descent Rate.

Figure 6.1-1: Excessive Descent Rate Alert and Warning Envelopes (Mode 1)



Appendix 2 – Weather Document issued to Flight 5966

The weather report issued to the flight crew at dispatch can be seen below.

From NTSB Meteorological Group Factual Report:
The document defines what weather information was issued to the flight prior to departure from St. Louis. The document includes the reported and forecast weather conditions for the route of flight and alternate airports, including notice to airmen and company related field condition reports. The KIRK RAMTAF as included in section 9.0 above does not automatically get printed on to the document and was issued separately.

19 2330 778408 MQY-XJM
WXM-FLT CEA5966/19 STL IRK RTE 41 ALT UIN STL TOA 192330
SKD 2342/0035Z REVISION 1
MAP FEATURES WEST
VALID 19/1430Z-20/1100Z
INTENSE LOW PRESSURE SYSTEM OFFSHORE OF THE PACIFIC NW WILL
CONTINUE TO PROVIDE WIDESPREAD RAIN SHOWERS TO NRN CA WITH
SCT SHOWERS EXPECTED ACROSS MUCH OF CA/OR/WA DURING TUESDAY
AFTERNOON/EVENING. THIS ACTIVITY WILL CONTINUE TO SPREAD
INLAND ACROSS NV/UT/SRN ID/WY AND BRING SCT RAIN/SNOW SHOWERS
TO THE INTERMOUNTAIN WEST BY LATE EVENING TUESDAY. SCT SNOW
SHOWERS ARE EXPECTED IN THE HIGHER ELEVATIONS OF THE NRN CA
SIERRA MTNS AND THE WASATCH MTNS IN UT. LOW PRESSURE LOCATED
ACROSS SRN MANITOBA WILL CONTINUE TO MOVE NE DURING THE DAY
TUESDAY. SCT SHOWERS ARE EXPECTED WITH THIS FEATURE ACROSS
ND/MN/SRN MANITOBA/WRN ONTARIO.
TSTM OUTLOOK...NO ORGANIZED AREAS OF TSTMS EXPECTED DURING
THE DAY TUESDAY.
WNI/MH
STL
192251Z 34007KT 2SM BR OVC005 11/10 A2990 RMK AO2 SLP127
T01060100
IRK
192255Z AUTO 02007KT 5SM HZ OVC009 10/ A2993 RMK AO2
SLP141 T0100 TSNO
UIN
192254Z AUTO 05006KT 4SM BR OVC006 10/09 A2992 RMK AO2
CIG 005V010 SLP133 T01000094
STL TAF KSTL 191732Z 191818 36007KT 4SM BR OVC005
FM0000 01006KT 5SM BR OVC008
FM0700 03005KT 2SM BR OVC005 TEMPO 0913 1/2SM FG OVC002
FM1300 05006KT 4SM BR OVC009
UIN TAF AMD KUIN 192227Z 192218 03008KT 4SM BR OVC006
FM0300 03005KT 3SM BR OVC008
FM1400 06007KT 4SM BR OVC010
MK1 WST 192255
CONVECTIVE SIGMET 84E
VALID UNTIL 0055Z
FL GA AL MS
FROM 30NE SQS-ATL-30SW TLH-20ESE JAN-30NE SQS
AREA EMBD SEV TS MOV FROM 27035KT. TOPS ABV FL450.
TORNADOES...HAIL TO 2 IN...WIND GUSTS TO 60KT POSS.
CONVECTIVE SIGMET 85E
VALID UNTIL 0055Z
FL GA
FROM 40SSE IRQ-10WNW CRG-40ENE ABY-40SSE IRQ

AREA EMBD TS MOV FROM 25030KT. TOPS TO FL390.
CONVECTIVE SIGMET 86E
VALID UNTIL 0055Z
FL AND CSTL WTRS
FROM CRG-70E CRG-20ENE ORL-30W ORL-CRG
AREA SEV TS MOV FROM 28015KT. TOPS ABV FL450.
HAIL TO 1 IN...WIND GUSTS TO 50KT POSS.

CONVECTIVE SIGMET 87E
VALID UNTIL 0055Z
FL AND CSTL WTRS
FROM 40W VRB-30S VRB-MIA-40S FMY-40W VRB
AREA TS MOV LTL. TOPS ABV FL450.
CONVECTIVE SIGMET 88E
VALID UNTIL 0055Z
MD VA NC
FROM 30WSW SBY-10NNW RDU
LINE EMBD TS 40 NM WIDE MOV FROM 25030KT. TOPS TO FL380.
CONVECTIVE SIGMET 89E
VALID UNTIL 0055Z
NY RI CSTL WTRS
FROM 120SE ACK-180SE ACK
LINE EMBD TS 35 NM WIDE MOV FROM 25025KT. TOPS TO FL370.
CONVECTIVE SIGMET 90E
VALID UNTIL 0055Z
NC
MK2 WST 192255
CONVECTIVE SIGMET 37C
VALID UNTIL 0055Z
TN AL MS
FROM 30ENE MEM-30NNW MSL
LINE SEV TS 25 NM WIDE MOV FROM 28020KT. TOPS TO FL440.
TORNADOES...HAIL TO 1 IN...WIND GUSTS TO 50KT POSS.
OUTLOOK VALID 200055-200455
FROM CVG-50SE CVG-BNA-40SSW CEW-LEV-70SE LCH-30SW MLU-30W
MEM-PXV-CVG
REF WW 866 867.
WST ISSUANCES EXPD. REFER TO LATEST ACUS01 KWNS FROM STORM
PREDICTION CENTER FOR SYNOPSIS AND METEOROLOGICAL DETAILS.
FISCHER
NOTAMS
09/103 STL 12R/30L NONSTD MARKING WEF 0409150345
10/144 STL UAV 5000/BLW 6NMR STL298033/13SE H19 AVOIDANCE ADZD
1330-2130 DLY WEF 0410191330-0410222130
10/154 STL TOWER 698 84 AGL 2 W LGTS OTS ASR 1063205 TIL
0411030926
10/004 IRK ASOS 121.125 OTS WEF 0410191300-0410192330
06/019 UIN 18/36 CLSD
FTZ 10/150 FTZ VOR OTS WEF 0410191400-0410191900
MSP 08/002 MSP VOR OTS WEF 0408021200
ONA 10/001 ONA VOR/DME OTS WEF 0410041500
MKT 10/004 MKT VOR VOICE OTS
PPI 10/010 PPI NDB OTS
FIELD CONDITIONS
IRK 192032
FC/
FC
-FIELD REPORT- STATION- KIRKSVILLE DATE- 10/19 TIME- 1531
EXISTING TAA
RWYS-------STATUS------CONDITIONS---REMARKS-----------------
36/18 OPEN DRY BRAG 24
FOR AFTER HOURS ASSISTANCE CNTC AT

DEICING IN EFFECT Y/N N LOCATION

REMARKS ....
....
UPDATED BY BRIAN SALSBERRY.. PHONE NO 6270100
UIN 191919
FC/
FC
-FIELD REPORT- STATION- QUINCY DATE- 19OCT TIME- 1420
EXISTING TAA
RWYS-------STATUS------CONDITIONS---REMARKS-----------------
4/22 OPEN DRY BRAG
13/31 OPEN DRY BRAG
18/36 CLOSED
FOR AFTER HOURS ASSISTANCE CNTC D.EVANS AT 217-222-4867
.
DEICING IN EFFECT Y/N N LOCATION
CORPORATE AIRLINES OPS FREQUENCY 130.00
REMARKS ....
TAXIWAY E CLOSED...
UPDATED BY DAWN EVANS....... PHONE NO 217-885-3120
END DATA

Appendix 3 – Extracts from the NTSB Cockpit Voice Recorder Factual Report

HOT 1 – Pilot in Command HOT Microphone Voice or Sound
HOT 2 – Second In Command HOT Microphone Voice or Sound

1912:51
HOT-1 all I'm thinking of is a Philly # cheese steak and an iced tea.
1912:55
HOT-2 sounds good........

1909:24
HOT-2 * have a good time flying with you.
1909:26
HOT-1 yeah, me too.

1909:27
HOT-2 just let you know that.
1909:30
HOT-1 gotta have fun.
1909:31
HOT-2 that's truth man. gotta have the fun.
1909:35
HOT-1 too many of these # take themselves way too serious, in this job. I hate it, I've flown with them and it sucks. a month of # agony.

After Kirk Wx report......
1914:06
HOT-1 we're not getting in.
....

1914:20
HOT-1 three hundred sixty feet.
1914:21
HOT-2 Jesus Christ. [spoken in a whispered voice]
1914:26
HOT-2 go all this # way.
1914:30
HOT-2 well, let's try it.

1914:39
HOT-2 that # sucks.
1914:41
HOT-1 does suck.
1914:42
HOT-2 [sound of sigh]
1914:45
HOT-1 [sound of humming]

1915:03
HOT-1 [sound of humming, yawning and tapping] I don't want to get, go all the way out here for nothing tonight. it's gonna blow #..... it's gonna blow the butt, blow the butt, blow the butt. what have we got here. three sixty, thirteen twenty.

1915:32
HOT-1 I'll be so happy when we have an ILS everywhere we go.

1915:48
HOT-1 [sound of burp] I thought we were gonna have it easy tonight. it was gonna be....

1920:20
HOT-2 it's three miles and mist now. [sound of sigh]
....

1920:25
HOT-1 so it's going down the tubes.... #.

1921:44
HOT-2 you know, I think you're gonna need to just shut the # up.
1921:49
HOT-1 love to poke my head back around and say that. you know ladies and gentlemen uh, we've thought about it....
1921:55
HOT-2 [sound of laughter] it was unanimous up here.
1921:57
HOT-1 • we've come to the conclusion that you people should all shut the # up.

1923:29
HOT-1 one eleven point five, three fifty seven's the inbound. twenty five hundred at KEMMY. thirteen twenty is our MDA. and we have a three hundred sixty foot approach set in the radar altimeter.

1924:36
HOT-1 negative, we're going into the crap. look, ooh, it's so eerie and creepy.
1924:38
HOT-2 ooh, negative.
1924:40
HOT-1 get a suffocating feeling when I see that.

1925:19
HOT-2 well we can level off at thirty one hundred feet. how about that?
1925:26
HOT-1 yeah... yeah baby.
1925:44
HOT-2 cause we know our #.... [sound of yawn]

1928:50
AWOS ... niner Celsius. dew point zero niner Celsius. altimeter two niner niner five. remarks, thunderstorm, information not available....
1929:00
HOT-1 temp 'n dew point's right where you don't want it.

1932:12
HOT-1 give ourselves as much time as we can.
1932:13
HOT-2 selected indicating ten.... since we're not going to doing holds like that one #.

1936:35.7
HOT-1 what do you think?
1936:35.9
HOT-1 thank you.
1936:36.8
HOT-1 I can see ground there.
1936:37.2
HOT-3 minimums, minimums.
1936:41.9
HOT-2 I can't see #.
1936:43.5
HOT-1 yeah, oh there it is. approach lights in sight.
1936:44.2
HOT-3 two hundred.
1936:44.7
HOT-2 * in sight.
1936:46.6
HOT-2 continue.

1936:47.7
HOT-1 we get rid of the director.
1936:48.6
HOT-B [sound of beep]
1936:50.5
CAM [sound similar to increase in engine RPM]
1936:50.5
HOT-1 getting a little slow.
1936:50.6
HOT-2 flaps thirty five?

1936:51.9
HOT-1 no....
1936:52.2
HOT-3 sink rate.
1936:52.8
HOT-1 ...no.
1936:53.2
HOT-2 trees.
1936:54.0
HOT-B [sound similar to stall warning horn] ?????
1936:54.4
HOT-1 no, stop.
1936:55.2
CAM [sound of impact]
1936:56.6
HOT-1 oh, my God.
1936:57.0
CAM [sounds of numerous impacts]
1936:57.5
HOT-2 holy #.
1936:58.6

Yawning References
1915:03
HOT-1 [sound of humming, yawning and tapping]

1923:43
HOT-2 three sixty. [sound of yawn]

1925:44
HOT-2 cause we know our #.... [sound of yawn]

1929:27
HOT-2 [sound of yawn] *. how would you like approach checklist?

Sighing References
1932:45
HOT-2 [sound of a sigh] all right.

1914:42
HOT-2 [sound of sigh]

1920:05
HOT-2 [sound of sigh]

1920:20
HOT-2 it's three miles and mist now. [sound of sigh]

1922:59
HOT-2 [sound of sigh] let's see. speeds are off the fifteen five card. fifteen, twenty one and thirty. be darned. I already had that in there.

1932:45
HOT-2 [sound of a sigh] all right.

Appendix 4

Flight Safety Foundation Material

Flight Safety Foundation

ALAR

Approach-and-landing Accident Reduction

Tool Kit

Approach-and-landing Risk Reduction Guide

The Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) Task Force designed this guide as part of the *FSF ALAR Tool Kit*, which is designed to help prevent ALAs, including those involving controlled flight into terrain. This guide should be used to evaluate specific flight operations and to improve crew awareness of associated risks. This guide is intended for use as a strategic tool (i.e., for long-term planning).

Part 1 of this guide should be used by the chief pilot to review flight operations policies and training. Part 2 should be used by dispatchers and schedulers. The chief pilot should provide Part 3 to flight crews for evaluating pilot understanding of company training objectives and policies. Part 4 should be used by the chief pilot and line pilots.

This guide is presented as a "check-the-box" questionnaire; boxes that are not checked may represent shortcomings and should prompt further assessment.

Part 1 — Operations: Policies and Training

Check the boxes below that apply to your specific flight operations.

Approach

Crew Resource Management

- ☐ Is risk management taught in initial training and recurrent training?
- ☐ Are crew resource management (CRM) roles defined for each crewmember?
- ☐ Are CRM roles defined for each crewmember for emergencies and/or system malfunctions?
- ☐ Are standard operating procedures (SOPs) provided for "sterile-cockpit"[1] operations?
- ☐ Are differences between domestic operations and international operations explained in CRM training?
- ☐ Is decision making taught in CRM training?

Approach Procedures

- ☐ Do detailed and mandatory approach-briefing requirements exist? (See Part 4 below.)
- ☐ Are approach risks among the required briefing items?
- ☐ Are standard calls defined for approach deviations?
- ☐ Are limits defined for approach gate[2] at 1,000 feet in instrument meteorological conditions (IMC) or at 500 feet in visual meteorological conditions (VMC).
- ☐ Is a missed approach/go-around recommended when stabilized approach criteria (Table 1) are exceeded?
- ☐ Is a "no fault" go-around policy established? If so, is it emphasized during training?
- ☐ Does the checklist policy require challenge-and-response for specified items?
- ☐ Does the checklist policy provide for interruptions/distractions?
- ☐ Is a go-around recommended when the appropriate checklist is not completed before reaching the approach gate?

Table 1
Recommended Elements of a Stabilized Approach

All flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC). *An approach is stabilized when all of the following criteria are met:*

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than V_{REF} + 20 knots indicated airspeed and not less than V_{REF};
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted;
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and,
9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

An approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

Source: Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force (V1.1 November 2000)

- ❑ Are captain/first officer weather limits provided for approach (e.g., visibility, winds and runway conditions)?
- ❑ Are crewmember roles defined for approach (e.g., crewmember assigned pilot flying duties, crewmember monitoring and conducting checklist, crewmember who decides to land or go around, crewmember landing aircraft, exchange of aircraft control)?

Fuel

- ❑ Are fuel minimums defined for proceeding to the alternate airport, contingency fuel, dump-fuel limits?
- ❑ Are crews aware of when to declare "minimum fuel" or an emergency?
- ❑ When declaring an emergency for low fuel, is International Civil Aviation Organization (ICAO) phraseology required (e.g., "Mayday, Mayday, Mayday for low fuel")?

Approach Type

- ❑ Is your risk exposure greatest during precision, nonprecision, circling or visual approaches? Is the training provided appropriate for the risk?
- ❑ Are SOPs provided for constant-angle nonprecision approaches (CANPAs) using rate of descent or angle?

Environment

- ❑ Is training provided for visual illusions on approach (e.g., "black hole effect,"[3] sloping terrain, etc.)?
- ❑ Is training provided for minimum-safe-altitude awareness?
- ❑ Does a policy exist to use the radio altimeter as a terrain-awareness tool?
- ❑ Are crews required to adjust altitudes during approach for lower than international standard atmosphere (ISA) standard temperatures?

- ❑ Are crews aware that most approach-and-landing accidents occur with multiple conditions present (e.g., rain and darkness, rain and crosswind)?

Airport and Air Traffic Control (ATC) Services

- ❑ Are crews aware of the increased risk at airports without radar service, approach control service or tower service?
- ❑ Is training provided for unfamiliar airports using a route check or a video?
- ❑ Is potential complacency at very familiar airports discussed?
- ❑ Are crews provided current weather at destination airfields via automatic terminal information service (ATIS), airborne communications addressing and reporting system (ACARS) and/or routine weather broadcasts for aircraft in flight (VOLMET)?

Aircraft Equipment

- ❑ Are procedures established to evaluate the accuracy and reliability of navigation/terrain databases?
- ❑ Are mechanical checklists or electronic checklists installed?
- ❑ Is a radio altimeter installed in the pilot's normal scan pattern?
- ❑ Does the radio altimeter provide visual/audio alerting?
- ❑ Is a wind shear alert system (either predictive or reactive) installed?
- ❑ Is a ground-proximity warning system (GPWS) or a terrain awareness and warning system (TAWS)[4] installed?
- ❑ Is a traffic-alert and collision avoidance system (TCAS) installed?
- ❑ Are head-up displays (HUDs) installed with a velocity-vector indicators?
- ❑ Are angle-of-attack indicators installed?
- ❑ For aircraft with a flight management system (FMS), are lateral navigation/vertical navigation (LNAV/VNAV) approach procedures database-selected?
- ❑ Are pilots prevented from modifying specified FMS data points on approach?
- ❑ Is the FMS system "sole-means-of-navigation" capable?
- ❑ Is there a policy for appropriate automation use (e.g., "full up for Category III instrument landing system, okay to turn automation off for a daylight visual approach")?
- ❑ Is there a policy requiring standard calls by the pilot not flying for mode changes and annunciations on the mode control panel?
- ❑ Is training provided and are policies established for the use of all the equipment installed on all aircraft?
- ❑ Are current and regulator-approved navigation charts provided for each flight crewmember?

Flight Crew

- ❑ Is there a crew-pairing policy established for new captain/new first officer based on flight time or a minimum number of trip segments?
- ❑ Is the check airmen/training captain program monitored for feedback from pilots? Are additional training needs, failure rates and complaints about pilots from line operations tracked? Is it possible to trace these issues to the check airmen/training captain who trained specific pilots?
- ❑ Is there a hazard reporting system such as a captain's report? Are policies established to identify and to correct problems? Is a system set up to provide feedback to the person who reports a hazard?

Safety Programs

- ❑ Is a nonpunitive safety reporting system established?
- ❑ Is a proactive safety monitoring program such as a flight operational quality assurance (FOQA) program or an aviation safety action program (ASAP) established?

Landing

- ❑ Is training provided and are policies established for the use of visual landing aids?
- ❑ Is it recommended that crews use all available vertical guidance for approaches, especially at night?
- ❑ Is training provided and are policies established for landing on contaminated runways with adverse winds?
- ❑ Are crews knowledgeable of the differences in braking deceleration on contaminated runways and dry runways?
- ❑ Does training include performance considerations for items such as critical touchdown area, braking required, land-and-hold-short operation (LAHSO), engine-out go-around, and full-flaps/gear-extended go-around?
- ❑ Does the aircraft operating manual (AOM)/quick reference handbook (QRH) provide crosswind limitations?
- ❑ Is a policy in effect to ensure speed brake deployment and autobrake awareness?
- ❑ Does policy prohibit a go-around after reverse thrust is selected?

Part 2 — Dispatcher/Scheduler

Check the boxes below that apply to your specific flight operations.

- ❑ Does the company have a dispatch system to provide information to assist flight crews in evaluating approach-and-landing risks?

Approach and Landing

- ❑ Are dispatchers and captains familiar with each other's authority, accountability and responsibility?
- ❑ Are crews monitored for route qualifications and appropriate crew pairing?
- ❑ Are crew rest requirements defined adequately?
- ❑ Does the company monitor and provide suitable crew rest as defined by requirements?
- ❑ Are crews provided with timely and accurate aircraft performance data?
- ❑ Are crews assisted in dealing with minimum equipment list(MEL)/dispatch deviation guide (DDG)/configuration deviation list (CDL) items?
- ❑ Do dispatch-pilot communications exist for monitoring and advising crews en route about changing conditions?
- ❑ Are updates provided on weather conditions (e.g., icing, turbulence, wind shear, severe weather)?
- ❑ Are updates provided on field conditions (e.g., runway/taxiway conditions, braking-action reports)?
- ❑ Is there coordination with the captain to determine appropriate loads and fuel required for the effects of ATC flow control, weather and alternates?
- ❑ Are all the appropriate charts provided for routing and approaches to destinations and alternates?
- ❑ Is a current notice to airmen (NOTAM) file maintained for all of your operations and is the appropriate information provided to crews?

Part 3 — Flight Crew

Check the boxes below that apply to your specific flight operations.

- ❑ Do you believe that you have appropriate written guidance, training and procedures to evaluate and reduce approach-and-landing risks?

Approach

- ❑ Is the Flight Safety Foundation *Approach-and-landing Risk Awareness Tool (RAT)* provided to flight crews, and is its use required before every approach?
- ❑ Does the approach briefing consist of more than the "briefing strip" minimum? (See Part 4 below.)

- ❑ Do briefings include information about visual illusions during approach and methods to counteract them?
- ❑ Are the following briefed: setup of the FMS, autopilot, HUD, navigation radios and missed approach procedures?
- ❑ Is a discussion of missed approach/go-around details required during every approach briefing?
- ❑ Are performance minimums briefed for the approach gate?
- ❑ Are standard calls required for deviations from a stabilized approach?
- ❑ Does the briefing include execution of a missed approach/go-around if criteria for the approach gate are not met?
- ❑ Are stabilized approach criteria defined? Is a go-around recommended in the event that these criteria are not met?
- ❑ Does your company practice a no-fault go-around policy?
- ❑ Are you required to write a report to the chief pilot if you conduct a missed approach/go-around?
- ❑ Do you back up the flight plan top-of-descent point with your own calculation to monitor descent profile?
- ❑ Are approach charts current and readily available for reference during approach?
- ❑ Are policies established to determine which crewmember is assigned pilot flying duties, which crewmember is assigned checklist duties, which crewmember will land the aircraft and how to exchange aircraft control? Do these policies change based on prevailing weather?
- ❑ Do terrain-awareness procedures exist (e.g., calling "radio altimeter alive," checking radio altimeter altitudes during approach to confirm that the aircraft is above required obstacle clearance heights)?
- ❑ Do altitude-deviation-prevention policies exist (e.g., assigned altitude, minimum descent altitude/height [MDA(H)], decision altitude/height [DA(H)])?
- ❑ Are you familiar with the required obstacle clearance criteria for charting design?
- ❑ Do altimeter-setting procedures and cross-check procedures exist?
- ❑ Do temperature-compensation procedures exist for temperatures lower than ISA at the destination airport?
- ❑ Are you aware of the increased risk during night/low-visibility approaches when approach lighting/visual approach slope indicator/precision approach path indicator aids are not available? How do you compensate for these deficiencies? For example, are runways with vertical guidance requested in those conditions?
- ❑ Are you aware of the increased risk associated with nonprecision approaches compared with precision approaches?
- ❑ Is a CANPA policy established at your company? Are you aware of the increased risk associated with step-down approaches compared with constant-angle approaches?
- ❑ Is a policy established for maintaining visual look-out, and is there a requirement to call "head-down"?
- ❑ Does a look-out policy exist for approach and landing in visual flight rules (VFR) conditions?

Part 4 — Recommended Approach-and-landing Briefing Items

For the approach-risk briefing, refer to top-of-descent use of the FSF *Approach-and-landing RAT*.

In addition to the briefing strip items (e.g., chart date, runway, approach type, glideslope angle, check altitudes), which of following items are briefed, as appropriate?

- ❑ Automation setup and usage
- ❑ Navigation equipment setup and monitoring
- ❑ Rate of descent/angle of descent

- ❑ Intermediate altitudes and standard calls
- ❑ Altitude-alert setting and acknowledgment
- ❑ MDA(H)/DA(H) calls (e.g., "landing, continue, go-around"); runway environment expected to see (offsets); lighting
- ❑ Radio-altimeter setting in the DH window, calls required (e.g., "radio altimeter alive" and "below 1,000 feet" prior to an intermediate approach fix; "below 500 feet" prior to the final approach fix [FAF]; "go around" after the FAF if "minimums" is called [with radio altimeter at 200 feet] and if visual contact with the required references is not acquired or the aircraft is not in position for a normal landing)
- ❑ Aircraft configuration
- ❑ Airspeeds
- ❑ Checklists complete
- ❑ ATC clearance
- ❑ Uncontrolled airport procedures
- ❑ Manual landing or autoland
- ❑ Missed approach procedure/go-around
- ❑ Performance data
- ❑ Contaminated runway/braking action and autobrakes
- ❑ Illusions/hazards or other airport-specific items
- ❑ Abnormals (e.g., aircraft equipment/ground facilities unserviceable, MEL/DDG items, glideslope out)
- ❑ Runway (e.g., length, width, lighting, LAHSO, planned taxiway exit)
- ❑ Procedure for simultaneous approaches (as applicable)

References

1. The *sterile cockpit rule* refers to U.S. Federal Aviation Regulations Part 121.542, which states: "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 eating meals, engaging in nonessential conversations within the cockpit and nonessential communications between the cabin and cockpit crews, and reading publications not related to the proper conduct of the flight are not required for the safe operation of the aircraft. For the purposes of this section, critical phases of flight include all ground operations involving taxi, takeoff and landing, and all other flight operations below 10,000 feet, except cruise flight." [The FSF ALAR Task Force says that "10,000 feet" should be height above ground level during flight operations over high terrain.]
2. The Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force defines *approach gate* as "a point in space (1,000 feet above airport elevation in instrument meteorological conditions or 500 feet above airport elevation in visual meteorological conditions) at which a go-around is required if the aircraft does not meet defined stabilized approach criteria."
3. The *black-hole effect* typically occurs during a visual approach conducted on a moonless or overcast night, over water or over dark, featureless terrain where the only visual stimuli are lights on and/or near the airport. The absence of visual references in the pilot's near vision affect depth perception and cause the illusion that the airport is closer than it actually is and, thus, that the aircraft is too high. The pilot may respond to this illusion by conducting an approach below the correct flight path (i.e., a low approach).
4. Terrain awareness and warning system (TAWS) is the term used by the European Joint Aviation Authorities and the U.S. Federal Aviation Administration to describe equipment meeting International Civil Aviation Organization standards and recommendations for ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings. "Enhanced GPWS" and "ground collision avoidance system" are other terms used to describe TAWS equipment.

Flight Safety Foundation

CFIT Checklist

Evaluate the Risk and Take Action

Flight Safety Foundation (FSF) designed this controlled-flight-into-terrain (CFIT) risk-assessment safety tool as part of its international program to reduce CFIT accidents, which present the greatest risks to aircraft, crews and passengers. The FSF CFIT Checklist is likely to undergo further developments, but the Foundation believes that the checklist is sufficiently developed to warrant distribution to the worldwide aviation community.

Use the checklist to evaluate specific flight operations and to enhance pilot awareness of the CFIT risk. The checklist is divided into three parts. In each part, numerical values are assigned to a variety of factors that the pilot/operator will use to score his/her own situation and to calculate a numerical total.

In *Part I: CFIT Risk Assessment,* the level of CFIT risk is calculated for each flight, sector or leg. In *Part II: CFIT Risk-reduction Factors,* Company Culture, Flight Standards, Hazard Awareness and Training, and Aircraft Equipment are factors, which are calculated in separate sections. In *Part III: Your CFIT Risk,* the totals of the four sections in *Part II* are combined into a single value (a positive number) and compared with the total (a negative number) in *Part I: CFIT Risk Assessment* to determine your CFIT Risk Score. To score the checklist, use a nonpermanent marker (do not use a ballpoint pen or pencil) and erase with a soft cloth.

Part I: CFIT Risk Assessment

Section 1 – Destination CFIT Risk Factors	Value	Score
Airport and Approach Control Capabilities:		
ATC approach radar with MSAWS	0	______
ATC minimum radar vectoring charts	0	______
ATC radar only	-10	______
ATC radar coverage limited by terrain masking	-15	______
No radar coverage available (out of service/not installed)	-30	______
No ATC service	-30	______
Expected Approach:		
Airport located in or near mountainous terrain	-20	______
ILS	0	______
VOR/DME	-15	______
Nonprecision approach with the approach slope from the FAF to the airport TD shallower than 2 ¾ degrees	-20	______
NDB	-30	______
Visual night "black-hole" approach	-30	______
Runway Lighting:		
Complete approach lighting system	0	______
Limited lighting system	-30	______
Controller/Pilot Language Skills:		
Controllers and pilots speak different primary languages	-20	______
Controllers' spoken English or ICAO phraseology poor	-20	______
Pilots' spoken English poor	-20	______
Departure:		
No published departure procedure	-10	______

Destination CFIT Risk Factors Total (–) ______

Section 2 – Risk Multiplier

	Value	Score
Your Company's Type of Operation (select only one value):		
Scheduled	1.0	____
Nonscheduled	1.2	____
Corporate	1.3	____
Charter	1.5	____
Business owner/pilot	2.0	____
Regional	2.0	____
Freight	2.5	____
Domestic	1.0	____
International	3.0	____
Departure/Arrival Airport (select single highest applicable value):		
Australia/New Zealand	1.0	____
United States/Canada	1.0	____
Western Europe	1.3	____
Middle East	1.1	____
Southeast Asia	3.0	____
Euro-Asia (Eastern Europe and Commonwealth of Independent States)	3.0	____
South America/Caribbean	5.0	____
Africa	8.0	____
Weather/Night Conditions (select only one value):		
Night — no moon	2.0	____
IMC	3.0	____
Night and IMC	5.0	____
Crew (select only one value):		
Single-pilot flight crew	1.5	____
Flight crew duty day at maximum and ending with a night nonprecision approach	1.2	____
Flight crew crosses five or more time zones	1.2	____
Third day of multiple time-zone crossings	1.2	____
Add Multiplier Values to Calculate Risk Multiplier Total		____
Destination CFIT Risk Factors Total × Risk Multiplier Total = CFIT Risk Factors Total	(−)	____

Part II: CFIT Risk-reduction Factors

Section 1 – Company Culture

	Value	Score
Corporate/company management:		
Places safety before schedule	20	____
CEO signs off on flight operations manual	20	____
Maintains a centralized safety function	20	____
Fosters reporting of all CFIT incidents without threat of discipline	20	____
Fosters communication of hazards to others	15	____
Requires standards for IFR currency and CRM training	15	____
Places no negative connotation on a diversion or missed approach	20	____

115-130 points	Tops in company culture
105-115 points	Good, but not the best
80-105 points	Improvement needed
Less than 80 points	High CFIT risk

Company Culture Total (+) ____ *

Section 2 – Flight Standards

	Value	Score
Specific procedures are written for:		
Reviewing approach or departure procedures charts	10	______
Reviewing significant terrain along intended approach or departure course	20	______
Maximizing the use of ATC radar monitoring	10	______
Ensuring pilot(s) understand that ATC is using radar or radar coverage exists	20	______
Altitude changes	10	______
Ensuring checklist is complete before initiation of approach	10	______
Abbreviated checklist for missed approach	10	______
Briefing and observing MSA circles on approach charts as part of plate review	10	______
Checking crossing altitudes at IAF positions	10	______
Checking crossing altitudes at FAF and glideslope centering	10	______
Independent verification by PNF of minimum altitude during stepdown DME (VOR/DME or LOC/DME) approach	20	______
Requiring approach/departure procedure charts with terrain in color, shaded contour formats	20	______
Radio-altitude setting and light-aural (below MDA) for backup on approach	10	______
Independent charts for both pilots, with adequate lighting and holders	10	______
Use of 500-foot altitude call and other enhanced procedures for NPA	10	______
Ensuring a sterile (free from distraction) cockpit, especially during IMC/night approach or departure	10	______
Crew rest, duty times and other considerations especially for multiple-time-zone operation	20	______
Periodic third-party or independent audit of procedures	10	______
Route and familiarization checks for new pilots		
Domestic	10	______
International	20	______
Airport familiarization aids, such as audiovisual aids	10	______
First officer to fly night or IMC approaches and the captain to monitor the approach	20	______
Jump-seat pilot (or engineer or mechanic) to help monitor terrain clearance and the approach in IMC or night conditions	20	______
Insisting that you fly the way that you train	25	______

300-335 points	Tops in CFIT flight standards
270-300 points	Good, but not the best
200-270 points	Improvement needed
Less than 200	High CFIT risk

Flight Standards Total (+) _____ *

Section 3 – Hazard Awareness and Training

	Value	Score
Your company reviews training with the training department or training contractor	10	______
Your company's pilots are reviewed annually about the following:		
Flight standards operating procedures	20	______
Reasons for and examples of how the procedures can detect a CFIT "trap"	30	______
Recent and past CFIT incidents/accidents	50	______
Audiovisual aids to illustrate CFIT traps	50	______
Minimum altitude definitions for MORA, MOCA, MSA, MEA, etc.	15	______
You have a trained flight safety officer who rides the jump seat occasionally	25	______
You have flight safety periodicals that describe and analyze CFIT incidents	10	______
You have an incident/exceedance review and reporting program	20	______
Your organization investigates every instance in which minimum terrain clearance has been compromised	20	______

You annually practice recoveries from terrain with GPWS in the simulator	40	______
You train the way that you fly	25	______

285-315 points	Tops in CFIT training	
250-285 points	Good, but not the best	**Hazard Awareness and Training Total** (+) ____ *
190-250 points	Improvement needed	
Less than 190	High CFIT risk	

Section 4 – Aircraft Equipment

Aircraft includes:	**Value**	**Score**
Radio altimeter with cockpit display of full 2,500-foot range — captain only	20	______
Radio altimeter with cockpit display of full 2,500-foot range — copilot	10	______
First-generation GPWS	20	______
Second-generation GPWS or better	30	______
GPWS with all approved modifications, data tables and service bulletins to reduce false warnings	10	______
Navigation display and FMS	10	______
Limited number of automated altitude callouts	10	______
Radio-altitude automated callouts for nonprecision approach (not heard on ILS approach) and procedure	10	______
Preselected radio altitudes to provide automated callouts that would not be heard during normal nonprecision approach	10	______
Barometric altitudes and radio altitudes to give automated "decision" or "minimums" callouts	10	______
An automated excessive "bank angle" callout	10	______
Auto flight/vertical speed mode	-10	______
Auto flight/vertical speed mode with no GPWS	-20	______
GPS or other long-range navigation equipment to supplement NDB-only approach	15	______
Terrain-navigation display	20	______
Ground-mapping radar	10	______

175-195 points	Excellent equipment to minimize CFIT risk	
155-175 points	Good, but not the best	**Aircraft Equipment Total** (+) ____ *
115-155 points	Improvement needed	
Less than 115	High CFIT risk	

Company Culture ________ + Flight Standards ________ + Hazard Awareness and Training ________
+ Aircraft Equipment ________ = CFIT Risk-reduction Factors Total (+) _______

*** If any section in Part II scores less than "Good," a thorough review is warranted of that aspect of the company's operation.**

Part III: Your CFIT Risk

Part I CFIT Risk Factors Total (–) _____ + Part II CFIT Risk-reduction Factors Total (+) _____

= CFIT Risk Score (±) _____

A negative CFIT Risk Score indicates a significant threat; review the sections in Part II and determine what changes and improvements can be made to reduce CFIT risk.

FLIGHT SAFETY FOUNDATION

AUGUST–NOVEMBER 2000

FLIGHT SAFETY DIGEST

SPECIAL ISSUE

ALAR

Approach-and-landing Accident Reduction

FLIGHT SAFETY FOUNDATION 1947–2000

Flight Safety Digest

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In This Issue

Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially in 1947 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 830 member organizations in more than 150 countries.

Foreword

This issue of *Flight Safety Digest* presents the Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) Briefing Notes. This set of 34 unique documents is one product of the ongoing work of volunteers (see page vi) throughout the world who — with the support of their organizations — have addressed the primary causes of fatalities in commercial aviation. The Foundation-led controlled-flight-into-terrain (CFIT)/ALAR accident-reduction effort was begun in the early 1990s.

The briefing notes are a follow-on to "Killers in Aviation: FSF Task Force Presents Facts About Approach-and-landing and Controlled-flight-into-terrain Accidents" published in *Flight Safety Digest* in early 1999. They are one product in the extraordinary FSF *ALAR Tool Kit*, which will be released officially by the Foundation in January 2001. The tool kit is published on a compact disc (compatible with Macintosh® and Windows® operating systems) and includes a variety of products, all aimed to help prevent ALAs, including those involving CFIT. Nearly all of the products can be viewed and printed from the CD, which includes the following:

- Several Microsoft® PowerPoint® presentations review a variety of topics in the context of ALAs such as air traffic control (ATC), flight operations and training, aircraft and ground equipment, CFIT, and the economics of safety;
- FSF *Approach-and-landing Risk Awareness Tool* raises flight crew awareness of hazards in that phase of flight;
- FSF *Approach-and-landing Risk Reduction Guide* provides chief pilots, line pilots and dispatchers with a means to determine if training, standard operating procedures and equipment are adequate to cope with risks;
- FSF *CFIT Checklist* is a risk-assessment tool that can be used to evaluate specific flight operations and enhance pilot awareness of CFIT;
- A variety of posters (produced by *Business & Commercial Aviation*) illustrate important messages based on the recommendations of the task force;
- FSF *Standard Operating Procedures Template*;
- Nearly 100 selected FSF publications are linked to the briefing notes and provide additional facts and examples;
- FSF *Controlled Flight Into Terrain: An Encounter Avoided* is a video that reviews a business aviation ALA involving CFIT; and,
- A variety of other products.

The following conclusions and recommendations, adapted from task force findings, provided the framework for the briefing notes:

Conclusion No. 1: Establishing and adhering to adequate standard operating procedures (SOPs) and flight crew decision-making processes improve approach-and-landing safety.

Recommendations

- Nations should mandate, and operators should develop and implement, SOPs for approach-and-landing operations. The data showed that the absence of SOPs resulted in higher exposure to approach-and-landing incidents and accidents.
- Operators should develop practical SOPs for a normal operating environment. The involvement of pilots is essential in the development and evaluation of SOPs; they will identify and will help eliminate inadequate procedures; and they will support adherence to SOPs that they helped to create.
- Operators should conduct regular evaluations of SOPs to remove procedures that are obsolete or ineffective, and to include new ones as required. Pilot input should be a primary resource for such evaluations.
- Operators should provide education and training that enhance flight crew decision making and risk management. Whether the training comprises a version of crew resource management (CRM) or other aids, the goal is to develop satisfactory flight crew decision making. Sufficient resources must be allocated to achieve this goal.
- Operators should develop SOPs for the use of automation in approach-and-landing operations, and train flight crews accordingly.
- All operators should have a written policy in their flight operations manuals (FOMs) for defining the role of the pilot-in-command in operationally demanding situations. The data show that task saturation and overload of the pilot flying are factors in ALAs. Company policy on the sharing of flight deck duties must recognize that the effective distribution of tasks and decision making among crewmembers is essential to avoid overloading the pilot flying. Training should provide SOPs for the practice of transferring pilot-flying duties during operationally demanding situations.

Conclusion No. 2: Failure to recognize the need for a missed approach and to execute a missed approach is a major cause of ALAs.

Recommendations

- Company policy should specify a well-defined approach gate for approach-and-landing. Criteria for reaching the decision to conduct a go around should include:
  - Visibility minimums required before proceeding past the final approach fix (FAF) or the outer marker (OM);
  - Assessment at FAF or OM of crew and aircraft readiness for the approach; and,
  - Minimum altitude at which the aircraft must be stabilized.
- Companies should implement and should support no-fault go-around policies. Training systems and company management should reinforce those policies.

Conclusion No. 3: Unstabilized approaches cause ALAs.

Recommendations

- Operators should define the required elements of a stabilized approach in their FOMs, including at least the following:
  - Flight path;

- Airspeed;
- Power setting;
- Attitude;
- Sink rate;
- Configuration; and,
- Crew readiness.

- Company policy should state that a go-around is required if the aircraft becomes unstabilized during the approach. Training should reinforce this policy.
- Pilots should "take time to make time" when the flight deck environment becomes task saturated or confusing. This means climbing, holding, requesting vectors for delaying purposes, or conducting a missed approach. "Rushing" approaches and "press-on-itis" (continuing toward the destination despite a lack of readiness of the airplane or flight crew) are factors in ALAs.
- Nonprecision approaches are five-times more hazardous than precision approaches. The implementation of constant-angle nonprecision approach (CANPA) procedures should be expedited globally, and pilots should be trained to use them.
- Pilots also should be educated on approach-design criteria and obstacle-clearance requirements.

Conclusion No. 4: Improving communication and mutual understanding between controllers and pilots of each other's operational environment will improve approach-and-landing safety.

Recommendations

ATC should:

- Introduce joint training programs that involve controllers and pilots to:
  - Promote mutual understanding of each other's procedures, instructions, operational requirements and limitations;
  - Improve controllers' knowledge of the capabilities and limitations of advanced-technology flight decks; and,
  - Foster improved communication and task management by pilots and controllers during emergency situations.
- Ensure that controllers are aware of the hazards of ambiguous communication, particularly during in-flight emergencies. The use of standard ICAO phraseology should be emphasized.
- Implement procedures that require immediate clarification/verification by a controller if communication from a pilot indicates a possible emergency.
- Implement procedures for ATC handling of aircraft in emergency situations to minimize pilot distractions.
- In cooperation with airport authorities and rescue services, implement procedures for emergencies and implement standard phraseology.
- Develop, jointly with airport authorities and local rescue services, training programs that are conducted on a regular basis.

Pilots should:

- Confirm each communication with the controller and request clarification/verification when necessary.
- Report accurately abnormal/emergency situations, and use ICAO standard phraseology.

Conclusion No. 5: The risk of ALAs increases in operations conducted in low light and poor visibility, on wet runways, or runways contaminated by standing water, snow, slush or ice, and with the presence of visual/physiological illusions.

Recommendations

- Pilots should be trained to recognize these conditions before they are assigned line duties.
- Pilots should use a risk assessment tool or a checklist to identify approach-and-landing hazards; appropriate SOPs should be implemented to reduce risk.
- Operators should develop and should implement CANPA procedures to enable pilots to conduct stabilized approaches.
- Operators should develop and should implement a policy for the use of appropriate levels of automation for the approach being flown.

Conclusion No. 6: Using the radio altimeter effectively will help prevent ALAs.

Recommendations

Education is needed to improve pilot awareness of radio-altimeter operation and its benefits.

- Operators should install radio altimeters in their aircraft and activate "smart call-outs" at 2,500 feet, 1,000 feet, 500 feet, the altitude set in the DH (decision height) window, 50 feet, 40 feet, 30 feet, 20 feet and 10 feet for terrain awareness. The smart-call-outs system recognizes when an ILS approach is being conducted, and some call-outs can be eliminated to prevent confusion.
- Operators should and specify SOPs for radio altimeter and require that the radio altimeter be used during the approach.
- Development and installation of advanced terrain awareness and warning systems (TAWS) should be continued; "enhanced ground-proximity warning system" and "ground collision avoidance system" are other terms used to describe TAWS equipment. TAWS is effective in reducing CFIT accidents. This recommendation, however, recognizes that time will be required to implement TAWS worldwide and to ensure that terrain-awareness tools are used correctly.

Conclusion No. 7: Collection and analysis of in-flight data (e.g., flight operational quality assurance [FOQA] programs) can be used to identify trends that can be used to improve approach-and-landing safety.

Recommendations

- FOQA should be implemented worldwide in conjunction with information-sharing partnerships such as the Global Aviation Information Network (GAIN), British Airways Safety Information System (BASIS) and FAA Aviation Safety Action Program (ASAP).
- Examples of FOQA benefits (safety improvements and cost reductions) should be publicized widely.
- A process should be fostered to develop FOQA and information-sharing partnerships among regional airlines and business aviation operators.

Conclusion No. 8: Global sharing of aviation information decreases the risk of ALAs.

Recommendations

- De-identification of data is essential in FOQA/information-sharing programs.
- Pilots who are aware of an accident and its causes are likely to avoid repeating the events that would lead to a similar accident. Distribution of accident reports in the pilots' native languages will enhance their understanding of safety information.

- Public awareness of the importance of FOQA/information sharing must be increased through a coordinated and responsible process.

Optimum Use of Current Technology/Equipment

- Operators should consider the immediate benefit of optimizing the use of current technology such as:
  - TAWS;
  - Quick access recorder (QARs) to support FOQA programs;
  - Radio altimeter with smart call-outs;
  - Precision approach guidance, whenever available, and visual approach slope indicator (VASI) or precision approach path indicator (PAPI) during the visual segment of the approach;
  - Global positioning system (GPS)-based lateral navigation and barometric vertical navigation (pending enhancements that will enable precision approaches with GPS);
  - Communication/navigation/surveillance (CNS) equipment, such as controller-pilot data-link communication;
  - Mechanical checklists or electronic checklists to improve checklist compliance (particularly amid interruptions/distractions); and,
  - Airport/approach familiarization programs based on:
    - Charts printed at high-resolution;
    - Video display; and/or,
    - Simulator visual presentations.

Together, we continue to make a safe transportation system safer.

Stuart Matthews
President and CEO
Flight Safety Foundation

November 2000

CFIT/ALAR Action Group (CAAG)

In April 1999, the CFIT/ALAR Action Group (CAAG) was created to supersede the FSF ALAR Task Force. The CAAG is involved currently in implementing the task force's recommendations.

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Flight Safety Foundation

ALAR

Approach-and-landing Accident Reduction

Tool Kit

ALAR Briefing Notes

Airbus Industrie provided major leadership in the development of the FSF ALAR Briefing Notes.

The Go-around

Approach Techniques

Landing Techniques

Flight Safety Foundation

ALAR
Approach-and-landing Accident Reduction
Tool Kit

Approach-and-landing Risk Awareness Tool

Elements of this tool should be integrated, as appropriate, with the standard approach briefing prior to top of descent to improve awareness of factors that can increase the risk of an accident during approach and landing. The number of warning symbols (⚠) that accompany each factor indicates a relative measure of risk. Generally, the greater the number of warning symbols that accompany a factor, the greater the risk presented by that factor. Flight crews should consider carefully the effects of multiple risk factors, exercise appropriate vigilance and be prepared to conduct a go-around or a missed approach.

Failure to recognize the need for a missed approach and to execute a missed approach, is a major cause of approach-and-landing accidents.

Flight Crew

- Long duty period — reduced alertness ⚠⚠
- Single-pilot operation ⚠⚠

Airport Services and Equipment

- No approach radar service or airport tower service ⚠⚠⚠
- No current local weather report ⚠⚠
- Unfamiliar airport or unfamiliar procedures ⚠⚠
- Minimal or no approach lights or runway lights ⚠
- No visual approach-slope guidance — e.g., VASI/PAPI ⚠
- Foreign destination — possible communication/language problems ⚠

Expected Approach

- Nonprecision approach — especially with step-down procedure or circling procedure ⚠⚠⚠
- Visual approach in darkness ⚠⚠
- Late runway change ⚠⚠
- No published STAR ⚠

Environment

- Hilly terrain or mountainous terrain ⚠⚠
- Visibility restrictions — e.g., darkness, fog, haze, IMC, low light, mist, smoke ⚠⚠
- Visual illusions – e.g., sloping terrain, wet runway, whiteout/snow ⚠⚠
- Wind conditions — e.g., cross wind, gusts, tail wind, wind shear ⚠⚠
- Runway conditions — e.g., ice, slush, snow, water ⚠⚠
- Cold-temperature effects — true altitude (actual height above mean sea level) lower than indicated altitude ⚠

Aircraft Equipment

- No GPWS/EGPWS/GCAS/TAWS ⚠⚠⚠
- No radio altimeter ⚠⚠⚠
- No wind shear warning system ⚠
- No TCAS ⚠

Definitions of acronyms appear on next page.

- Greater risk is associated with conducting a nonprecision approach (rather than a precision approach) and with conducting an approach in darkness and in IMC (rather than in daylight and in VMC). The combined effects of two or more of these risk factors must be considered carefully.
- Crews can reduce risk with planning and vigilance. If necessary, plans should be made to hold for better conditions or to divert to an alternate airport. Plan to abandon the approach if company standards for a stabilized approach are not met.
- After commencement of the approach, *a go-around or a missed approach should be conducted when*:
  - Confusion exists or crew coordination breaks down;
  - There is uncertainty about situational awareness;
  - Checklists are being conducted late or the crew is task overloaded;
  - Any malfunction threatens the successful completion of the approach;
  - The approach becomes unstabilized in altitude, airspeed, glide path, course or configuration;
  - Unexpected wind shear is encountered — proceed per company SOP;
  - GPWS/EGPWS/GCAS/TAWS alert — proceed per company SOP;
  - ATC changes will result in an unstabilized approach; or,
  - Adequate visual references are absent at DH or MDA.

Table 1
Recommended Elements of a Stabilized Approach

All flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC). *An approach is stabilized when all of the following criteria are met:*

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than V_{REF} + 20 knots indicated airspeed and not less than V_{REF};
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted;
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and,
9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

An approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

Source: Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force (V1.1, November 2000)

Notes:

1. All information in the FSF Approach-and-landing Risk Awareness Tool is based on data published in "Killers in Aviation: FSF Task Force Presents Facts about Approach-and-landing and Controlled-flight-into-terrain Accidents," *Flight Safety Digest* Volume 17 (November–December 1998) and Volume 18 (January–February 1999).
2. ATC = Air traffic control
   DH = Decision height
   EGPWS = Enhanced ground-proximity warning system
   GCAS = Ground-collision avoidance system
   GPWS = Ground-proximity warning system
   IMC = Instrument meteorological conditions
   MDA = Minimum descent altitude
   PAPI = Precision approach path indicator
   SOP = Standard operating procedure
   STAR = Standard terminal arrival route
   TAWS = Terrain awareness and warning system
   TCAS = Traffic-alert and collision avoidance system
   VASI = Visual approach slope indicator
   VMC = Visual meteorological conditions

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Appendix 5

Normal Non Precision Approach Profile Notes

(Attachment 10 to NTSB Operational Factors Report)

BAE SYSTEMS Report Number: AWR/461/J32/1
7 September 2005

Attachment 10

to Operations Group Factual Report

DCA05MA04

NORMAL NON PRECISION APPROACH PROFILE NOTES

Normal Non Precision Approach - Profile Notes

When established on a course inbound to the Final Approach Fix (FAF), select flaps 10°and begin slowing to 130 KIAS. Approximately 3 - 4 miles prior to the FAF, at a maximum airspeed of 160 KIAS, the Flying Pilot will call "GEAR DOWN, FLAPS 20°, BEFORE LANDING CHECKLIST". All efforts should be made to stabilize the aircraft in the landing configuration prior to reaching the FAF.

At the FAF, start timing and reduce power to maintain the briefed approach speed and approximately 1,000 fpm rate of descent (as necessary), until reaching MDA. If possible, plan to arrive over the FAF with airspeed stabilized at 130 knots, or the briefed approach speed.

If the missed approach point is reached without establishing visual contact, a missed approach must be initiated.

In the event that visual contact is attained that will allow the descent to continue to 100' above TDZE, (i.e., approach lights in sight), the NFP will call "APPROACH LIGHTS IN SIGHT, CONTINUE". The Non Flying Pilot will then continue to make the appropriate altitude calls.

In the event that visual contact is made with the runway, the Non Flying Pilot will call "RUNWAY IN SIGHT" and will continue to make the appropriate altitude callouts, referenced to Airport Elevation.

Upon hearing the "Runway In Sight" call by the Non Flying Pilot, the Flying Pilot will transition to visual cues outside the cockpit, and upon seeing the runway/airport will state "GOING VISUAL, LEAVING MINIMUMS, FLAPS 35°".

The Non Flying Pilot will continue to monitor the approach and all flight instruments, and will callout any abnormalities.

Upon reaching the Missed Approach Point, if the Non Flying Pilot has not stated "Runway In Sight", or if transition to visual cues is not possible, or if the aircraft is not in position for a normal landing, the Flying Pilot will initiate a missed approach by stating "MISSED APPROACH".