AIRCRAFT ACCIDENT REPORT

HELICOPTER CRASH ON THE LAKE DURING TRAINING
FOREST AVIATION HEADQUARTERS
KA-32T, HL9413
YEONGAM LAKE, YEONGAM-GUN, JEOLLANAM-DO
23 NOVEMBER 2009

JULY 12 2011

AVIATION AND RAILWAY ACCIDENT INVESTIGATION BOARD
MINISTRY OF LAND, TRANSPORT AND MARITIME AFFAIRS
REPUBLIC OF KOREA

According to the provisions of the Article 30 of the Aviation and Railway Accident Investigation Act of the Republic of Korea, it is stipulated;

The accident investigation shall be conducted separately from any judicial, administrative disposition or administrative lawsuit proceedings associated with civil or criminal liability.

And in the Annex 13 to the Convention on International Civil Aviation, Paragraphs 3.1 and 5.4.1, it is stipulated as follows;

The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of the activity to apportion blame or liability. Any investigation conducted in accordance with the provision of this Annex shall be separate from any judicial or administrative proceedings to apportion blame or liability.

Thus, this investigation report issued as the result of the investigation on the basis of the Aviation and Railway Accident Investigation Act of the Republic of Korea and the Annex 13 to the Convention on International Civil Aviation, shall not be used for any other purpose than to improve aviation safety.

In case of divergent interpretation of this report between the Korean and English languages, the Korean text shall prevail.

Aircraft Accident Investigation Report

Aviation and Railway Accident Investigation Board, Helicopter crash on the lake during the containing-water training for fire fighting, Forest Aviation Headquarters, KA-32T helicopter, HL9413, Yeongam Lake, Yeongam-gun, Jeollanam-do, 23 November 2009. Aircraft Accident Report ARAIB/AAR0905, Seoul, Republic of Korea

The Aviation and Railway Accident Investigation Board (ARAIB), Republic of Korea, is a government organization established for independent investigation of aviation and railway accident, and the ARAIB conducts accident investigation in accordance with the provisions of the Aviation and Railway Accident Investigation Act of the Republic of Korea and Annex 13 to the Convention on International Civil Aviation.

The objective of the investigation by the ARAIB is not to apportion blame or liability but to prevent accidents and incidents.

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Helicopter crash on lake during training

Forest Aviation Headquarters

KA-32T, HL9413

Yeongam Lake, Samho-myeon, Yeongam-gun, Jeollanam-do, Republic of Korea

23 November 2009 at 11:17 (Korea Standard Time)[1)]

Synopsis

On 23 November 2009 at 11:17, rotorcraft HL9413 of the Yeongam Forest Aviation Office (hereinafter referred to as "Yeongam Office") of the Forest Aviation Headquarters, Korea Forest Service was crashed on the Yeongam Lake during the containing-water training of for forest fire fighting.

HL9413 was an aircraft classified as "aircraft for use by State agency, etc."[2)] in accordance with the Republic of Korea Aviation Act Article 2 (Definitions) and was flying under the visual flight rules. The number of the crew aboard the aircraft at the time of the accident was a total of three persons including one instructor pilot and two student pilots[3)]. All of them were dead due to this accident and the aircraft was totally destroyed.

The Aviation and Railway Accident Investigation Board(ARAIB) determines that the causes of this accident was that "When Student B was approaching the water of Yeongam Lake to contain water he flew at a fast descent speed of 4～5m/s at an forward speed of less than 50 km/h, and was late in applying the collective because he had illusions about the approach and descent speeds over the water, and because of this the aircraft fell into settling with power." Contributing to this accident was that "despite that Student B flew exceeding the limits of approach and descent speeds specified in the Flight Manual when approaching the water surface, the instructor pilot did not warn about this in advance or make corrective maneuvers."

As a result of its investigation of this accident, the ARAIB makes seven safety recommendations to the Forest Aviation Headquarters.

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1) Unless otherwise indicated, all times in this report are Korea Standard Time based on 24 hours.

2) Aircraft owned or leased by national and local governments and other public organizations excluding the aircraft for the military, police and customs.

3) New pilots belonging to the Yeongam Office under the Forest Aviation Headquarters; they were assigned to the training for forest fire fighting on a KA-32 type of aircraft on the day of accident.

1. Factual Information

1.1 History of Flight

On the day of accident, the instructor pilot (hereinafter referred to as "instructor") and student pilots of HL9413 completed preparations for flight training at 09:50 and reported the flight to the head of the Yeongam Office, before the instructor and one student pilot (hereinafter referred to as "Student A") started up the engine of the aircraft at 10:05, and another student pilot (hereafter referred to as "Student B") submitted the flight plan in the flight operation office to the Incheon Flight Information Center (FIC).

According to the flight plan submitted, HL9413 was to carry out training flight in the Yeongam area for two hours from 10;00.

The instructor was on the right seat[4] of the cockpit, Student A on the left seat[5] and Student B on the rear seat.

HL9413 took off in the north direction at the Yeongam Office at 10:17:32 as shown in Photo 1, and at about 10:19[6] it contacted the radio operator[7] of the Yeongam Office and after takeoff it flew in the direction of Seonghwa College runway.[8]

HL9413 conducted flight training for Student A at a point[9] about 2 km north from the aircraft crash point before he was relieved by Student B at 11:02:12.

After HL9413 landed on the runway(②)[10] of the Seonghwa Airfield Student A was relieved by Student B. Student B took the left seat of the cockpit and executed two pattern flights. For the first pattern flight, he took off in the runway 15 direction (③) of Seonghwa Airfield, and for the next pattern flight he took off in the 33 direction (④) as the wind direction was changed.

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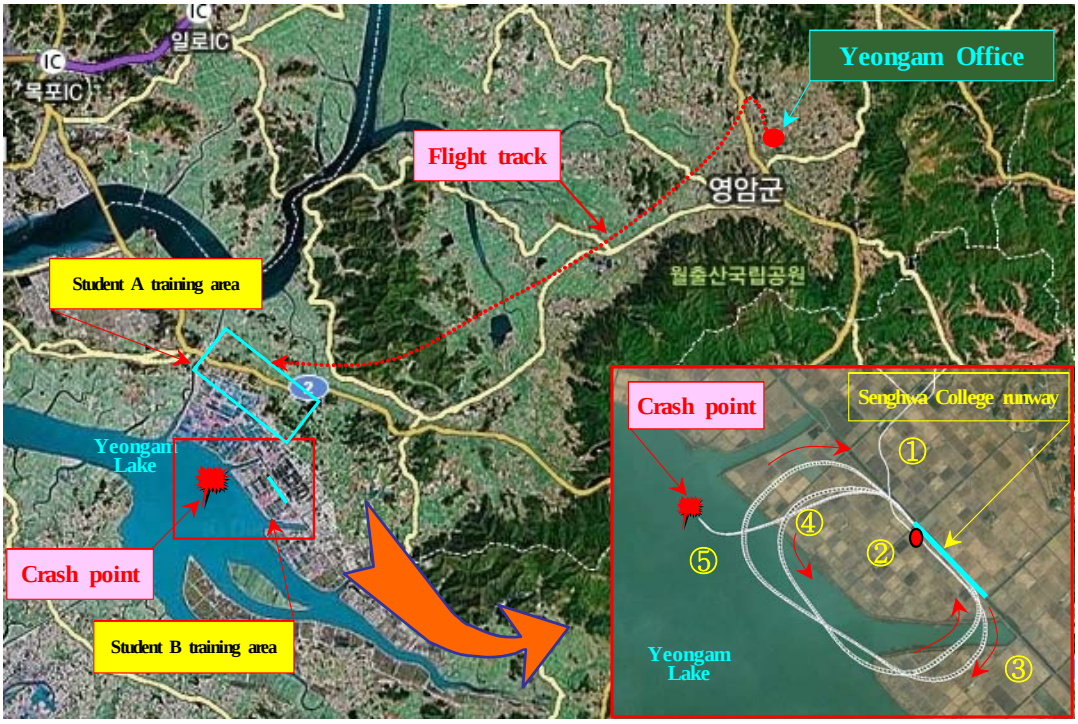
4) Instructor/co-pilot seat
5) Captain's seat
11) Time recorded at the Yeongam Office communication room
7) As a radio operator of the Yeongam Office communication room, he is in charge of aircraft radio communication and position tracking.
8) Located in a farmland north of Yeongam Lake about 22 km southwest of the Yeongam Office.
9) Student A training area of Photo 1
10) A runway in operation for pilot training at Seonghwa College located in Seongjeon-myeon, Gangjin-gun, Jeollanam-do; directions 15-33, 20 m wide and 450 m long, paved (34° 41′ 48.60″N, 126° 31′ 9.64″E)



[Photo 1] Training area and flight track

According to the recordings of the cockpit voice recorder, Student B expressed awkwardness about the control stick of the left seat and about the flight during the pattern flight, saying to the instructor, "The collective is very much low. It makes very difficult for a man with a short arm", "It looks different between from your side (instructor's seat) and from my side (catapin's seat)", "In this condition, the collective, this is too low, so it is a little inconvenient for me", etc. To such expressions, the captain responded, "But this ... frankly, you will realize later that this is more convenient..."

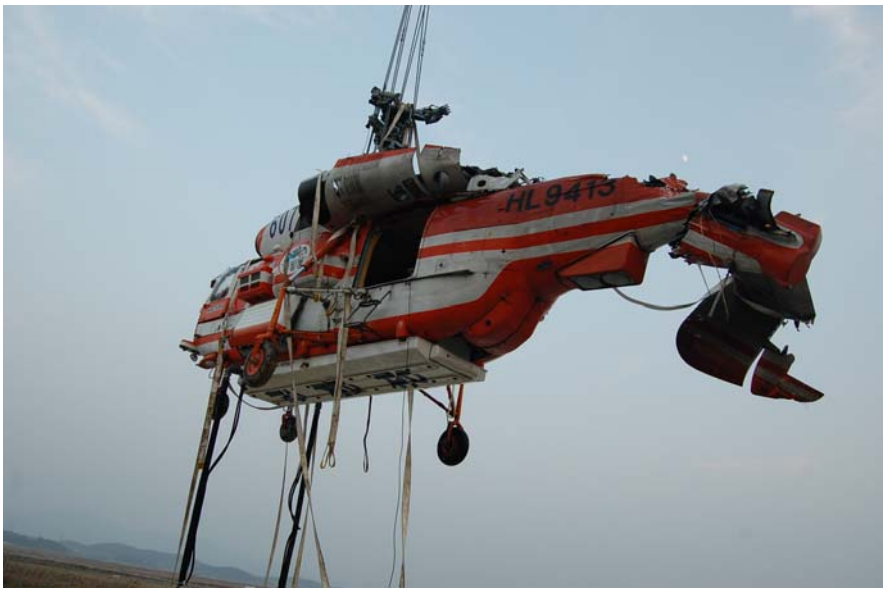
After completing the pattern flight, the instructor and Student B flew (⑤) to above Yeongam Lake for containing-water training. At the time HL9413 flew at an altitude lower than when it had flown the two pattern flights, and while it was approaching the point of containing water at a deep angle, it impacted on the water surface at 11:17:50. At the time when it impacted on the water surface, the speed was 16.83km/h(TAS), heading 337 degrees, and the aircraft attitude had a pitch of 8.35 degrees and a left tilt of 1.04 degrees.

1.2 Injuries to Person

Injury	Crew	Passenger	Other	Total
Fatal	2	1	0	3
Serious	0	0	0	0
Light/None	0	0	0	0
Total	2	1	0	3

1.3 Damage to Aircraft

The aircraft was totally destroyed due to the impact on crash. HL9413 subscribed[11] to hull insurance[12] and passenger accident insurance[13], which were within the term of validity at the time of the accident. Photo 2 below shows the aircraft under salvage work.



[Photo 2] HL9413 under salvage work

11) Green Insurance, Ltd. (representative of 10 domestic coinsurers): 2009. 7. 12. ~ 2010. 7. 11.
12) 1,996,095 US dollars
13) Two pilots (250 million won/person), 5 crew members and passengers (250 million won/person)

1.4 Other Damage

HL9413 had some of loaded fuel and oil leaked during salvage work, but they were collected immediately after leaking by using adsorptive cloth and there was no more spread of contamination.

1.5 Personnel Information

1.5.1 The Instructor Pilot

The instructor (male, age 53) served the military for about 16 years as a pilot of Army Aviation Corps, flying for a total of 2,459 hours. After he was discharged from the military service he flew 63.8 hours in civil aviation, before he was hired by the Korea Forest Service.

From 17 November 1987 when he was hired by the Korea Forest Service to the day of accident, the instructor flew for a total of 2,576,8 hours[14] including 1,412.7 hours[15] on the relevant type of aircraft, 24.2 hours as instructor, and 1,031.2 hours as captain.

The instructor's recent flight time was 0 hours for the latest 24 hours and 28.5 hours for the latest 90 days.

The instructor obtained[16] the instructor certifications for the relevant type of aircraft on 28 April 2003 from the Forest Aviation Headquarters, and held all valid certificates necessary for the flight.

1.5.2 Student Pilot A

Student A (male, age 47) served the military for about 19 years as an Army Aviation Corps rotorcraft pilot flying two types of aircraft for a total of 3,757 hours[17] before he

14) B206L-3: 731 hours, H369D: 133.2 hours, AS350B-2: 288.2 hours,
15) The time is calculated based on the pilot individual flight time record issued by the Forest Aviation Headquarters as of 22 November 2009.
16) Relevant document: Jinhwa 52170-303(2003. 4. 28) “Appointment of full pilots, etc. by requirements for qualification”
17) 500MD : 982 hours, UH-1H: 2,775 hours; total 3,757 hours

was discharged on 31 December 2006.

After he was discharged from the military service, he was hired as a rotorcraft pilot of the Forest Aviation Headquarters on 11 January 2007 and flew two types of aircraft for 560.3 hours before the accident, including 122.6 hours as a captain of B206, and on the day of accident he was conducting captain training for the aircraft type of KA-32.

The Student A's flight time on the relevant type of aircraft was 421.9 hours, of which 410.3 hours excluding 11.6 hours as student pilot (transition training) was as co-pilot, 0 hours for the latest 24 hours, and 23.2 hours for the latest 90 days.

Student A held all valid certificates necessary for the flight.

1.5.3 Student Pilot B

Student B (male, age 45) served the military for about 18 years as an Army Aviation Corps rotorcraft pilot, and flew three types of aircraft for a total of 3,348.4 hours[18] until he was discharged on 31 December 2006.

After he was discharged from the military he was hired as a Forest Aviation Headquarters rotorcraft pilot on 11 January 2007 and flew two types of aircraft for 580.8 hours, of which he flew 139.8 hours as a B206 captain, and on the day of accident he was under captain training for the KA-32 type of aircraft.

His total flight time on the relevant type of aircraft was a total 426.7 hours, of which 416.7 hours excluding 10 hours as student pilot (transition training) was as copilot, 0 hours for the latest 24 hours, and 36.6 hours for the latest 90 days.

He held all of the valid certificates necessary for the flight.

1.6 Aircraft Information

HL9413 was manufactured[19] by the KumAFE of Russia on 8 November 1994 and

18) O-1: 249.7 hours, 500MD: 48 hours, UH-1H: 2,469.7 hours; total 3,348.4 hours

was introduced by the Korea Forest Service on 3 April 1995.

Initially it was registered[20] as an aircraft of the Korea Forest Service and re-registered[21] as an "aircraft of national agencies, etc.," to be operated for an flight time of 2,078.8 hours until the day of accident.

HL9413 was equipped[22] with two engines of TB-3-117BMA type manufactured by Motorsich Co. of Ukraine, and its total service time until the day of accident was 937.3 hours for the left engine and 924.9 hours for the right engine.

HL9413's airworthiness certificate[23], operation limit designation[24], registration certificate, noise certificate[25] and radio station permit[26] were all valid.

HL9413 was equipped with a water tank[27] under the fuselage. This tank was to be filled with water by using two 3 m long rubber hoses[28]and the type of equipment was approved[29] by the manufacturer.

1.6.1 Aircraft Specifications

○ Dimension (Length/width/height)
- Length: 15.9 m
- Width: 3.805 m (with no main rotor)
- Height: 5.45 m

○ Engine
- Power output: 2,200 HP × 2
- Fuel: Jet A-1, Jet-8

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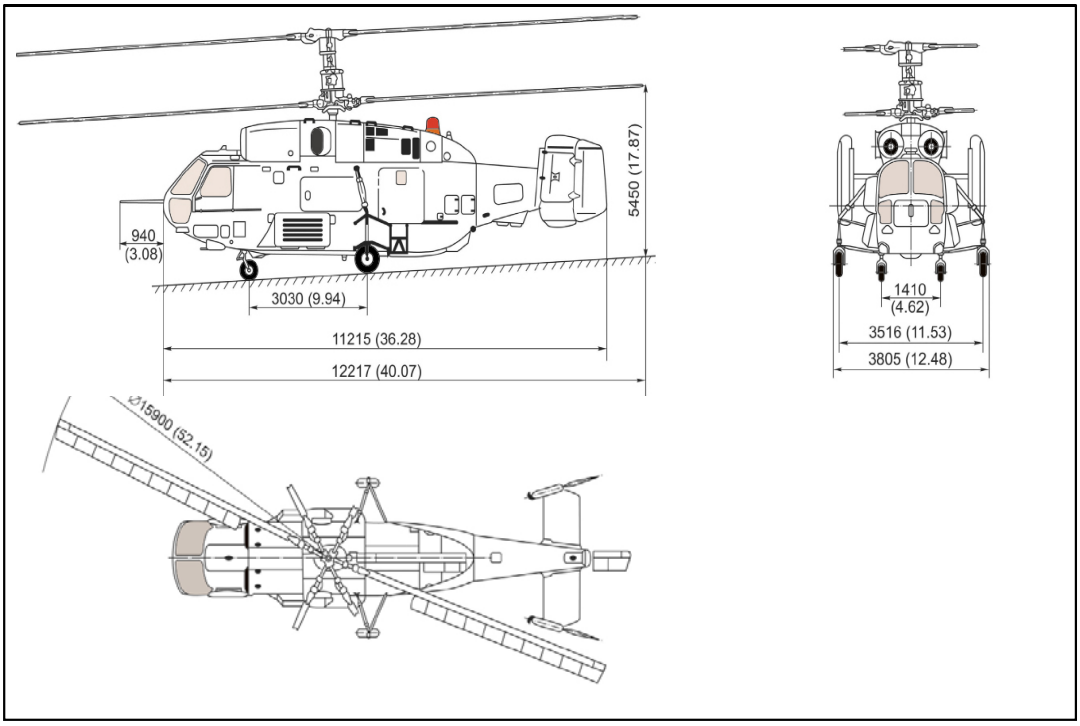
19) Type: KA-32T, serial number: 9009
20) FP607(1995 .4. 3)
21) HL9413(2007. 11. 29)
22) 2005. 6. 29.
23) Certificate number: AS08042, date of issue: 2008. 5. 29
24) Designation number: ASOL08042, date of issue: 2008. 5. 29
25) Certificate number: NS06007, date of issue: 2006. 6. 1
26) Permit number: 46-2006-10-0000012, date of issue: 2006. 8. 31
27) Model name: Symplex 10900=050 ,
28) Inner diameter 7.5 cm
29) Approval number: 36-32A/D7(2006. 4. 12)

○ Performance

- Speed: 200 Km/h (cruising), 230 Km/h (maximum)
- Weight: (Maximum)11,000 Kg, (tare weight) 6,640 Kg
- Seats: 18 persons



1.6.2 Aircraft Maintenance

According to the statements by the maintenance personnel, they could not find any abnormal signs in the fuselage, engines and control systems at the preflight check on the day of accident. Maintenance was properly carried out as specified in the maintenance manual provided by the Manufacturer and there were no defects recorded on the maintenance discrepancy record.

Nothing unusual was found in the fuselage and control systems from the results of analysis of the flight data recorder, and no evidence that was judged unusual was found in the fuselage and control systems either from the cockpit voice data recorded in the last flight section on the day of accident.

1.7 Meteorological Information

According to the testimony by a witness,[30] the weather in the vicinity of Yeongam and Yeongam Lake at the time when he arrived at the scene of the accident was haze[31] over the water surface and farmland, no winds and a still water.

The weather at the time of accident measured by the Weather Watch Office located in Yeonsan-dong, Mokpo City about 16.5 km northwest of the crash point was as shown in Table 1 below.

Time	Precipitation	Temp. (℃)	Humidity(%)	Wind direction (degree)	Wind speed (knot)	Atmospheric pressure (mb)	Remarks
10:00	None	8.8	68.9	165	4	1027.6	
11:00	None	10.5	65	156	5	1027.5	Crash time 11:17:50
12:00	None	12.6	54.2	199	4	1026.6	

[Table 1] Weather data measured by Mokpo Weather Watch Office

1.8 Aids to Navigation

Aids to navigation are not relevant to this accident.

1.9 Communications

HL9413 was equipped with three units of VHF communication equipment and one unit of HF communication equipment[32]. According to the cockpit voice recorder, they contacted Yeongam Office to report takeoff using on-board radio on the day of accident, and monitored the frequency of MCRC[33] during flight, and no evidence of communication failure was found.

30) Yeongam Police Station Samho District Unit Chief
31) Fog generated in stable air by dust or dry particles and the visibility on the day of accident was more than 6 miles.
32) 2 units of VHF (118~136.7 Mhz) for communication with air traffic control centers, one unit of VHF for internal communication in the Korea Forest Service, one unit of HF for internal communication (5 Mhz band)
33) MCRC: Master Control and Reporting Center

The place in which HL9413 conducted training was about 24 km southwest of the Yeongam Office. Communication with the Yeongam Office is possible without trouble by using on-board radio even at or below 1,000 ft.

1.10 Heliport Information

HL9413 took off from the Yeongam Office[34] on the day of accident, and used the Seonghwa College runway for Student B training flight. But any evidence that such facilities affected this accident was not found.

1.11 Flight Recorders

The flight recorders mounted on HL9413 were BUR-1-2-B(FDR)[35] made by NPO-PRIBOR Company of Russia and P-503B(CVR)[36] made by the Petrovsky Company. They were FDR/CVR separation type and collected from the HL9413 salvage site.

The ARAIB sent them to the Intestate Aviation Committee (IAC) of Russia for extraction and analysis of the data, which were done jointly by the Korea and Russia.

1.11.1 Flight Data Recorder

The ARAIB extracted from the FDR the flight data of total two hours and 16 minutes 44 seconds including the accident flight section and the prior flight section, and analyzed 28 flight parameters related to the accident among a total of 58 parameters extracted.

Following are the results of analyzing the flight data recorded in the FDR.

- ○ The engine was operating normally until it crashed on the water.
- ○ Nothing unusual was found in the fuselage until crash on the water.
- ○ The recording[37] of FDR parameters continued for 20 seconds after crash on the water.

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34) Located in Baikgye-ri Deokjin-myeon, Yeongam-gun, Jollanam-do
35) Out of this, magnetic media type tape of metal material (minimum 50 hours of the total recording time)
36) Wire media type
37) Parameter values after crash were recorded irregularly (abnormally) so they are not reliable.

○ The pilot maintained the descent speed at 4～5 m/s at the time of final approach to the water surface.

The flight progress of HL9413 in the final approach phase is as shown in Table 2 below:

Time	Speed(km/h)	Radio altitude(m)	Descent speed(m/s)	Remarks
11:17:34	70.61	54.7	-4.03	
11:17:37	59.02	42.2	-4.65	
11:17:40	53.73	30.3	-3.823	
11:17:43	20.18	20.1	-5.167	
11:17:46	13.81	10.3	-3.823	
11:17:49	16.83	0.0	-4.03	Normal parameter ended

[Table 2] Flight progress in the final approach phase

1.11.2 Cockpit Voice Recorder(CVR)

The voice data recorded in the CVR were for about 50 hours in all, and the ARAIB used data only for final 80 minutes out of the extracted voice records for investigation of the accident.

Anything that hinted about the situation or causes at the time of crash was not recorded in the CVR.

The contents of voice record of the CVR and the contents of the flight data record of the FDR were different in the recording method, so it was not possible to exactly match the times.

1.12 Wreckage and Impact Information

1.12.1 General Description

The Yeongam Lake is a lake desalinized after building embankment in the estuary of a ria coast (bay) and its maximum width is about 5 km. The crash point is 629 m in the direction of 281 degrees of the north embankment drainage lock of the Yeongam Lake,

whose depth is about 3～3.5m and underwater visibility is about 30～40cm.

After crash, HL9413 was overturned to left with the right main skid (wheel) only exposed out of water and the main rotor mast portion touching the bottom.[38)]

The wreckage of HL9413 was made to stand right by using a barge before the FDR and CVR were collected, and the fuselage was towed to shore with about 2/3 of it floated and then it was lifted onto ground.

By checking the wreckage after it was lifted onto ground, it was confirmed that the main rotor and mast portions were damaged and the tail boom was cut, and the canopy under the catapin's seat and the search light were damaged. Such damage to aircraft was judged to have happened while the aircraft crashed. The details of damage are as follows.

1.12.2 Fuselage

[Photo 3] Main damaged portions of fuselage

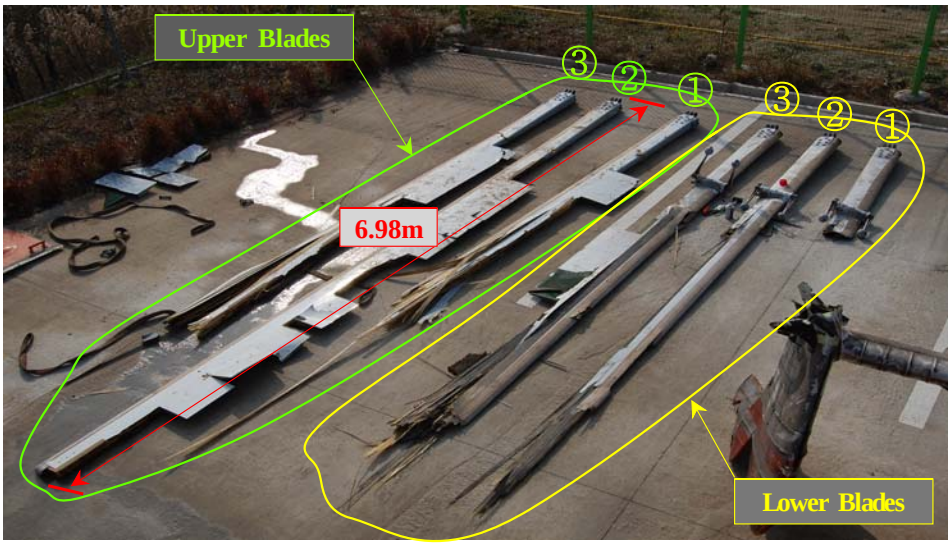
38) It was impossible to confirm it on the water and it was confirmed by the diver during salvage work.

The fuselage had the canopy (①) to the left bottom of the catapin's seat broken as shown in Photo 3 and the search light (②) broken and the search light mount pushed to the rear upward (blue arrow) to squash (black arrow) the surface of the fuselage. And the left cargo room door was judged to have broken away by impact on crash, but we could not collect it from the site. Other than that, we could not find any special damage.

1.12.3 Main Rotors

HL9413 has six coaxial reverse main rotor blades with three upper blades and three lower blades, and all the six were damaged by external impact on crash.

During salvage work, lower blade number 1 of the six blades had the pendulum[39] broken away so it could not be collected it, and the other five blades were broken from blade end to center portions. Photo 4 shows each of the blades damaged.



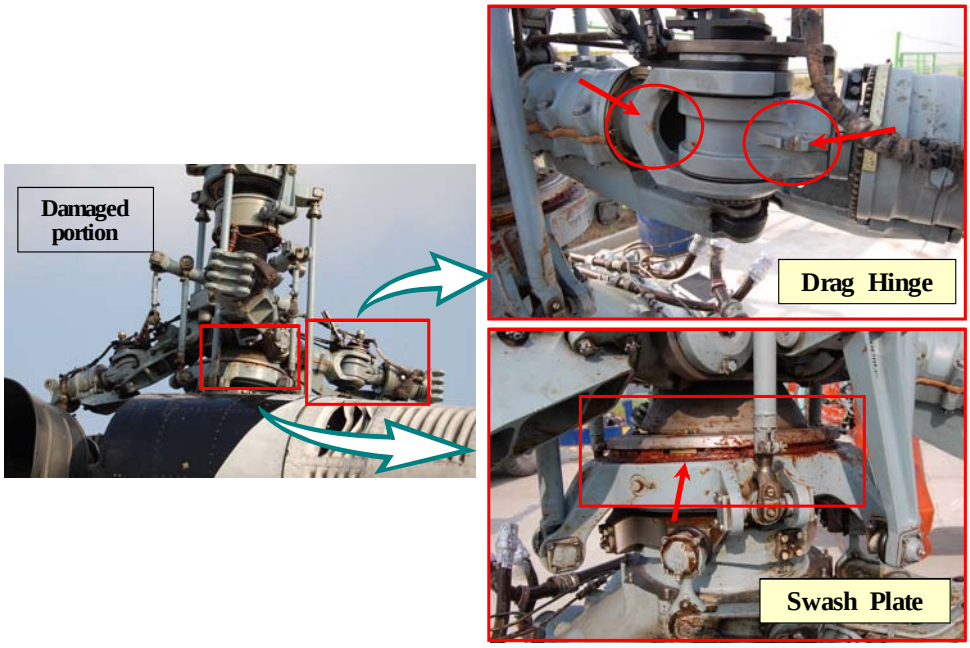
[Photo 4] Main rotor blades damaged

As shown in Photo 5, the mast had one (Number 1) of three lower main rotor blade hubs folded backward of the rotation direction to collide with the drag hinge to be depressed.

The lower swash plate had damage of the gap between top and bottom widened by

39) Pendulum: a pendulum installed on the lower main rotor blade of a KA-32 type of aircraft to absorb the vibration generated in the lower main rotor blade by downdraft in the upper main rotor blade.

external impact. Such damage was judged to have been caused as the rotor blade was folded in the opposite direction of rotation by strong resistance generated when the rotor blade collided with the water surface.



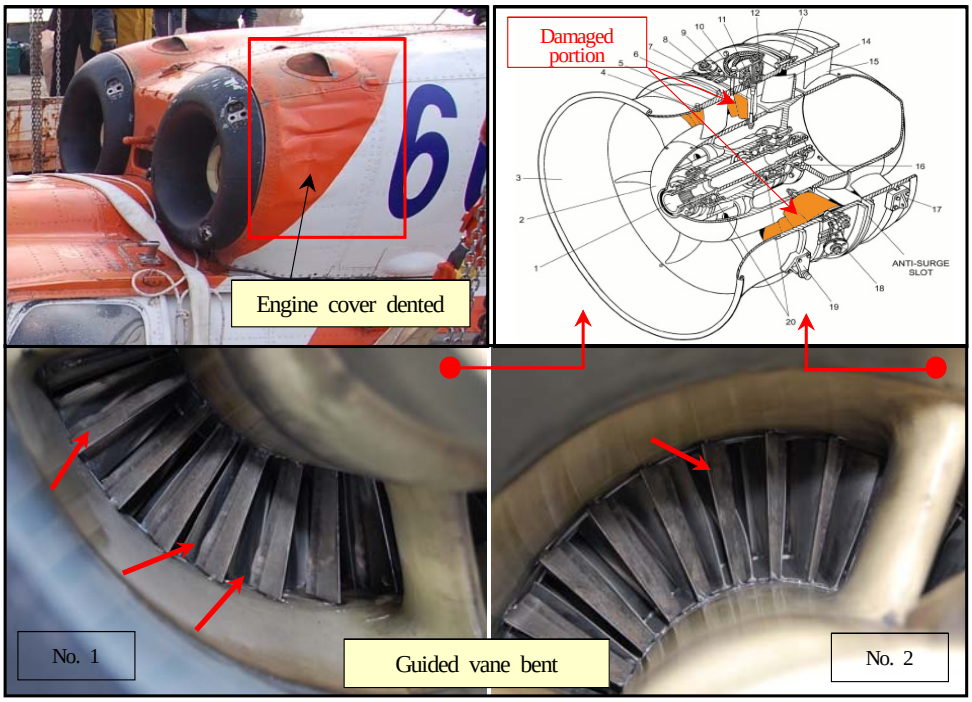
[Photo 5] Damage around the mast

1.12.4 Engines

By checking the exterior of the engines, no damage other than that the upper cover of the left engine air inlet was bent by being pressed by the rope that tied the aircraft to lift it up was found.

But the air inlet guide vane[40] of two engines had the weld broken away and bent forward but it had no FOD, and various lines (pneumatic, fuel, oil and electric wiring, etc.) and control rod were normally connected and no external damage was found. Photo 6 shows the damage to engine portions.

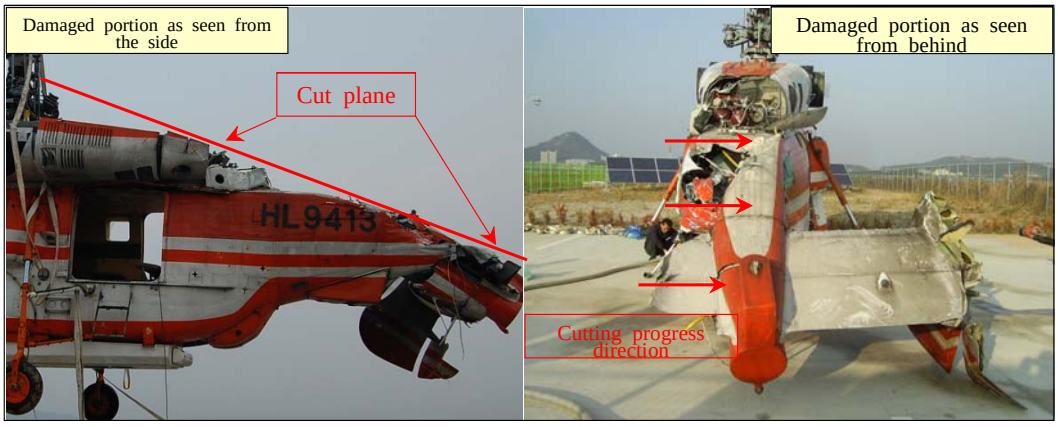
40) A blade for guiding air installed in front of the compressor of engine air inlet; it reduces the pressure of the air going to compressor and increases the speed and gives air direction so that air collides with the nozzle of compressor at optimum angle.



[Photo 6] Damage to engine

1.12.5 Tail Boom

The tail boom was cut away in a straight line from the air outlet cover to the vertical stabilizer of the fuselage top as seen from the side, and the cutting progressed from left to right of the nose direction. Photo 7 shows the damage to the tail boom.



[Photo 7] Damage to tail boom and cutting progress direction

Such damage is judged to have been caused as the lower main rotor blades came downward with strong flapping due to impact on crash, and the tail boom was cut by the

lower main rotor blades while it collided with the water and bounced up strongly.

1.12.6 Cockpit

All the instruments in the cockpit maintained intact without damage due to external impact, but most of them were water-logged so that the insides of the instruments were filled with water.

At the time of on-site investigation all data of instruments were put on record, but most of them indicated the data changed after the accident so it was impossible to obtain data that could prove the situation at the time of the accident, and the ARAIB checked the positions of various switches to find nothing unusual.

1.13 Medical and Pathological Information

The HL9413 flight crew members held valid medical certificates[41] and any medical and pathological evidence that is judged to have affected the accident was not found.

1.14 Fire

There was no fire in this accident.

1.15 Survival Aspects

1.15.1 General

According to the statements by the rescue personnel, the three pilots were found in the cockpit with the cockpit exit door closed, and all had the cockpit belts unfastened.

According to the results of death diagnosis by a medical organization located in Yeongam, all the three pilots had no special trauma and the direct cause of death was judged to be drowning.

41) Instructor: 071-0138(2009.10.13～2010.10.31), Student B: 071-0043(2009.10.23～2010.10.31)

The results of checking on the cockpit belt operation in the on-site investigation after salvage work produced nothing abnormal. But the shoulder harness of the catapin's seat was not installed.

The ballonets,[42] the waterborne floating device, were not expanded when the aircraft crashed, and the safety wire of the exit door emergency release handle on the right of the cockpit was found cut.

1.15.2 Search and Rescue

HL9413 took off from the Yeongam Office at 10:17:32 on the day of accident for training flight planned from 10:00 to 12:00, and according to the recording of the FDR, it crashed into Yeongam Lake at 11:17:50, about one hour after takeoff.

The Yeongam Office communication room called HL9413 on radio at about 11:20 when about one hour passed after HL9413 had taken off, but there was no response. At this time, the communication room did not try to contact any further, judging the training place would be an area impossible to communicate with or they were not responding because they were concentrated on training.

But because there was no communication despite that the training ending time was approaching, the communication room called HL9413 at about 11:50 again to no response, and although they used all the available radios[43] to call until about 12:10, there was still no response.

So the communication room let all the personnel know about the communication cut-off of HL9413 at about 12:10 and continuously tried to contact the pilots by calling pilots' personal cellphones but there was not response.

The Yeongam Office checked with the MCRC at about 12:50 to find the position of HL9413, and was notified that it was found[44] to be four miles east of Muan at about 12:40, and reported the current situation to the Forest Aviation Headquarters

42) Ballonets: Auxiliary air sacs used to float the helicopter on water for a certain time in helicopter ditching; they are mounted on the left and right sides at the bottom end of helicopter fuselage; in an emergency, when the pilot positions the ballonet selection switch at “Ballonet” or “Ballonet Load" and presses the switch on the collective, they expand with internal liquefied nitrogen popping.

43) FM, SSB, VHF radios

44) It was found to be an aircraft other than HL9413 in post on-site investigation.

Safety Section at 12:51 and requested the 119 Rescue Unit for the aircraft search.

On receiving the helicopter search request from the Yeongam Office, the Jeonnam Fire Prevention Headquarters Situation Room judged the missing helicopter to be in the whole area of Muan Peninsula and ordered the Mokpo Rescue Unit to mobilize the advance party immediately and to send a 119 helicopter.

The Jeonnam Fire Prevention Headquarters traced the positions of the mobile phones of the three pilots at 13:38 to confirm the fact that the final contact was made with the Haksan Station[45], Samho-eup, Yeongam-gun, so its own helicopter[46] was used to search the vicinity of Yeongam Lake to find the position of HL9413 that crashed into Yeongnam Lake at about 13:50.

Notified from the Yeongam Office at about 13:55 of the fact that the crashed helicopter was found, the Jeonnam Fire Prevention Headquarters immediately instructed the related agencies[47] to mobilize.

The 119 rescue team members[48] of the Yeongam Fire Station Samho District Unit that arrived[49] at the Drainage Lock of the Yeongham Lake following the mobilization instruction confirmed[50] the crash location of HL9413 looking at another helicopter of the Yeongam Office, and wearing uniforms for underwater life saving, requested[51] support of a fire fighting helicopter.

The rescue team members used a fire fighting helicopter to move to above the crash point, and then approached HL9413 by diving into water at 14:45, and found[52] two pilots in the cockpit by underwater search.

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45) A mobile phone base station located in Haksan-ri, Samho-eup, Yeongam-gun, Jeollanam-do; it is about 5 km away from the crash location.
46) B206(HL9179)
47) Haenam Rescue Unit, Mokpo Rescue Unit, Hadang Rescue Unit, Yeongam Jihwi, Samho Daehyeong, Samho Chemical
48) It was impossible to confirm the accurate time, but it is estimated about 14:35.
49) 4 rescue team members, 3 vehicles
50) Time when confirmation was reported: 14:38 (Time when it was recorded in Situation Diary)
51) Since the crash point is 629 m away from shore, we requested a helicopter to access the crash point.
52) The rescue team found two pilots who were aboard on the right side (topside of the helicopter overturned to left) during underwater search, but could not find one pilot who was aboard on the left cockpit seat because underwater visibility was not good.

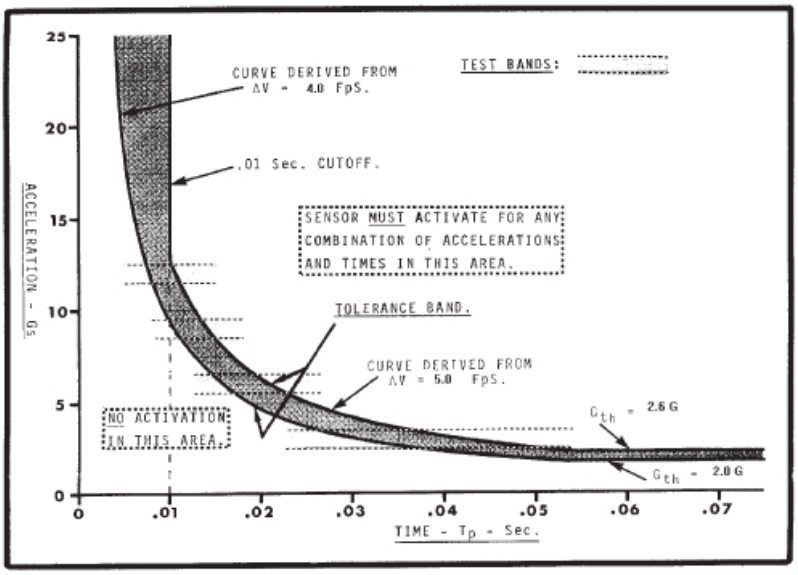
At 14:54 they opened the right exit door (instructor's seat) to get into the aircraft to lift up the instructor first before lifting up Student A and lifted up Student B at about 15:00 from the cockpit seat on the opposite side.

1.15.3 Emergency Locator Transmitter(ELT)

The Coast Guard Situation Room[53] did not receive the ELT signals at the time when HL9413 crashed.

The ELT installed on HL9413 was a C406-2HM model manufactured by the Artex Company of the United States. The activation condition is that the combination of the gravitational acceleration (G) value and time which is contained within the dark colored part on the graph presented in Fig. 1 below.

The maximum value of gravitational acceleration (G) at the moment of crash recorded finally in the FDR was -2.06G, and the cockpit ELT function switch was at the "Arm" position[54].



[Fig. 1] ELT activation condition graph G-Switch Curve

53) Organization in charge of receiving and forwarding ELT signals sent within the Incheon Search and Rescue Region

54) The normal position for activating the ELT when the helicopter crashed or impacted

The ELT antenna mounted on the tail boom was broken along with the tail boom by the lower main rotor blades.

The Forest Aviation Headquarters conducted HL9413's ELT activation tests every three months, and there was no history of ELT malfunction recorded in the maintenance record book.

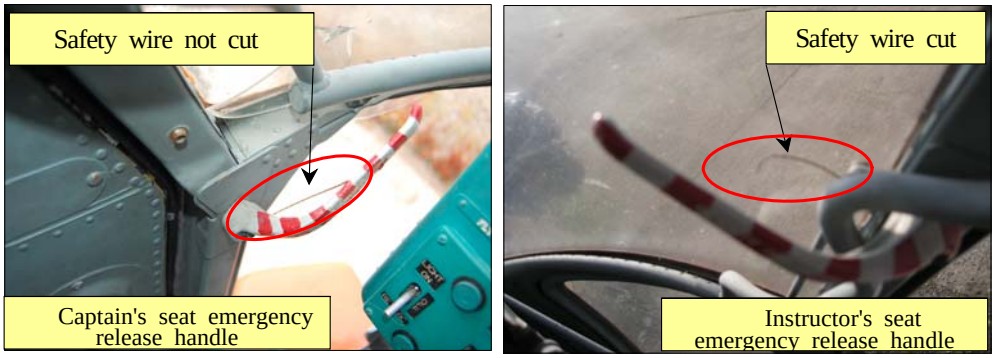
Photo 8 below shows the condition of the ELT function switch in the cockpit and damage to the antenna.

[Photo 8] Damage to ELT antenna and switch condition

1.15.4 Other Survival Aspects

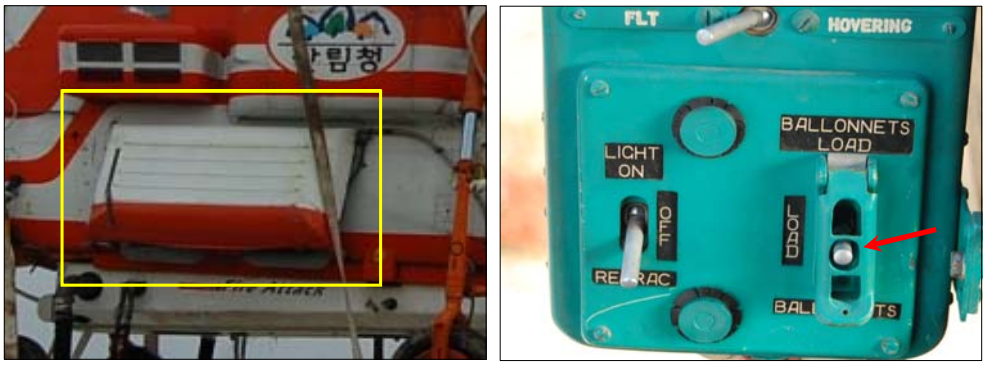
The education and training plan of the Forest Aviation Headquarters did not contain emergency escape training of pilots in preparation for helicopter crash on water. And the pilots did not wear life vests during flight on the day of accident, nor the life vests were furnished in a proper place in the aircraft so as to be usable immediately.

The emergency release handle safety wire of the right exit door (instructor's seat) was cut but the emergency release handle safety wire of the left exit door (student B's seat) was not cut. See Photo 9.



[Photo 9] Exit door emergency release handle safety wire condition

The ballonets mounted on HL9413 were not expanded (yellow rectangle), and the ballonet selection switch on the left instrument panel of the cockpit (captain side) was at the "Load" position (red arrow.) See Photo 10.



[Photo 10] Ballonets not expanded and switch position

The pilot belts were checked on site to find that the aircraft was operated without the captain's shoulder harness on and the pilot belts of all seats were unfastened and there were no functional abnormalities.

Photo 11 shows the cockpit seat belts of the captain's seat and instructor's seat.

[Photo 11] Cockpit seat belts of captain's seat and instructor's seat

The Forest Aviation Headquarters education and training did not contain KA-32 type emergency release handle opening training, and according to the statements by the pilots of the Yeongam Office, they have never received such training.

1.16 Tests and Research

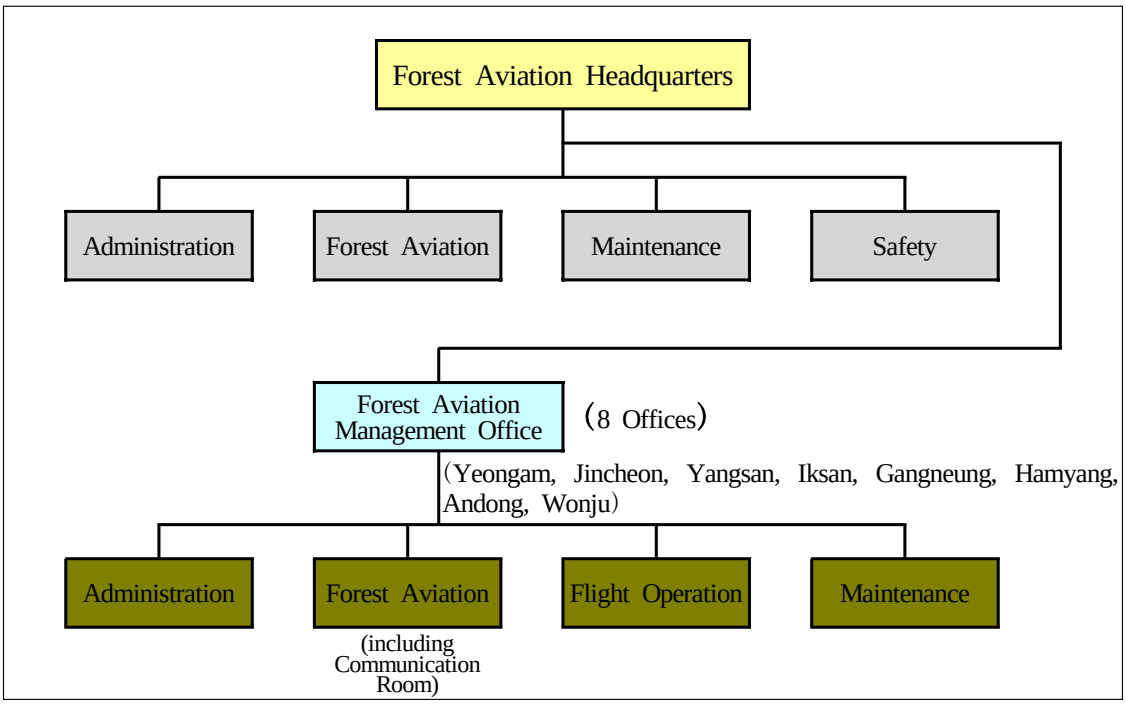
No tests and research were conducted in connection with this accident investigation.

1.17 Organizational and Management Information

1.17.1 General

The Forest Aviation Headquarters under the Korea Forest Service is a national agency that uses aircraft for forest fire control, preventive guidance flight, aerial pest control of forest, air patrol and policing of forest, helicopter support for forest project site confirmation and investigation, airlift of forest project personnel and material, and rescue and salvage work in case of accidents.

The Forest Aviation Headquarters has eight management offices as shown in Fig. 2, and each management office has aircraft and operation personnel deployed to perform the assigned duties.



[Fig. 2] Organization chart of the Forest Aviation Headquarters

1.17.2 Flight Operation Management

According to the statements by the pilots of the Yeongam Office, training flight is planned by the Flight Operation Office, approved by the head of the Office, and had it reflected on the flight plan, which is then notified to the relevant pilots.

And the relevant pilots are to check the flight plan and complete the study of flight before the flight time arrives and use available time to take mission briefing with the instructor, and make a flight plan no later than one hour before flight and submit it to the Incheon FIC.

Subsequently the pilots make preflight inspection on the aircraft and have the flight plan approved by and the flight reported to the head of the Management Office before they carry out the mission. At this time the pilots are to make position reports[55] every 30 minutes pursuant to Radio Communication Operation Manual 4.1 (Situation Communication) of the Forest Aviation Headquarters.

55) To the Forest Aviation Headquarters or the nearest Aviation Management Office.

The captain training flight of HL9413 was conducted by approval of the head of the Yeongam Office. The flight of HL9413 on the day of accident was approved lawfully in accordance with the relevant provisions and the flight plan was properly submitted[56] accordingly.

However, from the flight plan phase of HL9413 until the time when the accident happened, no personnel knew specifically about where and how the training would be conducted other than the fact the destination was listed in the flight plan.

The pilots' position reports are to be received by the radio operators of the Communication Room of the Management Office and are to be forwarded to the relevant personnel if necessary. But any evidence that the pilots made the specified position reports while they were carrying out the flight mission was not confirmed.

The Yeongam Office radio operator had the last contact at 10:19, which was immediately after HL9413 took off. He tried to contact at about 11:20 and about 11:50 but it was not successful, and at about 12:10 he forwarded the communication cut-off news to all personnel.

The Forest Aviation Headquarters Radio Communication Operation Manual or Work Manual did not contain any action procedures for the case that the specified radio communication is failed.

1.17.3 Pilot Training

According to the Forest Aviation Operation Manual 2.3.2.2 (Responsibilities and Duties of the Aviation Section Chief), the Forest Aviation Section Chief has the responsibilities of making and executing plans for education and training of pilots belonging to the Forest Aviation Headquarters. The ARAIB checked the actual condition of the education and training of the Yeongam Office to find that education and training were being conducted under the responsibility of the Head of the Yeongam Management Office.

According to the Forest Aviation Operation Manual 2.3.2.4 (Responsibilities and Duties of the Head of Management Office), the Head of the Yeongam Office is not responsible

56) To Incheon Area Control Center Flight Information Center

for education and training of its own pilots, and the same Manual 3.3 (Flight Crew Education and Training) provides that job training[57] is to be conducted by reflecting it on its own education plan, but not only the scope of job training was not defined but also where the responsibility lies was not clear.

The captain training conducted by the HL9413 pilots on the day of accident was conducted under approval[58] by the Head of the Yeongam Office in accordance with the internal document[59] planned by the Yeongam Office. This is different from the pilot education and training responsibility as specified in the Forest Aviation Headquarters Forest Aviation Operation Manual.

And in the Attached Table 3 and the Attached Table 9-1 of the Forest Aviation Operation Manual are specified the kind of pilot education and training, details of course subjects by kind of training, training time by course subject, etc. But the details of training according to the assigned subjects and time were not provided separately. And the ARAIB could not confirm any record of ground school supposed to be made by the instructor while he was conducting training or any record of specific plans of conducting flight school.

1.18 Additional Information

1.18.1 Aircraft Weight and Balance

HL9413 was equipped with a water tank[60] for forest fire fighting. Since the tank was made in consideration of the weight and balance, the ARAIB judged whether it was within the operation limits by considering only the weight.

HL9413 had completed flight three days before the accident, and after it had fuel supplied finally up to 570 gal, it did not fly for two days, and on the day of accident it flew about one hour from 10:19 to about 11:17.

And HL9413 had three pilots on board and was equipped with a water tank for forest fire fighting but crashed while it was moving to the Yeongam Lake to contain

57) Job training conducted repeatedly every year for all pilots of the Management Office.
58) The Head of the Yeongam Management Office approved the flight plan when the flight mission was reported on 23 November 2009.
59) Yeongam Forest Aviation Management Office-1981(2009.11.12)
60) Simplex 10900=050: Maximum capacity 3,000 liters

water. Considering that the water tank door switch[61] was at the "Open" position, it is judged that it had no water. The weight and balance calculated based on these are as follows:

Aircraft empty weight	6,942 kg
Fuel	1,180 kg
(Initial fuel: 570gal) - (Consumed fuel: 180gal)= (Remaining fuel: 390gal)	
Pilots (3 persons)	270 kg
Water tank	534 kg
Total weight at the time of accident	8,926 kg

So considering the HL9413's maximum takeoff weight of 11,000 kg and the weight of 8,926 kg at the time of accident, it had a margin of 2,074 kg.

61) One of three toggle switches mounted on the captain's seat cyclic; when the pilot sprays the water contained in the tank, it is switched to the Open position and when he contains water, it is switched to the Close position.

2. Analysis

2.1 General

The qualifications held by HL9413 pilots met the requirements specified in the Aviation Act and the Forest Aviation Headquarters Operation Manual. And they took a proper rest before flight, and no medical factors that could affect their duty performance were found.

Based on the FDR of HL9413, statements by the relevant personnel and wreckage inspection, no evidence that defects existed in the fuselage structure, control system and engine system before the accident was found, and the weight and balance of the aircraft were within the allowable limits.

HL9413's airworthiness certificate, operation limit designation, registration certificate, noise certificate and radio permit were all valid. Maintenance was carried out properly according to the methods and procedures specified in the manufacturer manual, and the flight operation was approved properly.

Intensive analysis was made on the weather factors, operation factors, education and training management, and survival factors, and based on this the progress of the accident was judged.

2.2 Weather Factors

There were no weather observation facilities in the vicinity of the crash point of HL9413, so the wind speed measured between 11:00 and 12:00 on the day of accident at the Weather Watch located in Yeonsan-dong, Mokpo City, which is nearest from the accident site (about 16.5 km west), was 4～5 knots.

But according to the statements by the police and 119 rescue team members who were dispatched to the site on the day of accident, at the time when they arrived at the

site, there was weak haze on the water of Yeongam Lake and in the whole area of farmland, and it was clear with no winds. There was a time difference of about 2～3 hours between the time when the helicopter crashed and the time when the police and 119 rescue team members arrived at the site, but most of them stated that the weather in the vicinity of Yeongam Lake was the same without change from the morning.

According to the cockpit voice recorder (CVR) data, the instructor and Student B, after they carried out the first pattern flight in the 15 direction from the Seonghwa College runway, they carried out the second pattern flight in the 33 direction due to the changed wind direction.

Therefore, although it is not possible to know the accurate wind direction a few minutes before the accident, it is estimated that there was a wind of about 4～5 knots around the runway that could be supposed to be in the 33 direction. But a wind direction of such an extent should have not affected the HL9413's execution of the flight mission.

Therefore, the ARAIB judged that the weather had not affected the accident on the basis of the above circumstances.

2.3 Flight Operation Factors

2.3.1 Flight Maneuvers Made by Student B

HL9413 had Student A relieved by Student B at 11:02:12, and Student B took the left cockpit seat (captain's seat) and carried out two pattern flights, and then took off the runway in the 33 direction before he crashed on the water of the Yeongam Lake.

Student B had a total flying time of 426.7 hours, but all of which was the time flown on the right cockpit seat.[62] Therefore, for Student B, it was during the captain training on the day of accident that he has never flown on the left cockpit seat

62) Student B completed transition training of total 10 hours but since he received training on the right cockpit seat also this time, he had no flight experience on the captain's seat.

(captain's seat).

The captain's seat of the KA-32 type had the height[63] of the collective from bottom made lower than the right cockpit seat (co-pilot's seat) with 13.5 cm (full down) and 9.1 cm (full up). Therefore, from the standpoint of Student B who was experiencing flight for the first time on the left cockpit seat, the collective maneuvers during flight should have been somewhat awkward. It was evidenced by the dialogue between instructor and Student B recorded in the CVR during the pattern flight as follows.

Time[64]	**Pilots**	**Dialogue**	**Remarks**
4:15:52	**Student B**	The collective is too low. It is difficult for a man with a short arm..	Immediately after shift
4:18:31	**Student B**	I see from a different position, so I feel different..	First pattern flight
4:18:41	**Student B**	Seeing from your side (instructor's seat) and seeing from my side (captain's seat), I feel the altitude different.	
4:18:48	Instructor	For me, it would be more convenient to use the collective there than here..	
4:18:58	**Student B**	In this condition, the collective, this, this is too low... It is inconvenient...	Recording end time 4:22:18
4:19:01	Instructor	But this... Frankly, you will know that side (captain's seat) would be better ...”	

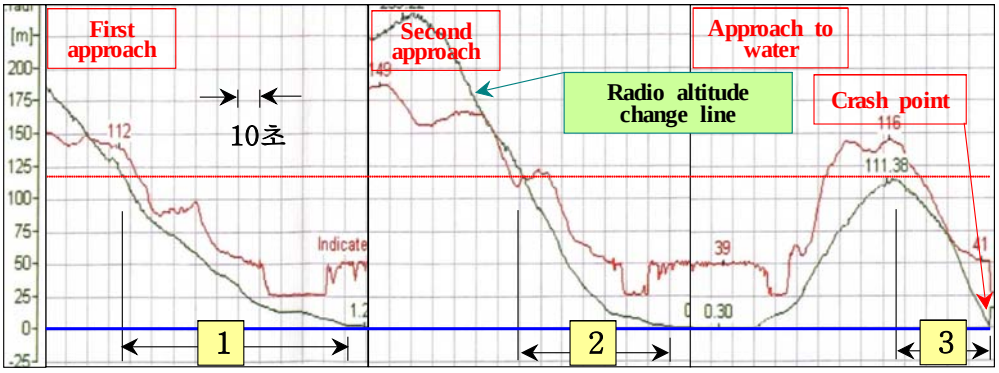
[Table 2] Dialogue between instructor and Student B during the pattern flight

By analyzing the FDR data, it is found that the descent speed for approaching the water of Yeongam Lake was significantly faster than the descent speed for approaching the Seonghwa College runway, comparing the descent speed when Student B approached the Seonghwa College runway during the pattern flight and the descent speed when he approached the water of Yeongam Lake.

Fig. 4 below is a graph showing the radio altitude change line (green solid line) over time during the pattern flight and the approach to the water of Yeongam Lake.

63) The height from the cockpit bottom to the top end of the throttle grip of the collective.
64) It is impossible to match CVR time and FDR time, so the CVE's own reference times were recorded.

As shown in the graph, it took about 70～100 seconds to approach (①, ②) the Seonghwa College runway from reference altitude[65] (red dotted line) to ground but it took about 43 seconds to approach (③) the water of Yeongam Lake.



[Fig. 4] Radio altitude change lines in the final approach phase

As shown in Table 3, comparing the vertical descent speed (Doppler Y-axis speed) and the forward speed for every three seconds at a speed less than 50 km/h to the descent completion point, it is found the vertical descent speed and the forward speed were the fastest during the approach to the water of the Yeongam Lake.

The descent speeds and forward speeds at which Student B approached the water of the Yeongam Lake were those which far exceeded the limits specified in the Operation Manual[66] provided by the manufacturer, that is, the descent speed -3 m/s should not be exceeded at an forward speed of less than 50 km/h.

65) Three approach flights are different in the initial altitude descent point, so the descent point during the approach flight to the water of Yeongam Lake that started descent at the lowest altitude was set as reference altitude.
66) Flight Manual 2.5 (General Flying Limitation)

Time (sec)	1st approach speed		2nd approach speed		Approach speed to water		Remarks
	Advance (km/h)	Descent (m/s)	Advance (km/h)	Descent (m/s)	Advance (km/h)	Descent (m/s)	
-15	2.65	-0.517	1.87	-0.723	70.61	-4.03	
-12	1.19	-0.31	1.59	-0.723	59.02	-4.65	
-9	1.36	-0.103	1.59	-0.413	53.73	-3.823	
-6	1.59	0.207	2.44	-0.31	20.18	-5.167	
-3	1.59	-0.31	2.52	-0.207	13.81	-3.823	
0	2.65	-0.31	3.04	-0.517	16.83	-4.03	Descent ending point

[Table 3] Comparison of vertical descent speeds of Student B

In Student B's speed reducing maneuvers at such a descent speed, he applied[67] the collective with a sufficient allowance of time when he was approaching the pattern flight as shown in Table 4, but when he approached the water of Yeongam Lake, he applied the collective abruptly from about 15 seconds before.

Time(sec)	1st Approach (Degree)	2nd Approach (Degree)	Approach to water (Degree)	Remarks
-25	13.87	13.87	6.24	
-20	13.82	13.48	7.7	
-15	13.19	12.94	10.88	
-10	12.94	12.55	12.5	
-5	12.7	12.01	13.19	
0	12.16	9.46	13.24	Descent ending point

[Table 4] Collective applying angles during approach flight

Therefore, the Student B's approach maneuvers were a combination of fast descent

67) By lifting the collective upward, the pitch of the main rotor is increased to increase lift.

speeds exceeding the allowable range, low forward speeds (less than 50 km/h), deep descent angles, and delays in applying the collective. Such maneuvers are a typical form that could cause settling with power[68] due to the characteristics of rotorcraft.

Student B normally carried out the two approach flights executed on the Seonghwa College runway, but in the approach flight to the water of Yeongam Lake he made maneuvers that caused settling with power as mentioned above. The reasons are suspected that: ① he should have been unfamiliar with his flying for the first time on the captain's seat of a KA-32 type after he was appointed as a pilot of the Korea Forest Service, ② the difference between the heights of the collective of the captain's seat and the collective of the co-pilot's seat might be inconvenient for him, ③ they started the first hour of transition training flight with forest fire control flight that has the highest level of difficulty, ④ they decided on a large lake, which is not easy to provide them with references of surrounding terrain, as the point for containing water, and ⑤ an approach flight to water makes it difficult to refer to the approach speed and sprays occur due to the downdraft at a low altitude and such sprays could limit the visibility of the surroundings. Considering the above, there is a possibility that Student B could have had illusions about the approach speed and descent speed when he was approaching on the unfamiliar captain's seat due to the characteristics mentioned above.

Therefore, the ARAIB judged that Student B was late in reducing the speed and applying the collective due to flight illusions when he was approaching the water, so that HL9413 fell into settling with power and crashed.

2.3.2 Instructor's Experience of Student Training

After obtaining the instructor pilot qualifications, the instructor conducted training flight for 24.2 hours on the KA-32 type for about six years and six months.

68) A phenomenon that appears when a rotorcraft descends at a low forward speed and vertical or near vertical speed; due to a strong downdraft and harmonized circular vortex, the aircraft suffers a severe uncontrollable settlement despite it has power.

Considering such a flying time, it can not be side that he has a sufficient experience of training flight. But in view of his flying time of 1,412.7 hours on the relevant type of aircraft and his forest fire control mission for a total of 431.2 hours, it can not be side that he has no problems with the flight skill.

According to the CVR analysis, the instructor explained well to the student pilots about cautions for each flight phase, but it is judged he neglected the fact that he should be always thoroughly alert to contingencies while a student is flying.

Of course, students are skilled pilots who had experience in various types of aircraft and have flown for plenty of time in the military, so the training could be somewhat different from that of newly appointed pilots. But since the student pilots who are not familiar with the type of aircraft concentrate most of their attention on aircraft control so that there is a lack in comprehensive judgment and attention distribution, the instructor should always be prepared for this.

Despite that Student B was approaching the water of Yeongam Lake at a fast descent speed and a slow forward speed differently from the way he approached during the two pattern flights, any evidence that the instructor cautioned about this or made defensive maneuvers was not found.

The possibility can not be exclude that such a result originated from the fact that the instructor was not sufficiently prepared for contingencies being overconfident that students are skilled pilots with plenty of experience, or from his individual personality that he delegates maneuvers to the student as far as possible to make him get the feel of flying quickly even if he made somewhat excessive maneuvers.

In order to preclude such a fault, it is required to let every instructor know that the instructor should always be thoroughly alert[69] to contingencies during training flight so that he can quickly take necessary action and whenever the student makes a risky or excessive maneuver he should immediately make corrective maneuvers.

69) Being ready so as to take over the control immediately whenever the student makes a risky maneuver or an error while cautiously observing the student's flight maneuvers.

In addition, the training that is conducted in different ways and procedures by different instructors should be standardized, and instructors should be evaluated periodically, and it is necessary to strengthen supervision over the operation of training courses.

2.3.3 Aircraft Tracking System

The aircraft tracking system of the Forest Aviation Headquarters is a system that is dependent simply on radio position reports by pilots. And it is specified that pilots make position reports through the nearest air traffic control facilities or the Forest Aviation Headquarters during their flight mission.

But according to the recordings of the CVR of HL9413, despite that the training and crash points of HL9413 were in a location where it is possible to contact the communication room of the Yeongam Office at or below 1,000 ft, the pilots did not make position reports to the Yeongam Office during flight.

And the HL9413 pilots were listening on the frequency of the MCRC during training flight, and the contents of the Yeongam Office calling HL9413 or the pilots calling the Yeongam Office were not recorded. And after the accident the ARAIB checked by comparing the frequency set on HL9413 and the frequency of the communication room to find that the position report frequency was not set on all radios of HL9413.

From such evidence it can be judged that it was customary that pilots do not make position reports if training flight was conducted by the Yeongam Office. And it seems that the communication room did not take any follow-up action, judging radio communication would be impossible because the aircraft was in a blind spot even though the position of the aircraft is not known within the specified time.

2.4 Training Management

According to the Forest Aviation Flight Operation Manual 2.3.22 (Responsibilities and Duties of the Aviation Section Chief), the responsibility for education and training of pilots belonging to the Forest Aviation Headquarters lies with the Forest Aviation Section Chief, and the same Manual 3.3 (Flight Crew Education and Training) provides that job training should be reflected on its own education plan to be conducted.

But the kind of job training is not specified in the Forest Aviation Flight Operation Manual, and not only it is not clear what department its own training plan belongs to but also any standards or guidelines for training management and procedures are not provided, and merely the qualification standards of instructors and training subjects and hours of flight crew members were provided.

In the Yeongam Office, the Captain Training Plan for Students A and B were personally made by Student A and approved by the Head of the Management Office before it was executed, and no one supervised the captain training or attended the briefing of flight training.

Considering that in the recording of the CVR, Student B mentioned inconvenience due to the difference in the collective height between the captain's seat and co-pilot's seat and that in the analysis of the FDR settling with power was caused by approaching at an excessively fast descent speed at a low forward speed during the approach to water, it seems that the instructor had not explained sufficiently about the cautions with respect to the characteristics of the KA-32 type and training subjects during ground school or preflight briefing.

Therefore, the ARAIB judged that the current education and training specifications and guidelines are unsatisfactorily made to make it difficult to expect the satisfactory effects of education and training and supervision function, so as a result, the education and training of the Yeongam Office were managed poorly, and these results had an indirect influence on this accident.

In addition, the Forest Aviation Headquarters has a problem that the level of achievement is different by student because the method and contents of teaching are different by instructor, but any system for standardizing such differences is not provided. Therefore, it is necessary to re-examine its own education and training system and develop a substantial education and training scheme before the relevant specifications are complemented.

Also, in the case that flight training should be conducted for many subjects like captain training, careful consideration should be given also to curriculum formation so that student pilots can be gradually familiarized with the characteristics of the aircraft type by starting the training with a subject having a relatively low level of difficulty.

2.5 Survival Aspects

2.5.1 Escape from the Cockpit

The pilots could not make an emergency escape after the aircraft crashed on the water of Yeongam Lake and all died, and the cause of death was found to be drowning.

Considering that the depth of water of Yeongam Lake is about 3.5 m, it is judged that if the pilots had opened the exit door and escaped after crash, they could have gone up the aircraft fuselage to request for help or moved to land about 600 m away by using the floating materials in the aircraft.

From the on-site investigation, it was found that the safety wire of the right cockpit emergency release handle was cut. And according to the statements by the 119 rescue staff, it was possible to open the right cockpit exit door normally from outside, and all of the cockpit seat belts of the pilots were unfastened, and an autopsy by a medical institution showed no trauma in the pilots.

Considering that the rescue personnel could open the right exit door normally, if the

pilots had had consciousness without a serious injury immediately after crash and the underwater visibility had been good, the instructor should have opened the exit door normally. But if the pilots had unfastened the cockpit seat belts hastily before the aircraft was stabilized on crash, it should not have been easy for them to find the exit door handle quickly because of a pressing situation where it is hard to breathe with a bad underwater visibility and because they lost the attitude sense in a rocking fuselage and muddy water coming in rapidly through the broken canopy or left rear exit door.

Nevertheless, considering that the safety wire of the right exit door emergency release handle was cut, there is a possibility that the instructor or Student A tried to escape by pulling the emergency release handle to escape after the aircraft crashed. But at this time the exit door was not separated.

So for investigation about the possibility of the right exit door not operating, the ARAIB tied a KO-0.5 safety wire[70] to the emergency release handle and pulled it to the release position to measure the tensile force, which was 10.1 kg[71], and it was confirmed that the exit door was smoothly separated at this time.

In the emergency escape system of HL9413, if normal release of the door is impossible because the cockpit exit door malfunctions, it is required to pull the emergency release handle, then the release trigger connected with the handle pushes the rail under the exit door backward (yellow arrow direction) to break away from the fixing slot, and the exit door is dropped downward, by its own weight, to be separated.

But at the time of accident HL9413 was overturned to left and the water pressure was pressing the right exit door, so there is a possibility that when the instructor or Student A (on the rear seat) pulled the emergency release handle, the rail under the exit door did not break away so the exit door was not separated.

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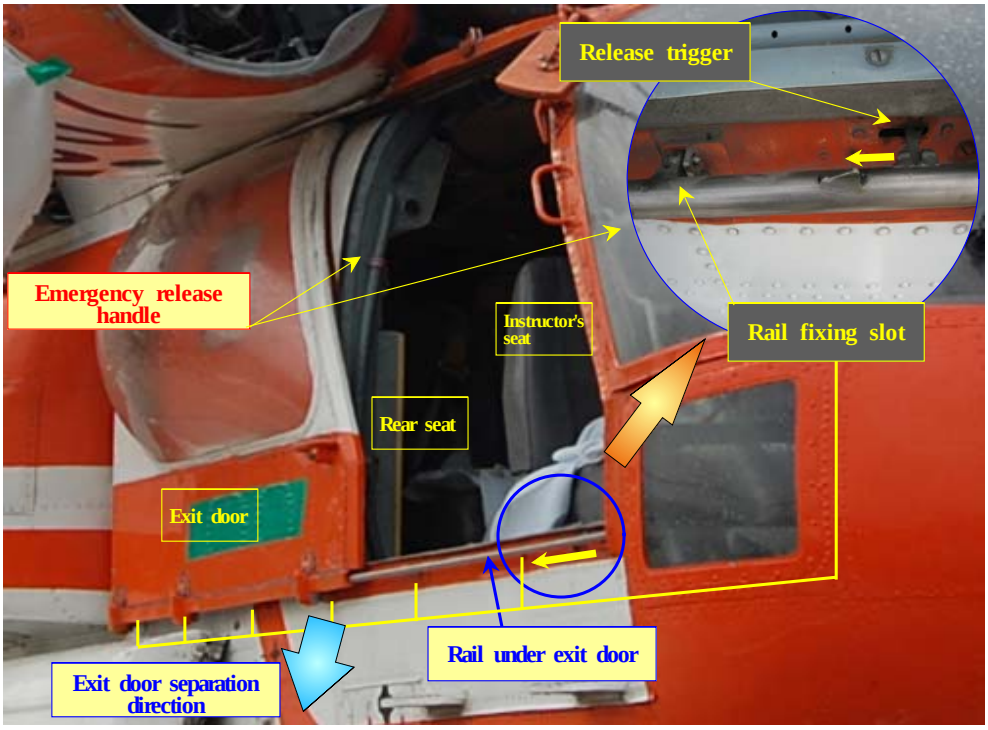
70) A metal line with a diameter of 0.5 mm; it has the same specification as the one tied to the emergency release handle of HL9413.
71) Allowable reference value specified in the Manual: 20 kg or less



[Photo 12] Rail under exit door and exit door separation direction

Therefore, in order to ensure safe escape and survival of pilots at crash on water, it is necessary that all pilots must receive underwater emergency escape training and carry specified emergency equipments or furnish them on board, and they are fully familiarized with the emergency escape procedures by practicing the exit door emergency release by type of aircraft.

2.5.2 Emergency Locator Transmitter

The ELT mounted on HL9413 is designed to activate when the combination of the time and G value presented in Fig. 1 is located in the dark-colored part of the graph. When the ELT is activated, the transmitted radio signal is to be received by the Coast Guard situation room through satellite, but on the day of accident the Coast Guard received no signals.

So the ARAIB tried to find the causes why the ELT signals was not received by

the Coast Guard and estimated that the distress signals were not transmitted by multiple causes of:

A. The main rotor blades cut the ELT antenna. If the antenna was cut, it becomes impossible to transmit the radio signals generated from the ELT.

B. Immediately after crash, HL9413 sank under the water. The ELT mounted on HL9413 is not waterproof, so if water penetrates into the ELT after crash, it's function stops and radio wave is not transmitted under water.

C. Since the maximum G value at the time of crash was 2.06G, which is equivalent to the critical point, the combination with the time exposed to impact could be out of the activation range.

Due to such results, the opportunity to quickly save lives by realizing the fact that the aircraft crashed and knowing where they were, was lost. Therefore, it is necessary for a fire fightion helicopter to have an automatically separated, if contacted with water, and activating ELT on board in preparation for crash on water.

2.5.3 Ballonets

The ballonets mounted on HL9413 provide buoyancy to the aircraft to stay over water for about five minutes if it expands fully so as to secure escape time for the pilots.

But at the time of HL9413 crash, because the pilots flew with the ballonet selection switch set at the "Load" position, instead of the "Ballonet" or Ballonets Load" position, it was estimated to be difficult to use them.

Of course, even if the HL9413 pilots released the ballonets immediately before crash, the ballonets could expand after the aircraft crashed because of the time factor, and if external air was cut off[72] because of water, the ballonets could not be expanded fully.

72) When the ballonets are expanded, the air sacs are filled 1/3 from the internal nitrogen tank and 2/3

But in the case that flight mission is carried out in a deep lake, if the ballonets were expanded immediately even after the aircraft crashed, it might be prevented that the aircraft sinks deep, so it would be helpful for pilots to escape.

Therefore, in operating on the water an aircraft equipped with ballonets, it is necessary for the Forest Aviation Headquarters to improve the procedure by requiring the pilots to fly with the ballonet switch set at the "Ballonets" or "Ballonets Load" position so as to improve the possibility of survival of pilots in an emergency.

2.5.4 Other Aspects

It was found that there was the safety belt but not the shoulder harness at the captain's seat. Although there is no evidence that the shoulder harness was a cause that the pilot could not escape, it is an important indispensable element[73] for the improvement of pilot's survival aspect.

The shoulder harness fixes the upper part of the pilot's body to the chair during aircraft crash or external impact so as to prevent lumbar injury that could happen when the pilot's head or upper body are injured by impact on the structures in the cockpit or the upper body is pulled severely.

So the cockpit belt is composed of a safety belt and shoulder harness, and when these two elements are provided the survival possibility increases.

Therefore, the Foreset Aviation Headquarters should keep all cockpit belts of aircraft ready for at all times.

In addition, the HL9413 pilots did not wear the safety gear such as life vest for over-water flight and they were not furnished in a place where they can be immediately

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with external air.

78) Aviation Act Enforcement Regulations Article 126 (Seats of passengers and flight crew members, etc.) and Flight Operation Technical Standards 7,1,21,2 (Seat safety belts and shoulder harness) specify that the cockpit seats of all aircraft should be provided with seat belts and shoulder harnesses.

available. Therefore, the pilots carrying out the mission on water should wear or carry necessary survival gear[74] in preparation for an emergency, and its operating procedures should be prepared for all flight crew members to train.

2.6 Accident Sequence

On the basis of the results of analysis described above, the ARAIB inferred the sequence of the HL9413 accident as follows.

A. HL9413 took off from the Yeongam Office at 10:17:32 to conduct forest fire control training for Student A north of Yeongam Lake, and after Student A was relieved by Student B at 11:02:12, it carried out two pattern flights normally.

B. Student B, after completing the pattern flights, departed the Seonghwa College runway in the 33 direction and approached the crash point on Yeongam Lake at 11:15:44 to contain water. At this time, HL9413 approached at a fast descent speed (4～5 m/s) at a speed less than 50 km/h, being late in applying (lifting) the collective.

C. When Student B descended at a fast speed exceeding the allowable range, the instructor failed to make corrective maneuvers early enough, and eventually Student B failed to adjust the descent speed, and as a result HL9413 fell into settling with power and crashed in Yeongam Lake.

D. Due to impact on crash the lower main rotor blades flapped strongly to cut the tail boom, and the rear exit door of the fuselage fell off, and the pilots reflexively unfastened the cockpit seat belts to escape before the fuselage was stabilized.

E. The main rotor blades were damaged on collision with the water surface, and the fuselage was overturned to left and sank, so the canopy under the captain's seat

74) Survival jacket including a life vest, small portable oxygen respirator and flare.

was pressed on the bottom under water to be damaged. So muddy water rapidly flowed in through the broken canopy and the rear exit door.

F. While the pilots were flustered and panicked in muddy water rapidly flowing in, the instructor or Student A on the rear seat pulled the emergency release handle of the right exit door. But the aircraft was overturned to left and the right exit door wouldn't separate as it was pressed by water pressure, so the pilots failed to escape from the crashed aircraft.

3. Conclusions

3.1 Findings

1. The certificates held by the HL9413 flight crew members met the requirements of the Aviation Act and the Forest Aviation Headquarters Forest Aviation Flight Operation Manual.

2. The flight crew members took a sufficient rest before the flight and no medical and pathological evidence that could have affect this accident was found.

3. The HL9413 aircraft was lawfully registered in accordance with the procedures specified in the Republic of Korea Aviation Act and obtained airworthiness certificate, operation limit designation, noise certificate and radio station permit, and the flight operation was approved.

4. Weather did not affect this accident.

5. Aircraft weight and balance were within the specified limits. No evidence that the aircraft had defects in the control system, power transmission system or engine before the accident, was found.

6. The provisions with regard to training contained in the Forest Aviation Flight Operation Manual of the Forest Aviation Headquarters have ambiguous and unspecific guidelines to make it difficult to expect educational effects and the education and supervision of each Management Office were not satisfactorily managed.

7. The responsibilities for making and executing training plans for pilots as specified in the Forest Aviation Flight Operation Manual of the Forest Aviation Headquarters lie with the Forest Aviation Section Chief, but they were being executed under the responsibility of the Head of the Management Office.

8. Instructor qualifications were specified in the Forest Aviation Flight Operation

Manual of the Forest Aviation Headquarters, but any system for periodically evaluating instructor's training ability or level was not provided.

9. The captain training for Students A and B was conducted by starting with the forest fire control subject, which is the highest in the level of difficulty.

10. Student B flew his total flying time of 426.7 on the KA-32 type on the co-pilot's seat, and he flew on the captain's seat for the first time on the day of accident.

11. Student B flew awkwardly mentioning during flight that he felt inconvenient as the height of the collective was different from that of the co-pilot's seat, and so it is presumed that because of this his distribution of attention was not properly made so that he had illusions about the approach altitude and descent speed while he was approaching the water surface.

12. The Forest Aviation Headquarters have not conducted underwater emergency escape training and survival gear usage training for its pilots before the HL9413 accident, nor made any training plans for this.

13. At the time of the HL9413 accident, the instructor and Students A and B did not wear survival gear nor it was furnished in the aircraft.

14. The HL9413 pilots did not make position reports every 30 minutes as clearly specified in the Communication Manual of the Forest Aviation Headquarters, and the Yeongam Office Communication Room misjudged that "the aircraft may have entered a communication blind area" and did not forward that situation to the related departments, so a lukewarm measure was taken on the communication cut-off situation.

15. HL9413 flew with the shoulder harness of the captain's safety belt was removed.

16. The HL9413 pilots flew with the selection switch of the ballonets, which are buoy devices, set at the "Load" position instead of the "Ballonets" or "Ballonets Load" position, so they were in a condition in which they could not use the ballonets immediately when they crashed on water.

17. It is presumed that the ELT was not activated st the time when HL9413 crashed on the Yeongam Lake.

3.2 Cause

The ARAIB determines the cause of the HL9413 accident as follows:

1. When Student B was approaching the water of Yeongam Lake to contain water he flew at a fast descent speed of 4～5m/s at an forward speed of less than 50 km/h, and was late in applying the collective because he had illusions about the approach and descent speeds over the water, and because of this the aircraft fell into settling with power.

And the contributing factor of this accident is as follows:

1. Despite that Student B flew exceeding the limits of approach and descent speeds specified in the Flight Manual when approaching the water surface, the instructor pilot did not warn about this in advance or make corrective maneuvers.

4. Safety Recommendations

Based on the findings from the accident of the rotorcraft (HL9413/KA-32T) belonging to the Forest Aviation Headquarters that occurred on 23 November 2009 at 11:17, the ARAIB issues safety recommendations as follows:

To the Forest Aviation Headquarters

1. Complement the Manual and Specifications including the followings: (AAR0905-01)

   a. In education and training in which many subjects are integrated like the captain training, conduct it starting with the subject that is low in the level of difficulty.

   b. Make it compulsory that the instructor be alert to contingencies such as student's risky or excessive maneuvers during training flight and make corrective maneuvers if necessary.

   c. Make schemes for evaluating instructor qualifications and standardizing education and training.

   d. Make detailed training guidelines and teaching plans for every subject, etc.

2. Conduct emergency escape training in preparation for crash on water by including it in the required training subjects. (AAR0905-02)

3. Secure equipment necessary for survival of pilots in case of aircraft crash, such as life vest, and educate about how to use it, and complement related specifications so that they must wear or carry when carrying out the flight mission over water. (AAR0905-03)

4. Complement the procedures such that during over-water flight the pilots fly with

the ballonet selection switch set at the "Ballonet" or "Ballonet Load" position to make it possible to use them immediately in an emergency (AAR0905-04)

5. Consider a scheme for improving the ballonnets in such a way that they are automatically expanded when a fire fighting aircraft crashed on water. (AAR0905-05)

6. Devise a scheme for loading or carrying an ELT that is automatically activated for speedy lifesaving when a fire fighting aircraft crashed on water. (AAR0905-06)

7. Check the condition of all cockpit safety belts of all aircraft owned by the Forest Aviation Headquarters so that they are all installed at all times. (AAR0905-07)