AVIATION OCCURRENCE REPORT

GEAR-UP LANDING

COUGAR HELICOPTERS INC.
EUROCOPTER AS332L
SUPER PUMA (HELICOPTER) C-GQCH
ST. JOHN'S, NEWFOUNDLAND
01 JULY 1997

REPORT NUMBER A97A0136

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Summary

The crew of the Super Puma helicopter, serial number 2139, were conducting an instrument landing system (ILS) approach to runway 29 in St. John's, Newfoundland. As the helicopter was about to touch down, the crew realized that the helicopter was lower than normal and that the landing gear was still retracted. The crew began to bring the helicopter into a hover; however, as collective pitch was applied, the nose of the helicopter contacted the runway surface. Once the hover was established, the landing gear was lowered and the helicopter landed without further incident. Damage was confined to two communications antennae, and the supporting fuselage structure of the aircraft. There were no injuries to the 2 crew members or 11 passengers.

Other Factual Information

The flight crew were certified and qualified for the flight in accordance to exsisting regulations. The occurrence flight was the second flight of the day for the flight crew. For the first flight of the day, the first crew member arrived at 0700 Newfoundland daylight time (NDT) for the planned morning flight. Because of poor weather conditions, the flight to deliver 11 passengers to the newly positioned Hibernia oil platform was delayed for several hours and finally departed at 1148. When the helicopter reached Hibernia, it landed, refueled, and then departed for St. John's; it arrived back at St. John's at 1514 without incident. The occurrence flight began at 1704; however, on arrival at Hibernia, the weather was so poor that the crew was unable to successfully complete an approach and landing, and they returned to St. John's. The flight proceeded uneventfully en route to St. John's at a cruising altitude of 4 000 feet above sea level (asl) and a groundspeed of approximately 145 knots.

Correlation of radio communication records and air traffic control radar data revealed the sequence of events during the flight. At 1926, about 40 minutes prior to landing and approximately 95 miles east of St. John's, the crew, operating under the callsign Cougar 33, contacted Gander Area Control Centre (ACC) by radio and requested clearance to the St. John's airport. Cougar 33 received clearance direct to the airport at an altitude of 4 000 feet asl and was advised that Runway 29 had the best visibility for landing with runway visual range (RVR) readings of 1 800 feet, but that visibilities were fluctuating up and down. When Cougar 33 was about 12 minutes and 28 miles back from landing, Gander centre issued a clearance for Cougar 33 to descend to 3 000 feet asl and 3 minutes later issued a further clearance for Cougar 33 to descend to 2 400 feet asl. Two minutes later, while Cougar 33 was 16 miles east-southeast of the airport, Gander Centre cleared the flight to the St. John's airport for a straight-in ILS approach to Runway 29 via the TESOX approach fix (see Appendix A).

Less than a minute later, with the flight now six minutes and 11 miles from touchdown, Cougar 33 was issued missed approach instructions that would set them up for another approach to St. John's should they not see the runway environment on completion of their current approach. The captain of Cougar 33, being concerned about the weather conditions and the potential for a low fuel situation developing, replied that in the event of a missed approach he wanted to proceed direct to their alternate landing site of Long Pond, where weather conditions were better. Long Pond is a designated alternate landing site 13 miles to the northwest of the St. John's airport. The Gander centre controller did not immediately comprehend where Cougar 33 wanted to go in the event of a missed approach and over the course of several transmissions during the next 45 seconds and two miles the misunderstanding was sorted out. Approximately one minute later Cougar 33 indicated that they were established on the ILS approach waiting to intercept the glidepath. Gander centre replied and advised Cougar 33 that they were six miles from the runway threshold and instructed them to

[1] All times are NDT (Coordinated Universal Time (UTC) minus two and one-half hours) unless otherwise noted.

[2] Units are consistent with official manuals, documents, and instructions used by or issued to the crew.

contact the St. John's control tower on a different radio frequency. The crew established radio contact with St. John's Tower and conducted normal communications throughout the remainder of the approach and landing.

A special weather observation was issued at 2223UTC, approximately 12 minutes prior to the occurrence, for the St. John's airport which indicated: indefinite ceiling 100 feet above ground level (agl) obscured one-eighth of a mile visibility in fog, the wind was from 020 degrees magnetic at two knots, the cloud layer was made up of ten-tenths of fog and the RVR readings for Runway 29 were 1 200 feet and 1 000 feet respectively.

At the time that Cougar 33 received clearance to descend out of 4 000 feet the crew completed the descent check which does not include landing gear. The landing gear is covered in the pre-landing check which consists of setting the engine bleed valves and lowering the landing gear. The pre-landing check is normally accomplished at a point prior to becoming established on the approach but the exact point at which the check should be done is left to the pilot's discretion. Company operating procedures dictate that the check is to be completed no later than five miles from landing. While no technical reference information was found indicating the extent to which setting the engine bleed valves effect fuel consumption, it was indicated that the timing for the execution of the pre-landing check should take into consideration the increased fuel consumption (approximately 5%) when the bleed valves are set. There was no indication that the pre-landing check was completed prior to the attempted touchdown.

The approach was flown by the copilot who operated and closely monitored the automated flight control system (AFCS) while the captain conducted the radio communications and monitored the overall progress of the approach. The crew kept the approach speed of the helicopter faster than normal to provide better separation from the faster traffic that was following them. When the aircraft intercepted the ILS glidepath while it was still near cruising speed, the AFCS first tried to slow down to descent speed which caused the aircraft to fly through the glidepath and placed the aircraft above the glidepath. The pilots were aware of being high on the glidepath, and they made several power adjustments during the approach which resulted in the aircraft reintercepting the glidepath shortly before decision height. Upon reaching decision height and with the runway environment visible, the captain assumed manual control of the aircraft and conducted the landing. In accordance with company operations policy, the copilot remained focussed on his flight instruments, even after the captain assumed control, so that he would be capable of reassuming control and executing an immediate overshoot, should the captain lose visual reference while carrying out the landing manoeuvre. The company's standard operating procedures also require the co-pilot to assist the captain by calling out airspeeds and altitudes until the aircraft touches down.

Aircraft records indicated that the aircraft was certified and equipped for the occurrence flight and that there were no known system anomalies when the crew accepted the aircraft for the flight.

The landing gear system is electrically controlled and hydraulically operated. The landing gear retraction-extension control switch and gear position indicators are located in the upper right corner of the centre console adjacent to the captain's (right-side pilot) left knee (see Figure 1). The landing gear warning system consists of flashing red warning light segments that are located in the lower portion of both the captain's and co-pilot's instrument panels and a three-second aural warning tone of 285 Hz that is heard in the crew's headsets. The system is activated whenever the landing gear is retracted, the radar altimeter senses that the aircraft is below 300 feet agl, and the airspeed is 60 knots or less. The landing gear warning system was checked after the occurrence and was confirmed to be operating correctly.

A barometric altimeter is the standard type of altimeter found in most aircraft, and is a special form of aneroid barometer that uses static atmospheric pressure to indicate an aircraft's height above mean sea level. The occurrence aircraft's barometric altimeter system did not incorporate an altitude warning device. A radar altimeter (or radio altimeter) is a more specialized device that indicates the exact height of the aircraft above the surface of the earth by transmitting radio waves toward the ground and reading the reflected signals. The instrument face of the radar altimeters were located in the lower portion of both the captain's and co-pilot's instrument panels. They were equipped with an altitude alerting function that activates a visual and audio warning when the aircraft reaches the preset height. The preset height is controlled by the pilot and is determined by the setting of a selector bug on the radar altimeter instrument. When the preset height is reached a red light on the radar altimeter indicator illuminates, a large amber decision height light adjacent to the attitude indicator illuminates, and 3 second tone of 454 Hz is heard in the pilots headsets. The crew was conducting a category 1 ILS approach to Runway 29 in accordance with the approach procedure published in the Canada Air Pilot (see Appendix B) with the exception that the decision height was reduced to 549 feet asl and 100 feet agl as had been authorized in an operations specification issued to the operator by Transport Canada. The occurrence helicopter was equipped in accordance with the Commercial Air Service

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3 The published approach procedure for the CAT 1 ILS to Runway 29 denotes a decision height of 649 feet above sea level and 200 feet HAT.

4 The operations specification document indicated that it was issued pursuant to Canadian Aviation Regulations subparagraph 704.08(g)(ii) and required operation in accordance with Commercial Air Service Standards subsection 724.08(6).

Standards referenced in the operations specification which require that the helicopter is equipped with two serviceable and functioning radar altimeter indicators having an altitude alert function. While setting up for the approach on the occurrence flight, the pilots set their radar altimeter preset height to 100 feet which corresponded to the anticipated height above the touchdown zone elevation (HAT) at the reduced decision height. The Category 1 ILS approach procedure charts published in the Canada Air Pilot are predicated on pilots monitoring the barometric altimeter reading to determine decision height while conducting an approach and do not provide radar altimeter reference altitudes.

While it is not the case with all ILS approach equipped runways, Runway 29 at the St. John's airport was equipped for Category 2 operations. Category 2 approach operations enable suitably equipped and authorized crews and aircraft to conduct an ILS approach to a 100 foot decision height. The published approach procedure for the Category 2 ILS approach to Runway 29 (see Appendix B) indicates that the decision height at 100 feet above touchdown zone elevation corresponds to a barometric altimeter reading of 549 feet asl, and a radar altimeter reading of 164 feet above ground. The instrument approach procedure chart for the Category 2 approach to Runway 29 includes a graphic representation that shows the upslope of the ground towards the threshold of Runway 29 at the St. John's airport.

Although not required by regulation the aircraft was equipped with a digital flight data recorder and a cockpit voice recorder. Unfortunately, by the time the operator was advised of the need to examine the recorder data and the units were submitted for analysis, the information pertaining to the occurrence flight had been overwritten by the recording of a subsequent flight. No useful information was obtained from either the flight data recorder or the cockpit voice recorder.

An audio tape recording of the occurrence aircraft's warning horns was made and analysis of the recording revealed that the actual frequency of the landing gear warning tone was 480 Hz and the frequency of the radar altimeter warning tone was 293 Hz. The derived frequencies may have been affected by a small amount of variation caused by a possible speed differential between the laboratory playback unit and the handheld unit that recorded the tones in the aircraft; however, the frequency values were sufficiently close to the reference values that they were considered to be valid representations of the audio tones heard by the crew. The warning tone recordings were digitally sampled and replayed both independently and simultaneously. While there was no scientific reference data available to establish whether tones of these frequencies could be easily distinguished from each other, the subjective assessment was that the tones are not sufficiently unique to preclude misinterpretation in the context of a busy cockpit environment. Additionally, constant frequency warnings tones such as these were considered to be difficult to differentiate should multiple warnings activate simultaneously.

In July 1992 the TSB submitted a Safety Information Letter (No. 1812) to Transport Canada regarding the similarity of certain aural warning horns as a result of a 1991 investigation (TSB Occurrence No. A91C0053) into an inadvertent gear-up landing of a Piper Navajo. The investigation found that the stall warning horn (675 Hz) and the landing gear warning horn (510 Hz) were of the non-pulsating single tone type and were too similar for easy distinction of their respective warning functions. The issue of potentially confusing aural warning horns was re-identified by the TSB in an

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[5] TSB Engineering Branch Report LP17/92 refers to this occurrence.

Aviation Safety Advisory (No. 950198) submitted to Transport Canada in September 1995. In their reply in July 1997 Transport Canada indicated that an Aircraft Certification Policy Letter (Issue No. 54, Audio Alerts and Warnings) was released in March 1997 for the purpose of outlining the existing standards and detailing procedures related to the assessment of audio warnings and to provide a mechanism to ensure standardized compliance. Paragraph 4.2(d) of the document states that "audio alerts should not be easily confused with one another."

Analysis

The aircraft records indicated that the aircraft was certified and equipped for the flight and there was no evidence found of any system malfunction during the flight. The crew were certified and qualified for the flight and although they were on their second trip during a long day, the duty times were within allowable guidelines. However, several other factors combined in this occurrence to create a situation where the crew inadvertently did not complete the pre-landing check and then did not recognize the landing gear warning when it activated prior to the attempted landing.

The flight was prolonged because the weather at the oil rig was too poor to allow for landing and refuelling. This placed the crew in the situation where they were unable to accomplish the intended mission and while they had sufficient fuel in accordance with regulations, the available time and options for the return flight were now more restrictive than if they had landed at the rig and refueled. The flight proceeded uneventfully while returning to St. John's. Air traffic control clearance to the airport and then for descent were received while the aircraft was still a substantial distance from landing, and as a result, the pre-landing check was delayed until the aircraft was closer to landing. The crew were advised of the weather conditions and found the ceiling and visibility were decreasing and were expected to be near approach limits by the time that they arrived, which further restricted their options.

The crew were aware that other higher speed aircraft were following them on the approach and the decision was made to maintain their cruising speed and delay slowing down to their normal approach speed. In this now time-restricted context, the crew received their overshoot instructions which would require them to go-around and set up for another approach. The crew knew the weather was slightly better at their alternate of Long Pond. The captain decided that if the approach was unsuccessful he wanted to overshoot and proceed to Long Pond rather than expend precious fuel and time on an extended procedure to re-attempt an approach that had already been unsuccessful. When the captain expressed this desire to air traffic control the controller did not initially comprehend what the captain was requesting and it took several radio transmissions to get things sorted out. This conversation took place during the time that the crew were transitioning to final approach between 11 and 6 miles from touchdown. The pre-landing check would normally have been completed at approximately this point during the approach and it is likely that the discussion regarding the missed approach intentions provided enough of a distraction that the crew missed completing the pre-landing check that they had previously delayed.

Shortly thereafter and just prior to the aircraft intercepting the ILS glidepath, the crew was instructed to change to the St. John's tower radio frequency. The aircraft then intercepted the glidepath and, because of the higher than ideal speed, the aircraft went high on the glidepath, which required the crew to make several power adjustments to slow down and then regain the desired approach profile. Despite having an automatic flight control system, the workload for both crew members would be high in this situation, and it is likely that the successful completion of the approach became a primary focus for the crew.

The crew regained the ideal ILS glidepath shortly before the decision height of 549 feet on the barometric altimeter. Just prior to reaching decision height the captain acquired visual reference and assumed manual control of the aircraft to conduct the landing. The crew were conducting the Category 1 ILS approach to a 100 foot decision height in accordance with the Transport Canada operations specification, and with no radar altimeter reference heights on the instrument approach procedure chart, the radar altimeter altitude alert was set to the published HAT of 100 feet. When the aircraft reached decision height it was still 164 feet above ground and therefore the radar altimeter altitude warnings activated, sometime after decision height was reached, during the time that the captain had assumed manual control and was slowing down and flaring for the touchdown.

The landing gear warning system is activated whenever the landing gear is retracted, the radar altimeter senses that the aircraft is below 300 feet above ground, and the airspeed is 60 knots or less. When the aircraft reached decision height it was below 300 feet above ground but it was travelling faster than 60 knots so the landing gear warning had not yet activated. The warning system activated sometime during the time that the captain was slowing down and flaring for the touchdown.

To carry out the landing the captain was flying by visual references which required looking ahead through the windshield and not directly at the instrument panel. With the prevailing low visibility conditions this manoeuvre required a high level of concentration on the part of the captain. The red warning lights for the radar altimeter and the landing gear warning are located in the lower portion of the instrument panel and during the landing they would both be at the lower edge of the captains peripheral vision. It is possible that the captain was concentrating on the visual landing manouevre to the extent that, when these visual warnings illuminated in his peripheral vision, they were either not noticed, or were interpreted as the radar altimeter warning which would be a normal event during the landing sequence.

After the captain acquired visual reference and took control, the co-pilot was dedicated to monitoring the flight instruments and calling out altitudes and airspeeds for the captain until a stable hover or touchdown was achieved. The red warning lights for the radar altimeter and the landing gear warning are located in the lower portion of the instrument panel on the co-pilot's instrument panel as well. The landing gear control panel, with the gear position indicators, was well out of the co-pilot's field of view on the opposite side of the centre console next to the
captain's left knee. The co-pilot did not recognize the landing gear warning when it activated and while it is likely that the co-pilot misinterpreted the visual warnings, an explanation for this phenomenon could not be determined.

The aural warnings for the radar altimeter and landing gear warning systems were close in frequency and both were non-pulsating constant frequency tones. It was discovered that these tones could easily be misinterpreted as one tone should they activate concurrently or in overlapping succession. These tones were heard by the crew through their headsets. At the approximate time that the tones would have activated several verbal calls were being made by the co-pilot and likely some verbal acknowledgements were being made by the captain as he was conducting the landing. It is very likely that both warning systems activated at or about the same time and the crew interpreted them as the radar altimeter warning. A radar altimeter warning would be an expected event during the course of a normal landing procedure and as such would not trigger the crew to change their course of action.

While there was no direct indication of the events inside the cockpit, such as could have been provided by the CVR, the factors and data relating to the occurrence indicate that while operating in a high-workload, time-restricted environment the crew inadvertently did not recall that the pre-landing check was not yet completed before attempting the landing. It is also most likely that the radar altimeter and landing warnings occurred in close succession and because of their similar characteristics were misinterpreted as an anticipated and non-critical advisory, in which case the landing gear warning went unrecognized.

The following Engineering Branch reports were completed:

LP109/97 - FDR/CVR Analysis

Findings

1. Aircraft records indicated that the aircraft was certified and equipped for the flight.

2. No evidence was found of any system malfunction during the flight.

3. The crew were certified and qualified for the flight and duty times were within allowable guidelines.

4. The crew delayed the pre-landing check and then while operating in a high-workload time-restricted environment did not notice that the pre-landing check was not yet completed.

5. As there was no radar altimeter reference heights on the Category 1 ILS instrument approach procedure chart, the crew used the HAT of 100 feet and set the radar altimeter altitude alert preset accordingly.

6. The published approach procedure for the Category 2 ILS approach to Runway 29 at St. John's indicates that a decision height of 100 feet HAT corresponds to a barometric altimeter reading of 549 feet above sea level, and a radar altimeter reading of 164 feet above ground.

7. The landing gear warning tone and the radar altimeter warning tone are similar in frequency and duration.

8. The warnings activated by the landing gear warning system were not recognized by the crew.

9. The crew did not recognize that the landing gear was retracted until touchdown was imminent.

10. The nose of the helicopter contacted the runway surface and sustained minor damage.

Causes and Contributing Factors

The crew intentionally delayed the execution of the pre-landing check and then while operating in a high-workload time-restricted environment the crew inadvertently did not recall that the pre-landing check was not yet completed. Subsequently, the crew did not recognize the landing gear warning prior to attempting to land which resulted in the nose of the helicopter contacting the runway surface while the landing gear was retracted.

Safety Action

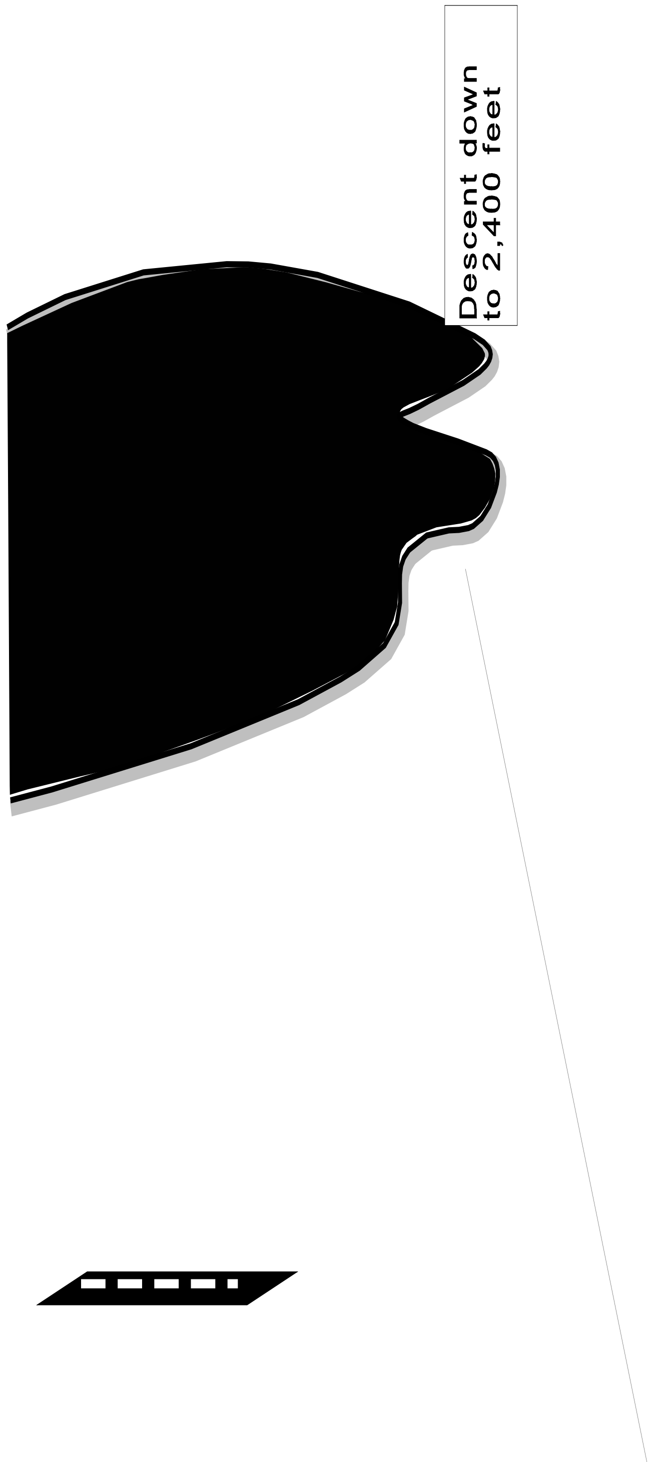
Since the occurrence the company has taken several initiatives to reduce the likelihood of a recurrence. Company procedures state that the pre-landing check is now completed at 10 miles from the landing site. The company believes that this is much earlier in the approach phase and as a result should ensure the completion of the pre-landing check at a time when other high priority tasks are not competing with each other for the attention of the pilots.

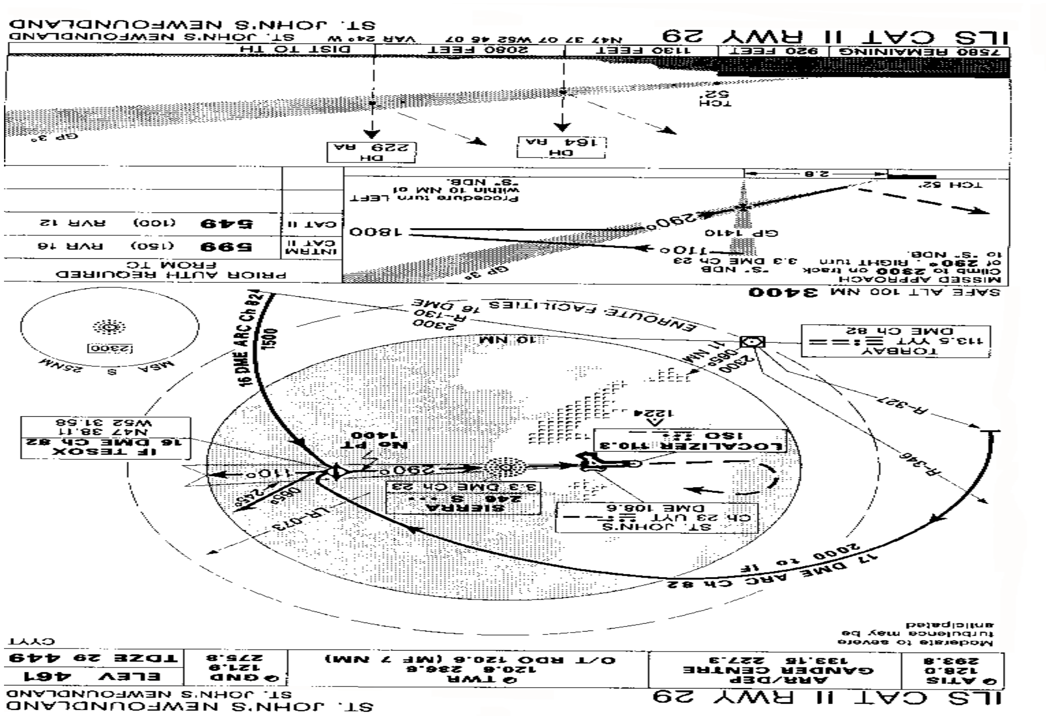
The company has introduced a final landing check that is carried out from memory and silently on short final. The check covers landing gear, warning lights, coupler, radar, engine instruments, bleed valves, and destination. The non-flying pilot carries out the check and reports to the flying pilot the "final check is complete".
At the time of the occurrence the Long Pond approach was an interim procedure that had been used during previous offshore activities. The approach has since been approved and the company has conducted at least three liaison visits to the air traffic control centre to review unique requirements and alternate landing sites.

It was noted that the warning tones for the radar altimeter and the landing gear were similar in frequency and are considered difficult to distinguish when they activate close together. The company is currently investigating optional modifications that may be made to either of these warning systems to make them more distinct.

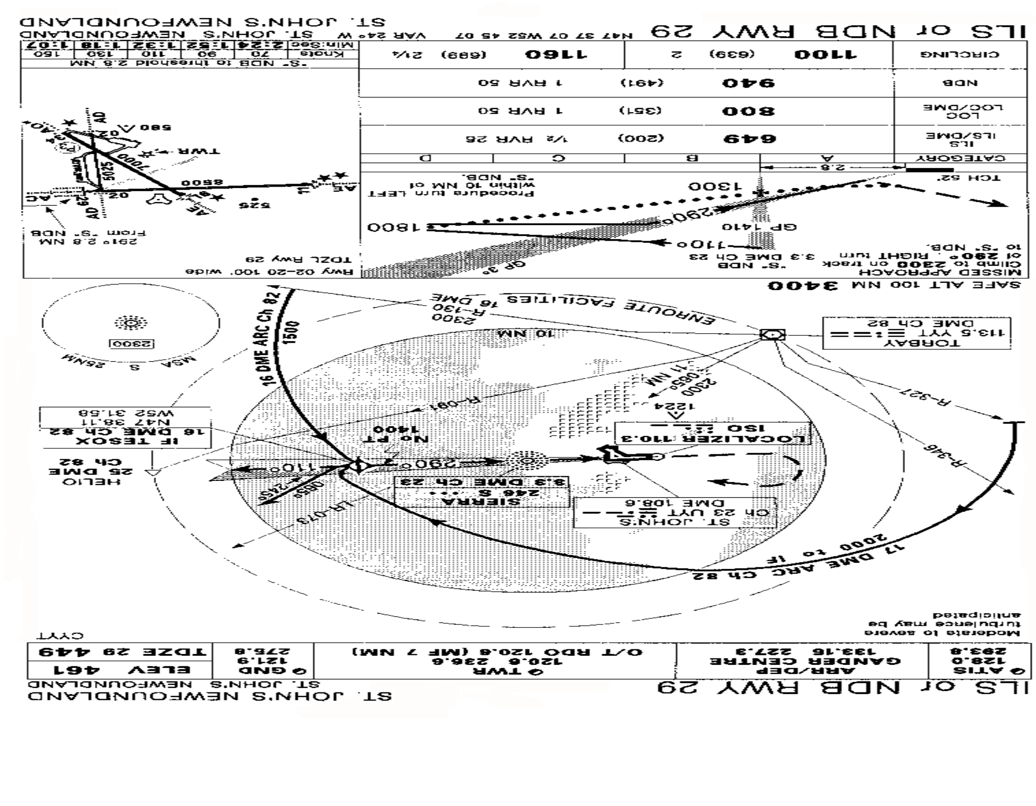
This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 16 September 1998.

Appendix A - Flight Profile





Appendix B - Instrument Approach Procedure Charts


ILS or NDB RWY 29
ST. JOHN'S NEWFOUNDLAND