Chapter 5 – The Human Factors of Surviving a Helicopter Ditching

by

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INTRODUCTION

When a helicopter ditches or 'flys in' to water it commonly inverts and rapidly sinks. For the full text on the human factors related to escape and survival from a ditched helicopter please refer to the AGARDograph 305(E) by this author [2]. For all of you who attend our courses, whether aircrew, flight surgeons, SAR technicians or survival instructors, or one of the many naval trades, we must continue to be vigilant. There is no excuse for slacking off!

While Chief Medical Officer for the Air Force about 12 years ago, I had to defend the requirement to continue HUET and EBS training once the new Cormorant (EH 101) maritime helicopter was introduced. I nearly lost the battle because I was arguing with a senior ex-CF104 fighter pilot who was in charge of Air Force operation – an icon to most of the more junior officers around the conference table. He was of the fatuous opinion that with three engines, it would never ditch, moreover he could not be persuaded to accept the fact that the majority of aircraft accidents are caused by some form of human error and less likely due to mechanical problems. Eventually, commonsense prevailed and I won!! Read on – the key points and updated information on helicopter ditchings are outlined in this paper.

BASIC STATISTICS

If you end up in the water, 15% of crew and passengers generally do not get out!

The first reported helicopter ditching occurred on November 1st 1944. Second Lt. Jack Zimmerman had to dive down to extract Private Troche from the flooded R-4 Sikorsky helicopter. No one paid much attention to deaths in helicopter ditchings until 1971 when Glancy [17] reported that in 55% of ditchings the cause of death was drowning/lost at sea. In 1973, Rice and Greear [23] reported that in 40% of their case study, the cause of death was drowning/lost at sea. Then in 1978, Cunningham [15] reported on 234 helicopter mishaps between 1963 and 1975. His significant findings were that the survival rate was 66% without dunker training and 91.5% with dunker training.

The advent of the North Sea Oil in the mid-1970s caused a sudden increase of helicopter ditchings. This resulted in the UK Civil Aviation Authority HARP report in 1984 [12]. This concluded that flying in a helicopter over water was much more dangerous than flying in a fixed wing aircraft over water. This created the requirement to train crew and passengers in helicopter underwater escape trainers and the requirement for the use of realistic exits.

Survival rates in survivable helicopter accidents from the 1980s and 1990s are presented below in Table 5-1 and 5-2 for military mishaps and Table 5-3 for commercial helicopter mishaps. The survival rates are comparable and little change has occurred over the last 35 years.

Table 5-1: Survival Rates in Military Helicopter Ditchings

	No. of Ditchings	Between Years	Survival Rate
French (Giry, et al. 1992, [16])	11	1980 – 1991	65%
Canadian (Brooks 1988, [1])	17	1952 – 1987	76%
British Military (Reader 1990, [22])	94	1972 – 1988	84%
USN/Marines (Kinker, et al. 1998, [19])	53	1985 – 1997	74%

Table 5-2: US Navy / Marine Corps Overwater Survival Mishap Data 1985 – 1997 (Kinker, Loeslein, Contarino 1998 [19])

Day Mishaps	44	**Survival Rate**	88%
Night Mishaps	23	**Survival Rate**	53%
Total	67	**Average**	75%

Table 5-3: Civilian Helicopter Ditchings World Wide 1971 – 1992 (Clifford 1993 [14])

No. of Helicopters	98
No. of Crew and Passengers	902
No. of fatalities	338
Survival Rate	62.5%

New data was reported by Taber and McCabe in 2005 who reviewed worldwide helicopter ditchings between 1971 and 2005. There were 511 accidents, 2478 people were involved and the survival rate was 66%. Of the 1643 people who survived at least 477 (30%) received some form of injury. [24]

The OGP study [13] in 2006 reconfirms the fact that flying in a helicopter is more dangerous than flying in a fixed wing aircraft. It also reconfirms the necessity to continue helicopter underwater escape training. The average offshore fatal occupant rate in 2004 was zero for the North Sea and 4.0 for the Gulf of Mexico.

The fact is that if you ditch in a helicopter there is likely a 15% chance that you will not survive.

DOES THIS SOUND FAMILIAR?

> *"The crew member, I believe helped get the door open. I jumped out as soon as I could get my belt off, but my husband was trapped inside. By this time the helicopter had turned me upside down and he was covered in debris, struggling, water up to his mouth and he was straining to keep his head above water. I was about to go back in after him when he was able to get his belt undone and swim free. And I* ***do mean swim****. The helicopter was going down."*

The most recent Canadian Military helicopter mishap happened the night of July 12, 2006, in the Atlantic Ocean, just offshore of Canso, Nova Scotia, Canada. Three of the seven occupants did not survive. This is the Directorate's of Flight Safety for the Canadian Air Force accident report:

> *"The accident involved a Cormorant Search and Rescue helicopter with a crew of seven. The crew had assumed SAR standby duties and was authorized to conduct a training mission to practice night boat hoists from the fishing vessel Four Sisters No.1, a member of the Canadian Coast Guard Auxiliary. The crew consisted of three pilots (left seat, right seat, and jump seat), two flight*

engineers and two SAR technicians. It was a brand new aircraft, with some new aircrew and fresh crew under training. [A recipe for caution]… The remainder of the crew occupied the cabin area. They comprised of a Flight Engineer (FE), a Flight Engineer under training (FEUT), a SAR Tech Team Lead (SAR Tech TL) and a SAR Tech Team Member (SAR Tech TM).

The aircraft departed Port Hawkesbury [Nova Scotia] just before midnight on 12 July 2006 to rendezvous with the Four Sisters No. 1 at approximately 2 nautical miles (NM) north of Canso, NS on Chebucto Bay. The weather was clear, visibility was good and the water was calm. After locating the ship, the helicopter used the "Over Water Transition Down" procedure and proceeded to the "rest" position, which is 100 ft above the water and a safe distance from the ship just off the hoisting position from which the crew would start the boat hoisting procedure.

At this point, the helicopter descended to 60 feet and the AC directed the flying pilot to go-around. The pilot acknowledged the go-around command and initiated the go-around procedure. During the overshoot attempt, the helicopter entered a nose-low attitude and seconds later the aircraft impacted the water at approx 30 to 50 knots in an 18 degree nose-down attitude with maximum torque being developed by the main rotor. Upon water impact, the front portion of the aircraft was destroyed while the cabin area aft of the forward part of the cargo door remained relatively intact; the aircraft immediately filled with water and rolled inverted. The crew of Four Sisters No. 1 made a "Mayday" call at approximately 0030L hrs 13 July 2006. The aircraft sustained "A" category damage.

The three pilots and the SAR Tech TL were injured, but survived the crash. The two flight engineers and the SAR Tech TM were unable to egress the aircraft and did not survive.

No pertinent technical deficiencies have been discovered to date and the investigation is focusing on environmental and human factors".

[Courtesy of the Canadian Air Force Flight Safety Office, Ottawa]
http://www.airforce.forces.gc.ca/dfs/docs/Fti/CH149914_e.asp

SO WHAT IS THE PROBLEM?

1) Absence of documentation of any underwater escape training.

Does that mean all our effort has been wasted over the last thirty years? No, it does not. The first observation is that neither the CAA, FAA, JAA nor any other accident investigation bureau ask whether the survivors had HUET training or Shallow Water Egress Trainer (SWET), etc., or not. So we only have anecdotal evidence, survivor's testimony and Cunningham's original study to demonstrate the positive effect of training. Our suspicions are that those who have drowned have either had no training or very simple SWET chair training. The latter in our opinion is unsatisfactory for teaching people to escape from an aisle seat, when an exit is blocked or when the potential survivor has to queue to wait for an exit. The SWET chair is good for basic familiarization and for teaching students to use Emergency Breathing Systems (EBS) – but obtaining certification to fly in a helicopter over water having been trained in a SWET chair is leading crew and passengers into a false sense of security (see later in the requirement for training).

2) Universal use of supplemental air has not been achieved yet.

A second observation concerning the apparent non-reduction in fatalities is that many people drown due to the inability to breath hold in cold water (see later). Supplementary air supplies were recommended 20 years ago. Several NATO countries have introduced EBS, and they are now standard issue to the US Navy and Marines

– but only the North Sea and Norwegian Sea Offshore oil and gas operators have provided devices to their passengers (see EBS lecture). They are not used in the Gulf of Mexico where there is the greatest loss of life!

3) Revision of the Human Factors involved in making a safe escape from a rapidly inverted and sinking helicopter.

Let us very quickly review the hazards facing the crew and passengers when they hear the command 'Ditching, ditching, ditching'.

- It commonly occurs during the critical phases of flight. So it is essential to be alert, mentally and physically prepared during take-off, approach, missed approach, transit, and hover.
- On strap in, it is vital you physically check that you are strapped in correctly, you have your life jacket and immersion suit fitted and secured correctly and that you do a physical and mental check on crash positioning and the procedures to be taken to locate the exit, the jettison lever (if fitted), releasing the seat harness, and the technique to navigate your way out of the inverted, flooded cabin.

The Tiger helicopter accident off the Cormorant Alpha in March 1992 is a classic example of this advice being ignored – 47 seconds in flight, 11 killed! On investigation, several people who drowned did not have their survival suits zipped up correctly. They likely drowned from cold shock. Another person did not strap in correctly and was drowned because he was snagged on his mike cord in the seat head rest. Unfortunately, when some of the Boards of Inquiry are read in retrospect one sees the following typical statements:

New York Helicopter Flight #2434 (AS 360) 4-26-83

- Question – Of what value were the emergency instructions to you?
- Answer #1 Passenger – "Absolutely no value. The only thing I knew from the tape was where the door was. It was a terrible ordeal, we were completely on our own to survive as best we could."
- Answer #2 Passenger – "Zilch!"

- Drowning is a leading cause of death in helicopter accidents. Cunningham (1978) found that in his study of 196 deaths, 37 drowned even though they were not injured [15]. Drowning was also blamed for 56% of civilian and 80% of military deaths in Clifford's 1993 report to the Civil Aviation Authority [14].
- Accidents occur very rapidly with little warning. So again it is worth repeating from above, that it is very important that you have mentally practiced all your ditching skills at strap-in, made sure your suit is correctly zipped up, that you know how to locate your exit and secondary exit and find the inflation toggle on your lifejacket, etc.

Hawaiian Helicopters off Molokai 7.14.94

- Question – What actions did you take before impact?
- Answer – There were none to take – it happened too fast.

- A poor crash position will cause your arms and legs to flail, they will be injured and it is unlikely that you will be able to unstrap. The result is that you will drown. You need a good crash position to:
  a) Reduce strike envelope;
  b) Stabilization in seat to reduce disorientation;
  c) Minimize body profile to inrushing water; and
  d) Smaller human target to debris.

- If the survivors have not stowed all their equipment correctly, there is a good chance that in the violence of the ditching, they may be injured by the flying debris to such a degree that they drown before making an escape.

- If the survivors have not paid attention to strapping in correctly, trouble awaits them. They may not be able to release the harness underwater because it is tucked under a bulky immersion suit, and/or the tail of the strap may float across the open end of the lap belt release mechanism making it impossible to find the edge of the catch. There are many testimonies from survivors about this problem. Here is a typical example:

New York Helicopter Flight #2434 (AS360) 4-26-83.

- Question – Did you have difficulty unbuckling your seat belt?
- Answer – It seemed to be jammed. It wouldn't release. About this time, I was getting concerned because we were sinking fast and none of us could get our seat belts unfastened.

- Helicopters don't float well (Table 5-4). Expect inrushing water. It will be terrifying. One pilot described it like being hit in the chest with a fire hose. It will cause panic, hyperventilation, disorientation, reduced breath holding, cardiac arrhythmias, and drowning.

Table 5-4: Helicopters Do Not Float Well (1980 – 1995)

- Percentage that sank immediately after ditching
  - Canadian Military……...26% (5)
  - British Military…….....50% (47)
  - French Military…….....72% (10)

  - British Commercial (CAA)…..37% (37)
  - US (FAA) Commercial……55% (42)

- Then expect to be inverted, and the more rapid the inversion, the greater the likelihood of injury and death (Table 5-5, 5-6 and 5-7).

Table 5-5: Impact Scenario and Number of Fatalities (Chen 1993 [9])

	No. of occupants per overall injury level				
	Fatal	Serious	Minor	Total on Board	% of fatally/ seriously injured
Immediate overturn	23	20	32	142	30.3%
Delayed overturn	1	3	3	44	9.1%

Table 5-6: Helicopters Commonly Invert while Sinking or Floating at the Surface (1972 – 1994)

- RAF study 100% (4 cases)
- RN study 47% (25 cases)
- FAA 66% (51 cases)
- CAA 50% (49 cases)

Table 5-7: Helicopter Ditching: Time of Crash and Survivability – Floated vs. Sinking (Taber and McCabe 2005 [24])

No. of ditching reports	511
No. of known position of helo after water entry	382
No. which stayed upright floating	56 (15%)
No. which inverted	326 (85%)
Of the 326 that inverted, No. that capsized immediately	250 (69%)

- This sudden inversion means that not only do the survivors have to escape from being completely submerged, but they have to navigate their way out upside down. This is guaranteed to disorientate everyone on board so adding to the terrible confusion. For example, we mocked up our Helicopter Underwater Escape Trainer to represent an 18 passenger Super Puma. We then loaded it with Survival Systems Ltd. instructors or Canadian Navy Clearance divers. All wore an emergency breathing system. It took 92 seconds for the last person to clear the cabin and arrive back at the surface. Half of the people had to use their EBS. [6]

- Survival statistics for night accidents are much worse than daylight accidents: there was an 82% survival rate for the day mishaps and only 58% for the night mishaps for US Navy / Marine Corps survival data of 24 survivable over water mishaps. [19] The survivor must be able to navigate his/her way to an exit in the darkness as exit lighting is only of minor help. Most of the journey will be done by feel after it has been practiced in the helicopter underwater escape trainer.

- It is most important to receive frequent refresher training. At a minimum at least every 3 years and ideally annually. The SWET chair is not satisfactory because: a) it does not disorientate everyone; and

b) does not provide the student the ability to practice crossing one seat directly to a window, or the aisle in case of a blocked exit on the side of the helicopter where the passenger would be sitting. [11]

- Don't forget "cold shock" if the water is below 15°C. During all of the sequence of steps described so far, the survivors are still holding their breath. Hayward has beautifully demonstrated that breath holding ability is reduced by 25 – 50% in water below 15°C [18]. In 0°C water, most people can only breath hold for 12 – 17 seconds to make their escape. Cheung, et al. [10] conducted a trial on 228 offshore oil workers to measure their breath holding ability. Figure 1 below illustrates their breath-holding ability in 24°C water. The water in the North Sea and around the East Coast of Canada rarely warms up to 17°C, and this is only for a few weeks in summer!

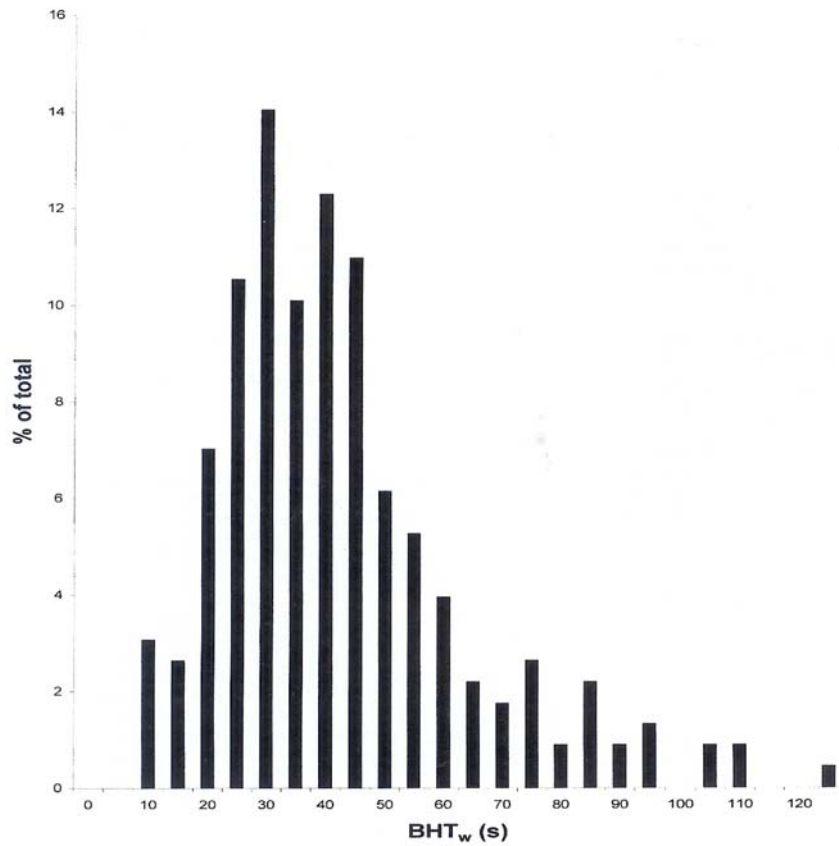

Figure 5-1: A Histogram of BHT Underwater in 228 Subjects (Cheung, et al. 2001).

- Some form of supplementary air – a rebreather or compressed air supply is required to assist those who cannot hold their breath and who would otherwise drown. The pros and cons of each system are discussed in a separate lecture.

- In 1997, Brooks and Bohemier [4] noted that there were at least 23 types of jettison mechanisms in the 35 maritime helicopters examined. Since then there have been at least three more types added to the inventory! So it is important to be trained in the one that you are going to use. Some are placed in quite radically different positions on the door or window, are different in the direction in which the

lever operates, and in the technique for pushing the window out or pulling the window in, etc. Helicopter manufacturers have failed to standardize the exits and ignored this vast diversity in exit design and mechanism over the last 20 years! You better get yourselves trained!

- In 1994, Brooks, et al. [5] conducted an experiment to identify the problem with the underwater location and operation of helicopter emergency exit mechanisms. They advised that all training should have exits fitted to their HUETs. To some degree this has happened, but the number of immersions has not been standardized yet. Some companies and military organizations stubbornly continue to use SWET chairs or HUETs without exits. In 1999, Mills and Muir [21] stated that the minimum competency level of a trainee in HUET should be to "demonstrate the ability, underwater in an inverted HUET, to release a representative seat restraint and escape exit release mechanism, and effect an escape unaided." To meet this competency level, Mills and Muir found that the trainee had to experience at least one inversion with the exit in. A recent independent study was conducted by Dalhousie University in 2006 reconfirmed these findings [20]. Subjects were divided into three groups with varied training in the HUET: group 1 performed 2 trials with no exits present; group 2 performed 3 trials, including one requiring the exit to be jettisoned; and group 3 performed a total of 6 trials, 4 of which had the exit present. They were tested six months later in one trial with the exit present and Table 5-8 below shows that the trainees benefited greatly from just one practice trial (group 2), and even more from additional practice trials (group 3) in the test configuration.

Table 5-8: Subjects Performance Six Months after Being Trained

Group	**Pass (no assistance needed)** (Count / % of Group)	**Fail (needed assistance)** (Count / % of Group)	**Total**
1	28 (54%)	24 (46%)	52
2	38 (81%)	9 (19%)	47
3	52 (96%)	2 (4%)	54
Total	**118 (77.12%)**	**35 (22.88%)**	**153**

So it is quite clear that a HUET fitted with the exits and allowing trainee's several practice trials is required to ensure retention and adequate performance of these skills.

- Do not forget that even if you know how the exits work and the location of the mechanisms, loss of gravitational references, increased buoyancy in the immersion suits, poor depth perception underwater, and the underwater magnification effects makes the levers look much closer than they really are. This all adds up to extra problems with making a successful escape.

You do not want to read this in your next Board of Inquiry or personally experience such an event.

> "The crash was so unexpected. There was only a loud "pop" and down we went. I only had one thought – get out of here. I was mad. Mad because nothing worked as it should. Mad because we had no instructions and there were no flotation devices. Terrified because my husband was trapped and then concerned because we had a good distance to cover and he cannot swim well. The water was like ice and I was shaking uncontrollably. Terrified because I was certain that the man next to us had drowned. He didn't have a chance if his seat belt had jammed as ours did. These were my thoughts at the time it was happening."

- After making your escape, beware, you are still not home and dry! When you get to the surface, your lifejacket may not inflate if it hasn't been maintained correctly. Equally, the life raft may have been punctured due to the fact that it has blown up against the side of the helicopter after you landed safely on the water. You can escape from the helicopter into the life raft by the dry method (dry shod) or wet method (swim away). There are problems with both methods and you must review the author's paper "The Abysmal Performance of the life raft" [3] included in the "Lifeboats and Life rafts" paper of this series. Preferred methods are dry shod and on the windward side, but there simply may not be enough time to do this and the survivors may have to go out however they can before the helicopter sinks. [7, 8]

- Do not believe the life rafts manufacturers who say that it is easy to board the life raft from the open ocean. It may be relatively easy to get into it in a warm swimming pool where most training takes place – but, in fact, it is quite difficult particularly when restricted by a bulky immersion suit – which incidentally may be flooded with water if it leaks, or was incorrectly zipped up, with a life jacket and cold hands. Training in the pool again leads the crew and passengers into a false sense of security. Training should also be done in open water. A lot of work still needs to be done on the design of life rafts for ditched helicopters. So remember, it is much more difficult to get into the life raft in the open ocean compared to the pool exercise you completed on your course.

SUMMARY

Flying in a helicopter over water is potentially very dangerous. In a survivable ditching potentially 15% of crew and passengers will drown in a daylight accident. This may increase to at least 50% in a night time accident. Be protected properly with a life jacket and survival suit. Be trained in a reputable underwater escape trainer fitted with exits and be mentally and physically prepared at all times. Strap in correctly, stow your equipment securely, be particularly alert during the critical phases of flight, assume the crash position on the command "ditching, ditching, ditching," follow the standard procedures for locating and jettisoning your exit, and you will end up safely ashore.

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