TSB Accident Board Findings

3.0 Findings

3.1 Findings as to Causes and Contributing Factors

1. Galling on a titanium attachment stud holding the filter bowl assembly to the main gearbox (MGB) prevented the correct preload from being applied during installation. This condition was exacerbated by the number of oil filter replacements and the re-use of the original nuts.
2. Titanium alloy oil filter bowl mounting studs had been used successfully in previous Sikorsky helicopter designs; in the S-92A, however, the number of unexpected oil filter changes resulted in excessive galling.
3. Reduced preload led to an increase of the cyclic load experienced by one of the titanium MGB oil filter bowl assembly attachment studs during operation of CHI91, and to fatigue cracking of the stud, which then developed in a second stud due to increased loading resulting from the initial stud failure. The two studs broke in cruise flight resulting in a sudden loss of oil in the MGB.
4. Following the Australian occurrence, Sikorsky and the Federal Aviation Administration (FAA) relied on new maintenance procedures to mitigate the risk of failure of damaged mounting studs on the MGB filter bowl assembly and did not require their immediate replacement.
5. Cougar Helicopters did not effectively implement the mandatory maintenance procedures in Aircraft Maintenance Manual (AMM) Revision 13 and, therefore, damaged studs on the filter bowl assembly were not detected or replaced.

6. Ten minutes after the red MGB OIL PRES warning, the loss of lubricant caused a catastrophic failure of the tail take-off pinion, which resulted in the loss of drive to the tail rotor shafts.
7. The S-92A rotorcraft flight manual (RFM) MGB oil system failure procedure was ambiguous and lacked clearly defined symptoms of either a massive loss of MGB oil or a single MGB oil pump failure. This ambiguity contributed to the flight crew's misdiagnosis that a faulty oil pump or sensor was the source of the problem.
8. The pilots misdiagnosed the emergency due to a lack of understanding of the MGB oil system and an over-reliance on prevalent expectations that a loss of oil would result in an increase in oil temperature. This led the pilots to incorrectly rely on MGB oil temperature as a secondary indication of an impending MGB failure.
9. By the time that the crew of CHI91 had established that MGB oil pressure of less than 5 psi warranted a "land immediately" condition, the captain had dismissed ditching in the absence of other compelling indications such as unusual noises or vibrations.
10. The captain's decision to carry out pilot flying (PF) duties, as well as several pilot not flying (PNF) duties, resulted in excessive workload levels that delayed checklist completion and prevented the captain from recognizing critical cues available to him.
11. The pilots had been taught during initial and recurrent S-92A simulator training that a gearbox failure would be gradual and always preceded by noise and vibration. This likely contributed to the captain's decision to continue towards CYYT.
12. Rather than continuing with the descent and ditching as per the RFM, the helicopter was levelled off at 800 feet asl, using a higher power setting and airspeed than required. This likely accelerated the loss of drive to the tail rotor and significantly reduced the probability of a successful, controlled ditching.
13. The captain's fixation on reaching shore combined with the first officer's non-assertiveness prevented concerns about CHI91's flight profile from being incorporated into the captain's decision-making process. The lack of recent, modern, crew resource management

(CRM) training likely contributed to the communication and decision-making breakdowns which led to the selection of an unsafe flight profile.

14. The throttles were shut off prior to lowering the collective, in response to the loss of tail rotor thrust. This caused significant main rotor rpm droop.
15. The pilots experienced difficulties controlling the helicopter following the engine shut-down, placing the helicopter in a downwind autorotative descent with main rotor rpm and airspeed well below prescribed RFM limits. This led to an excessive rate of descent from which the pilots could not recover prior to impact.
16. The severity of the impact likely rendered some passengers unconscious. The other occupants seated in the helicopter likely remained conscious for a short period of time, but became incapacitated due to the impact and cold water shock, and lost their breath hold ability before they could escape the rapidly sinking helicopter.

3.2 Findings as to Risk

1. Certification standards for Category A rotorcraft do not require a capability of continued safe operation for 30 minutes following a failure that leads to loss of MGB lubricant if such failures are considered to be extremely remote, placing passengers and crew at risk.
2. In distant offshore operations, including the East Coast of Canada, a 30-minute run dry MGB capability may not be sufficient to optimize eventual landing opportunities.
3. Inadequate systems knowledge related to abnormal and emergency conditions increases the risk of pilots relying on previously learned knowledge. This could lead to unintentional errors in interpreting symptoms of a system malfunction.

4. The decision not to identify time critical actions as memory items in the S-92A MGB malfunction procedure could lead to delays in carrying out actions that are vital to the safe continuation of flight.
5. The decision not to automate an emergency system activation, such as the MGB oil bypass system in the S-92A, increases the risk that critical actions will be omitted or delayed unnecessarily.
6. The lack of established standards for landing guidance definitions used in abnormal and emergency procedures leaves the definitions open to misinterpretation.
7. The lack of specific guidance and/or recommendations in the RFM pertaining to optimum airspeed and torque setting could result in the selection of a flight profile that accelerates the catastrophic failure of a gearbox that has lost oil pressure.
8. The combination of abnormal and emergency procedures into a single procedure, which focuses first on the abnormal condition, increases the risk that critical emergency actions will be delayed or omitted.
9. If manufacturers do not clearly identify critical aircraft performance capabilities in flight manuals, such as run dry time, there is increased risk that pilots will make decisions based on incomplete or inaccurate information during abnormal and emergency situations.
10. The omission of caution or warning messages from a quick reference legend could result in delays in locating the appropriate abnormal or emergency response in a pilot checklist.
11. The use of non-current publications such as RFM, standard operating procedures (SOPs) and checklists, increases the risk that critical steps of an approved procedure will be omitted or delayed.
12. Under the current regulations, CAR 703 and 704 operators are not required to provide CRM. As a result, there is an increased risk that crews operating under CAR 703 or 704 will experience breakdowns in CRM.
13. The current CRM regulation and standard for CAR 705 operators have not been updated to reflect the latest generation of CRM training or to include CRM instructor accreditation. As a result, there is a risk

that flight crews may not be trained in the latest threat and error management techniques.

14. The current basic survival training (BST) standards in Canada lack clearly defined, realistic training standards and equipment requirements. This could lead to differences in the quality of training and affect occupant survivability.

15. An interval of 3 years between recurrent BST may result in an unacceptable amount of skill decay between recurrent training sessions. This skill decay could reduce the probability of successful egress from a submerged helicopter.

16. Passenger Transportation Suit Systems (PTSS) designed to meet the standard for marine abandonment have high buoyancy and flotation capabilities. While useful in a marine abandonment situation, these features may interfere with a successful egress from a submerged helicopter.

17. There are minimal regulations and standards pertaining to offshore helicopter flight crew suit use and maintenance. This increases the risk that flight crews will be inadequately protected following a ditching or crash at sea.

18. Offshore helicopter flight crew suits that are not a high visibility colour reduce the probability of detection by search and rescue crews following a ditching or crash at sea. This could significantly delay rescue at night or in bad visibility.

19. Without regulations and standards pertaining to personal locator beacons (PLB) for helicopter occupants, inappropriate PLB types may be selected for helicopter transportation, resulting in delays locating a person floating in the ocean.

20. The use of improper passenger transportation suit system (PTSS) fitting techniques may result in unacceptable levels of water ingress and a subsequent rapid loss of body temperature, following a ditching or crash at sea.

21. There is no requirement for occupants of a helicopter to be equipped with EUBAs for prolonged over water flight. As a result, occupants

are exposed to an increased risk of drowning following a ditching or crash at sea.

22. The lack of regulation requiring pilots to wear helmets and visors places them at greater risk of incapacitation due to head injuries following a ditching or crash. This type of injury jeopardizes a pilot's ability to assist in the safe evacuation and survival of the passengers.
23. Ditching in adverse weather conditions, and sea states in excess of the capability of the emergency flotation system (EFS), places passengers and crew at risk.
24. If offshore helicopter EFS systems are only designed to withstand the force associated with a ditching, there is a continued risk that these systems will be disabled in survivable impacts contributing to occupant deaths from drowning.
25. Without an immediate signal being transmitted from an emergency locator transmitter (ELT), water attenuation of a useable ELT signal from a submerged aircraft may continue. This increases the risk of an ELT signal not being received and SAR resources not being launched in a timely manner.
26. The use of *g*-switches for the purpose of stopping a cockpit voice recorder (CVR) or combined CVR/FDR (flight data recorder) will likely continue to result in the loss of potentially valuable CVR or CVR/FDR data. As a result, there is an increased risk that future accident investigations will be impeded.

3.3 Other Findings

1. The survivor likely lived through the accident due to his age, fitness, mental preparation, recent helicopter underwater escape training (HUET), previous cold water acclimatization, and a strong will to survive.
2. It could not be determined why the survivor's body temperature dropped 7.2°C so quickly in the time he was exposed to water temperatures in the 0.2°C range.

3. Both organizations providing BST training in Canada met or exceeded the current BST training standards.
4. The E-452 PTSS met the Canadian General Standards Board (CGSB) standards and was considered adequate for the risks of the operational environment at the time of the occurrence.