국토교통부
Ministry of Land, Infrastructure and Transport

ARAIB/AAR1304

AIRCRAFT ACCIDENT REPORT

CRASH WHILE APPROACHING THE WATER SURFACE
FOREST AVIATION HEADQUARTERS
S-64E, HL9467
IMHA-DAM IN ANDONG-SI, GYEONGSANGBUK-DO
9 MAY 2013

NOVEMBER 2014

AVIATION AND RAILWAY ACCIDENT INVESTIGATION BOARD

This aircraft accident report has been prepared in accordance with the Article 25 of the Aviation and Railway Accident Investigation Act of the Republic of Korea.

According to the provisions of the Article 30 of the Aviation and Railway Accident Investigation Act, 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 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 test shall prevail.

Aircraft Accident Report

Aviation and Railway Accident Investigation Board. ***Crash While Approaching the Water Surface to Rinse a Water Tank, Forest Aviation Headquarters, S64E, HL9467, Imha Dam in Imha-myeon, Andong-si, Gyeongsangbuk-do, 9 May 2013.*** **Aircraft Accident Report ARAIB/AAR-1303. Sejong Special Self-Governing City, 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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Contents

Crash While Approaching the Water Surface to Rinse a Water Tank

- ○ Operator: Forest Aviation Headquarters
- ○ Manufacturer: U.S. Erickson Air-Crane Inc.
- ○ Type: S64E (Rotorcraft)
- ○ Registration Mark: HL9467
- ○ Location: In midstream at Imha-dam in Imha-myeon, Andong-si, Gyeongsangbuk-do
  (N 36°30'30.27", E 128°53'03.59", 156m ASL)
- ○ Date & Time: 9 May 2013, approximately 09:38 (KST[1])

Synopsis

On 9 May 2013, approximately 09:38, a S64E helicopter, HL9467, operated by Forest Aviation Headquarters, crashed in midstream at Imha Dam while approaching the surface of the water to rinse a water tank after forest fire suppression. HL9467 was a government aircraft[2], operated under visual flight rule (VFR). Aboard the aircraft were one captain and one first officer (FO), who sustained fatal injuries, and one aircraft mechanic, who was seriously injured. The aircraft was destroyed by the crash impact.

The Aviation and Railway Accident Investigation Board (ARAIB) determines that the cause of this accident was 「While on approach to the water surface of Lake Imha, the captain ignored the altitude alarm warning, and was mistaken about the altitude due to his failure to properly allocate attention and the "glassy water effect", which caused him to delay increasing power and fail to control the aircraft's sinking momentum, thereby crashing into the water.」 Contributing to

1) Unless otherwise indicated, all times stated in the report are Korean Standard Time (UTC +9).
2) The term "government aircraft" means aircraft owned or leased by the government, provincial government, or the public institutions and operated for the purposes related to one of the following missions: search and rescue in disaster; suppression and prevention of wildfire; rescue and emergency services including transportation of emergency patient; and other necessary service for public welfare and maintaining order.

this accident was 「Pilots exhibited a lack of CRM[3] skills in that the FO failed to call out major flight parameters such as approach altitude and sink rate until the aircraft crashed into the water, thereby failing to help the captain aware of a situation.」

Regarding this accident, the ARAIB addresses safety recommendations to the Civil Aviation Office, Forest Aviation Headquarters, and National Emergency Management Agency and Fire Service Headquarters of local autonomous bodies.

3) Crew Resources Management.

1. Factual Information

1.1 History of Flight

On 9 May 2013, approximately 09:38, a S64E helicopter, HL9467 (hereafter referred to as HL9467), operated by Forest Aviation Headquarters (hereafter referred to as FAH), crashed in midstream at Imha Dam while approaching the surface of the water in Lake Imha to rinse a water tank after forest fire suppression.

HL9467 was a government aircraft, operated under VFR. Aboard the aircraft were one captain and one FO, who sustained fatal injuries, and one aircraft mechanic, who was seriously injured. The aircraft was destroyed by the crash impact.

FAH has allocated HL9467 to Andong Forest Aviation Office (hereafter referred to as the "AFAO") and operated it since its delivery on 15 December 2007. At the time of the accident, the AFAO forward-deployed[4] a KA-32[5] to Yeongdeok to respond in advance[6] to a forest fire outbreak in Yeongdong Region.

On 8 May 2013, approximately 19:00, a forest fire occurred in Saam-ri, Namjeong-myeon, Yeongdeok-gun, Gyeongsangbuk-do, but FAH could not dispatch firefighting helicopters due to impending sunset. About 23:47, the Headquarters directed the AFAO beforehand to dispatch one extra-large helicopter and one large helicopter at the same time as sunrise the next day.

4) Andong Forest Aviation Office and Yangsan Forest Aviation Office (YFAO) have forward-deployed and operated a large helicopter by turns. At the time of the accident, a helicopter operated by Yangsan Forest Aviation Office was forward-deployed.

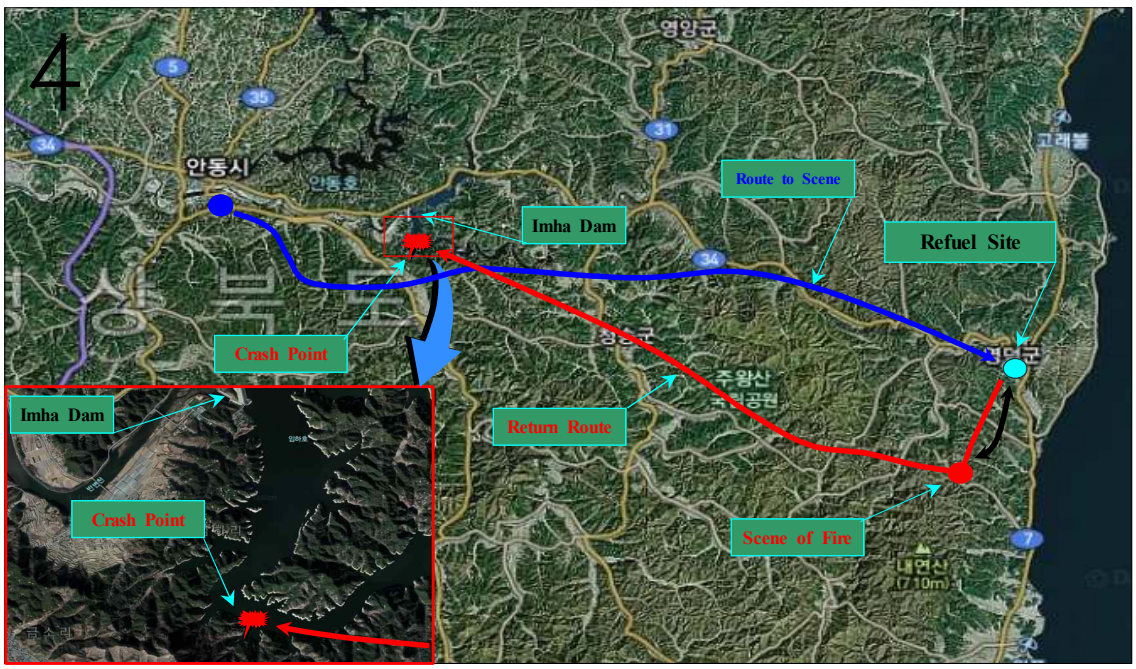
5) HL9429 (KA-32, No. 626).

6) In case of a forest fire outbreak in Yeongdong Region, if helicopters of Forest Aviation Office in Yeongseo Region are deployed, then they will have to go over the Taebaek Mountains to reach the scene, which are meteorological and geographical limits helicopters should be subject to. To overcome these limits, helicopters are forward-deployed and operated.

On the day of the accident, FAH first dispatched HL9429 that had been forward-deployed in Youngdeok to respond to the fire in Saam-ri. About 05:02, HL9429 took off from a temporary ramp in Youngdeok-eup, Youngdeok-gun, and arrived at the scene of the fire about 05:14. The helicopter patrolled the scene and reported to FAH that extra helicopters were needed due to the large size of the fire.

Accordingly, about 05:36, FAH instructed the AFAO and Yangsan Forest Aviation Office (YFAO) to dispatch two helicopters[7] and one helicopter[8], respectively. About 05:41, HL9423 of the AFAO first departed the Office and reached the scene about 06:05.

Subsequently, as shown in [Figure 1], HL9467 departed[9] the AFAO about 06:15, arrived on scene via refuel site about 06:33, then started[10] to suppress the fire.



[Figure 1] Flight Track and Crash Point of HL9467

7) HL9467 (S64E, No. 205), HL9423 (KA-32, No. 618).
8) HL9415 (KA-32, No. 609).
9) The quantity of fuel before takeoff was 1,290 G/A (confirmed by the aircraft mechanic).
10) HL9415 (KA-32, No. 609) that had departed the YFAO arrived on scene at 06:43.

HL9467, which completed the firefighting mission, landed at the refuel site about 07:45 and was refueled[11]. The aircraft reported the situation to FAH by telephone and was instructed to stand by for a moment in case of a recurrence of the fire. About 08:50, HL9467 was instructed to "check if any residual fire remained, then return to base" and took off from the refuel site about 09:01.

HL9467 patrolled the scene of the fire to check if any residual fire remained and dumped water once over the smoking area about 09:20. The aircraft confirmed that the fire was fully contained and departed the scene to return to the AFAO about 09:25.

The AFAO found that the flight track of HL9467 returning to the AFAO stopped[12] over Imha Dam about 09:38, and tried to communicate with HL9467 from 09:42 to 09:58, followed by no response.

According to the statement of HL9467's aircraft mechanic, the captain, the FO, and he took the left, right, and back seat, respectively, and during return to base, the captain said, "Let's rinse a water tank", and while HL9467 was approaching Lake Imha to draw water, the accident occurred.

1.2 Injuries to Persons

Injuries	Crew	Passenger	Others
Fatal	2	0	0
Serious	1	0	0
Total	3	0	0

※ One 119 rescue worker was fatally injured during underwater search operations.

11) Fuel Quantity Supplied: 866G/A (5,845.5 lbs), Total Quantity: 1,350G/A (9,112.5 lbs), ※ 1 gallon = 6.75 lbs.

12) Flight track displayed on the safety information system (SIS) of FAH.

1.3 Damage to Aircraft

As shown in [Figure 2], HL9467 was destroyed by the crash impact, which resulted in tail boom separation and main rotor damage.

HL9467 was insured[13] against hull damage[14], crew injury, and bodily injury and property damage[15], effective at the time of the accident.

[Figure 2] HL9467's Wreckage Recovered after the Crash

1.4 Other Damage

There was no damage other than to the aircraft caused by the crash into the

13) Samsung Fire & Marine Insurance Co., Ltd. and a consortium of 8 companies, Term of Validity: 12 Jul. 2012 - 11 Jul. 2013.
14) USD 15,170,902.
15) 3 Crew Members (KRW 0.3 billion/person), Bodily Injury/Property Damage Coverage.

water surface. A small amount of fuel that had leaked after the crash was immediately eliminated[16] from the scene.

1.5 Personnel Information

1.5.1 The Captain

The captain (male, age 58) had accumulated 8,632.2 total flight hours, including 5,788.1 hours[17] during military service. Since hired by FAH on 1 November 1996, he had accumulated 2,844.1 hours[18].

The captain had accumulated 852.7 hours[19] on the same type aircraft. He had flown 0 hour and 42.7 hours in 24 hours and 90 days, respectively, before the accident flight. He obtained all qualification certificates[20] required for operation.

While working for FAH, the captain completed[21] his type transition training and captain training offered by the manufacturer[22] from 5 October 2001 to 11 November 2001. In accordance with FAH's personnel order[23], he became a qualified captain and performed its duty. Also, in accordance with the Operations Regulation valid at the time, he was appointed as instructor[24] for the same type without separate instructor training and performed its duty.

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16) Absorbent pads were used by Imha Dam Water Resources Management Office.
17) O-1A (1,961 hrs), OH-23 (15 hrs), 500MD (351 hrs), UH-1H (3,461.1 hrs), UH-1H simulation (96 hrs): total 5,884.1 hrs.
18) AS350B-2 (653.1 hrs), B206L-3 (154.5 hrs), ANSAT (29.3 hrs), KA-32 (1,154.5 hrs), S64E (852.7 hrs): total 2,844.1 hrs.
19) PIC: 625.8 hrs, SIC: 42.1 hrs, IP: 174.8 hrs, SP: 10 hrs: total 852.7 hrs.
20) Commercial Pilot: License No. 12-2798 (Issue Date: 13 Sep. 1996), Type Rating: Rotorcraft/SEL (13 Sep. 1996), Rotorcraft/MEL (27 Feb. 2008), Aircraft/SEL·MEL (27 Feb. 2008), KA-32A (27 Feb. 2008), ANSAT (27 Feb. 2008), S64E (27 Feb. 2008), B206 (27 Feb. 2008), AS350 (27 Feb. 2008), HUGHES 500/369D (27 Feb. 2008), Radio Operator License: Registration No. 96-34-1-0079 (Issue Date: 11 Mar. 1996).
21) Manufacturer's "Type Transition Training": 240 hrs (6 weeks).
22) Erickson Air-Crane Inc. in Oregon, US.
23) Related documents could not be examined since the personnel order was issued a long time ago.
24) A person who completed the manufacturer's training and was appointed by the head of FAH.

In accordance with the Aviation Act revised on 8 November 2005, "government aircraft" was subject[25] to the same Act. Therefore, he obtained the type rating of the same aircraft on 5 September 2008 and the pilot training certificate on the basis of flight hours that he had accumulated as instructor at the time.

According to FAH's training record[26], the captain received his proficiency check from the "pilot examiner" on 13 December 2012 and "passed it".

According to the statements of his fellow captains, the captain went to work and left work from 6 to 8 May with no flight duties and after work, practiced playing the piano as a hobby in his official residence[27] for the 72 hours before the accident.

The captain received the airman medical examination[28] in accordance with the provisions of the Aviation Act, Article 31 (Airman Medical Certificate).

1.5.2 The First Officer

The FO (male, age 47) had accumulated 3,103.8 total flight hours, including 2,706 hours[29] during military service and 20.5 hours[30] in Tongil Air. Since hired by FAH on 8 November 2010, he had accumulated 377.3 hours[31].

25) Transitional measures concerning airmen engaged in piloting government aircraft: An airman engaged in piloting or the maintenance of government aircraft shall obtain a type rating pursuant to Article 28 not later than 31 December 2008 and be exempted from test or examination of a type rating pursuant to the provisions of Article 29 (2).
26) Forest Aviation Department-3074 (31 Dec. 2012), Report on Results of 2012 Proficiency Check.
27) 2 Jugong Apt. in Yongsan-dong, Andong-si, Gyeongsangbuk-do, 10 min. from the AFAO by car.
28) Effective Period: 25 Oct. 2012 - 31 Oct. 2013, Issue No.: 122-4077.
29) UH-60P (2,286.1 hrs), OH-23 (30.1 hrs), 500MD (389.8 hrs): total 2,706.4 hrs.
30) S61N (20.5 hrs): total 20.5 hrs.
31) KA-32 (278.6 hrs), S64E (98.7 hrs): total 377.3 hrs.

The FO had accumulated 98.7 hours[32] on the same type aircraft. He had flown 4 hours and 50.6 hours in 24 hours and 90 days, respectively, before the accident flight. He obtained all qualification certificates[33] required for operation.

After hired as FAH's pilot, the FO completed[34] his type transition training offered by the AFAO from 1 August to 9 September 2011. In accordance with FAH's personnel order[35], he became a qualified FO on 25 November 2011.

After that, the FO received his proficiency check[36] from 12 November to 14 December 2012 in accordance with FAH's Operations Regulation, Article 3.1.2.5 and Chapter 4 (Proficiency Check) as well as fire suppression training from 4 to 19 February 2013 in accordance with Article 3.3.3 of the Same Regulation.

According to the statements of his fellow pilots, the FO had a fire prevention patrol flight on 6 May (1.3 hours), performed photographing duty on 8 May (4 hours), and after work, took a walk near his official residence and took a rest without doing special activities for the 72 hours before the accident.

The FO received the airman medical examination[37] in accordance with the provisions of the Aviation Act, Article 31 (Airman Medical Certificate).

1.6 Aircraft Information

1.6.1 General

The prototype of HL9467 was CH-54A (Sikorsky) that had retired[38] after the

32) SIC: 83.8 hrs, SP: 14.9 hrs: total 98.7 hrs.
33) Commercial Pilot: License No. 12-007094 (Issue Date: 26 Dec. 2008), Type Rating: Rotorcraft/MEL (26 Dec. 2008), Instrument Flight Certificate (27 Oct. 2011), S64E (20 Oct. 2011), Radio Operator License: Registration No. 06-34-2-0054 (Issue Date: 18 Dec. 2006).
34) Ground Training 36 hrs, Flight Training 20 hrs.
35) Forest Aviation Department-3149, Pilot Qualification Certificate (S-64E, KA-32T, Bell206).
36) KA-32, A person in possession of 2 type ratings and more is evaluated in each type per year.
37) Effective Date: 13 Aug. 2012 - 31 Aug. 2013, Issue No.: 122-3452, with the limitation that he must wear corrective glasses during flight and possess a reserve pair of corrective glasses.

use by US forces. The US Erickson Air-Crane Inc. purchased its type rating from Sikorsky in 1992 and reproduced[39] the aircraft on 15 December 2007. FAH purchased the reproduced aircraft and registered it on 24 December 2007. HL9467 had been operated for 3,125.3 total hours (TSN)[40] before the day of the accident.

HL9467 was equipped with two JFTD12A-4A type turbo-shaft engines manufactured[41] by the US Pratt and Whitney on 17 August 1985, which used Jet A-1 fuel. The total service times of No.1 and No.2 engines are 579.3 hours and 493.4 hours, respectively, before the day of the accident.

HL9467 held a valid aircraft registration certificate[42], airworthiness certificate[43], radio station license[44], and operating limitations specification[45].

General specifications of HL9467 are shown in [Table 1].

Category	Specification	Category	Specification
L/W/H	27/6.6/7.7 m	Fuel Consumption/Hr	3,284 lbs (500 gal)
Max. Takeoff Weight	19,051.2 kg	Water Tank Capacity	10,031 ℓ
Empty Weight	8,585.3 kg	Water Tank Weight	880 kg
Vne/Cruising Speed	207/178 km/h	Snorkel Weight/L	260 kg/9 m
Fuel Capacity	8,876 lbs (1,351 gal)	Endurance/Range	2 hrs 30 min/ 462 km

[Table 1] General Specifications of HL9467

38) The last CH-54A was retired from US forces in 1993.
39) Serial No.: 64050.
40) Time Since New.
41) Serial No.: 673497 (No. 1), 676463 (No. 2).
42) Certificate No.: 2010-177 (Registration Date: 24 Dec. 2007), Registration Mark: HL9467.
43) Certificate No.: AB12055 (Issue Date: 18 Oct. 2012).
44) License No.: 49-2007-10-0000018 (Issue Date: 2 Apr. 2012).
45) Issue No.: ABOL12055 (Issue Date: 18 Oct. 2012).

1.6.2 Aircraft Maintenance

HL9467's most recent 150-hour inspection and 30-hour inspection were carried out from 10 to 21 September 2012 and from 10 to 11 March 2013, respectively. Also, a total of 11 service bulletins (SBs) were performed. Aircraft maintenance was adequately performed in accordance with FAH's maintenance regulations, and the procedures and methods specified in the manufacturer's maintenance manual. Maintenance activities found no anomalies.

The aircraft journey log of HL9467 recorded no aircraft defects before the day of the accident, and the aircraft mechanic stated that there had been no defects found on the preflight inspection and during flight.

1.6.3 Weight and Balance

When HL9467 took off from the AFAO on the day of the accident, it was boarded by two pilots and one aircraft mechanic, equipped with a water tank[46] for fire suppression.

After completing its firefighting mission on scene, HL9467 was filled with 866 gal (5,845.5 lbs)[47] of fuel at the refuel site in Yeongdeok, and while approaching the water surface in Lake Imha to rinse a water tank during return, the accident[48] occurred.

The post-accident wreckage examination revealed that 2,200 lbs, 2,500 lbs, and 2,700 lbs of fuel remained in the forward tank, aft tank, and auxiliary tank, respectively. Based on this fact, weight and balance of HL9467 were determined

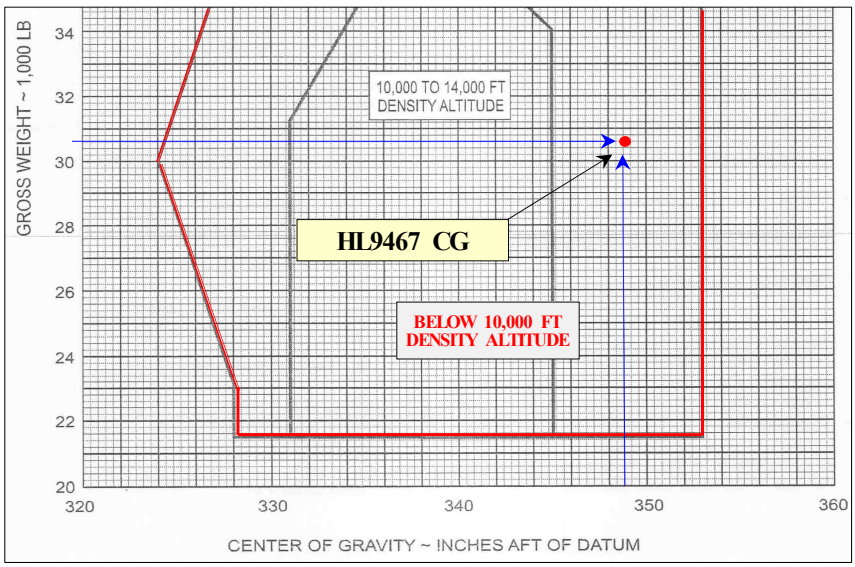
46) W×L×H: 2.2 m×1.8 m×4.9 m, Max. Capacity: 100,031 ℓ, Empty Weight: 880 kg, Snorkel (L/W): 9 m/260 kg.
47) Total Fuel Load: 1,350 gal (9,112.5 lbs).
48) Approximately 37 min of flight.

as follows:

Category		Weight (lbs)	Arm (Inch)	Moment	Remarks
Basic Weight[49]		19,857.0	341.1	6,773,222.7	
Water Tank/P-Snorkel		2748.5	354.2	973,518.7	
Fuel	Forward	2,210	280.8	620,568	
	Rear	2,500	397.3	993,250	
	Auxiliary	2,700	461.3	1,245,510	
Pilots (2)		400	94	37,600	
Mechanic (1)		200	130	26,000	
Gross Weight		30,615.5	348.5	10,669,669.4	

[Table 2] Weight and Balance Table

As shown in [Table 2], the center of gravity (CG) of HL9467 at the time of the accident was determined to be 348.5 inch aft of datum, which was within the aft center of gravity limits (353 inch) based on the "Center of Gravity Limits Chart" specified in HL9467's flight manual[50] as shown in [Table 3].



[Table 3] HL9467's CG Limits and CG Location at the Time of the Accident

49) Basic Empty Weight + Oil.
50) Flight Manual, Part Ⅰ, Section Ⅰ (Operating Limitation), Page 1 - 6.

1.7 Meteorological Information

According to the statement of the aircraft mechanic, the pilots referred to meteorological information given by the operation center of the AFAO, Internet weather data provided by the Korea Aviation Meteorological Agency (KAMA), and visual observations on scene[51], all of which indicated visual meteorological conditions (VMC).

According to the AMOS data provided by KAMA, weather conditions on scene were as follows in [Table 4].

Category	Time	Temp (℃)	WD	WS (m/s)	Humidity (%)	QNH (mb)
Andong	06:00	12.1	SSE	1.1	82	1016.4
	09:30	20.4	WNW	1.4	49	1015.4
Youngdeok	06:30	17	S	2.0	54	1014.6
	09:00	24.1	WSW	1.7	30	1014.1

[Table 4] Weather Conditions on Scene on the Day of the Accident

1.8 Aids to Navigation

HL9467 did not use any aids to navigation for the flight on the day of the accident.

1.9 Communications

Communications equipment on HL9467 did not affect this accident.

51) Wind Calm, Visibility 10 km, Few Clouds.

1.10 Heliport Information

The heliport used by HL9467 did not affect this accident.

1.11 Flight Recorders

The prototype of HL9467 (CH-54) was originally produced in 1968, used as a military plane until 20 January 1992, and reborn as S-64E on 15 December 2007. In accordance with the Enforcement Rule of the Aviation Act, Article 135-2 (Accident Prevention Equipment), the aircraft shall be equipped[52] with the CVR, which, in this case, was CVR-120[53] manufactured by the US Universal Avionics.

At the time of the accident, the CVR submerged into the water. On 9 May 2013, it was collected immediately after the wreckage recovery and sent to the US National Transportation Safety Board (NTSB), which retrieved initial data from the CVR. The ARAIB received the data from the NTSB on 28 May 2013 and made use of it for investigation.

The CVR recorded four channels of data, and their recording time is as follows:

Category		CH #1	CH #2	CH #3	CH #4
Recording Area		CAP Seat	FO Seat	Cockpit Area	Backup
Time	High Quality	30 min	30 min	30 min	
	Standard Quality	2 hrs (including 3 Channels)			2 hrs

[Table 5] CVR Data

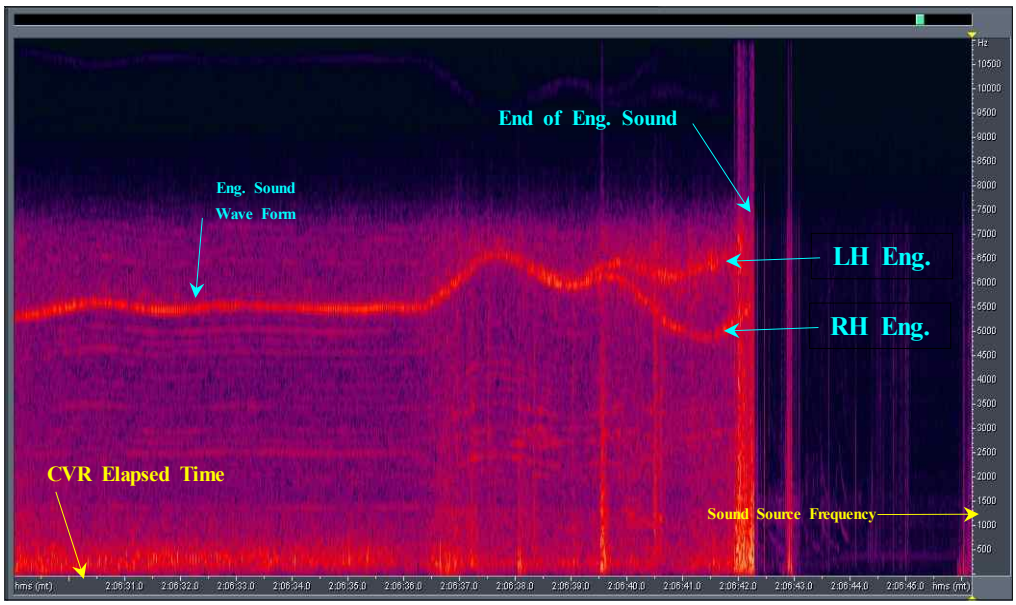
52) Rotorcraft with more than 3,180 kg of MTOW, manufactured after 1 Jan. 1987.
53) P/N: 1603-02-12, S/N: 1752.

The data recorded during the final flight leg (refuel site - crash site) of HL9467 was 30 minutes in length, last 15 minutes of which were transcribed, and their main content is shown in [Table 6].

Time		Speaker	Content	Remarks
KST	Inversed Time			
09:23:31.4	H-15:04	CAP	• Shall we return? We...	On Scene
09:23:34.2	H-15:01.3	No. 618	• Yes, let's return to base.	KA-32
09:23:38.7	H-14:56.7	CAP	• You control. (FO: I have control)	Control Column Transfer
09:37:07.8	H-01:27.6	CAP	• I have control.	Control Column Takeover
09:37:09.7	H-01:26.7	FO	• You have control...	
09:37:09.7	H-01:26.7	CAP	• Let's rinse a water tank.	
09:37:11.1	H-01:24.3	FO	• Go ahead.	
09:37:13.3	H-01:22.1	CAP	• (Humming)	
09:37:24.9	H-01:10.5	CAP	• Hey! Don't hold the column! Don't hold it! (Humming)	
09:38:14.3	H-00:21.1		• Beep!! (Low Altitude Warning)	250 ft (radio-altimeter)
09:38:23.0	H-00:12.4	FO	• (Sound of Sigh)	
09:38:27.8	H-00:07.6		• Beep!! Beep!! (for 0.5 sec)	100 ft Warning (radio-altimeter)
09:38:33.0	H-00:02.4	FO	• Sinking! Sinking!	
09:38:34.1	H-00:01.3	Mechanic	• Ah!! (Sound of Surprise)	
09:38:34.4	H-00:01		• Beep!! (Low Altitude Warning for 2.4 sec)	
09:38:35.4	H		• Bang!! (Engine Sound Separation Starts)	1st Crashing Sound
09:38:36.9	H+00:01.5		• Bang!!	2nd Crashing Sound
09:38:39.3	H+00:03.9		• (Sound of Impacting Water, Sound of Sinking)	Recording Stopped after 3.6 sec

[Table 6] Transcript of Last 15 Min of the Final Flight Leg

Also, the spectrum image of the engine sound recorded during the crash is shown in [Figure 3].



[Figure 3] Spectrum Image of the Engine Sound

1.12 Wreckage and Impact Information

1.12.1 Terrain of the Site

The accident site, Imha Dam, extended into three administrative districts, Andong-si, Cheongsong-gun, and Yeongyang-gun, is an artificial freshwater lake whose construction began in 1984 and finished in December 1993, and whose maximum reservoir capacity is 595 million tons at full water level.

At the time of the accident, approximately a half of the maximum capacity was filled with water with a depth of 150.2 meters[54], a weight of 290 million tons, and a surface area of about 16 km^2. The crash point's river width and average depth were about 350 meters and about 45 - 50 meters, respectively.

54) Depth measuring point, about 2.9 km north of the crash point.

The wreckage was located about 35 meters deep.

Trees of 20 - 30 meters high were under water on scene. Underwater visibility was relatively O.K., but as water currents caused a lot of dust particles to float in water, visibility was reduced to 60 - 80 cm, which resulted in difficulty in wreckage recovery.

1.12.2 Wreckage Distribution

Since the aircraft crashed into the water, a wreckage distribution map could not be developed.

1.12.3 Wreckage Recovery

After the crash of HL9467, the search team confirmed floating debris of the helicopter and a band of oil at the point of flight track disappearance on the "aircraft tracking system". Based on the statement of the survivor (aircraft mechanic), search and wreckage recovery operations immediately began.

Recovery operations were conducted twice, and the recovery procedures are as follows: balloons were used to float underwater wreckage on the water; a tug boat pulled the wreckage to the edge of the water[55]; and a large crane was used to transport the wreckage onto the ground.

The first recovery operation was conducted from 10 to 15 May 2013 when the forward fuselage and 5 main rotor blades were recovered. The second recovery operation was performed from 10 to 12 June 2013 when the tail rotor

55) A point about 3 km from the crash point.

was retrieved.

Yet the tail boom, 1 main rotor blade, 1 tail rotor blade, and the severed snorkel were not recovered. It is determined that they were separated and washed away when the wreckage was pulled to the edge of the water, but search operations by the use of ROV[56] and SONAR[57] were not possible due to a dense forest of trees at the bottom of the reservoir.

1.12.4 Wreckage Examination Result

Wreckage examination revealed that major damage to HL9467 focused on main rotor blades, upper/lower portions of the forward fuselage, tail boom, and engines. The main rotor blades were separated when they struck the surface of the water and the fuselage during crash. The forward fuselage was damaged when it was hit by main rotor blades and a snorkel, and the bottom of the reservoir.

The tail boom was severed at two locations, and the tail rotor was damaged when it hit the surface of the water and the tail boom. All instruments were submerged.

It is determined that most of the damage was caused by the crash into water and the submergence in the water, whereas part of it in the process of wreckage recovery. Details of the damage are as follows:

56) Remotely Operated Vehicle (ROV) is a small undersea vehicle equipped with a camera, manipulators, and a propulsion device, which is remotely controlled by an operator who is not in the vehicle and used for underwater search operations.

57) SOound Navigation And Ranging (SONAR) is a technique that uses sound propagation to detect underwater topography and objects.

1.12.4.1 Forward Fuselage

As shown in [Figure 5], the upper portion of the right pilot seat (red arrow) was damaged when it was hit by the main rotor blades. The left nose (red circle) was crushed and scraped when it was hit by the bottom of the reservoir. The portion below the mechanic seat (yellow arrow) was dented inwards by an external force caused by the snorkel.

[Figure 5] Fuselage Damage

All canopies except for the forward one of the left pilot seat were damaged. The doorframe of the right cockpit door was damaged and dented inwards by impact forces caused by the main rotor. The interior of the damaged forward fuselage was covered with mud and pebbles found at the bottom of the reservoir.

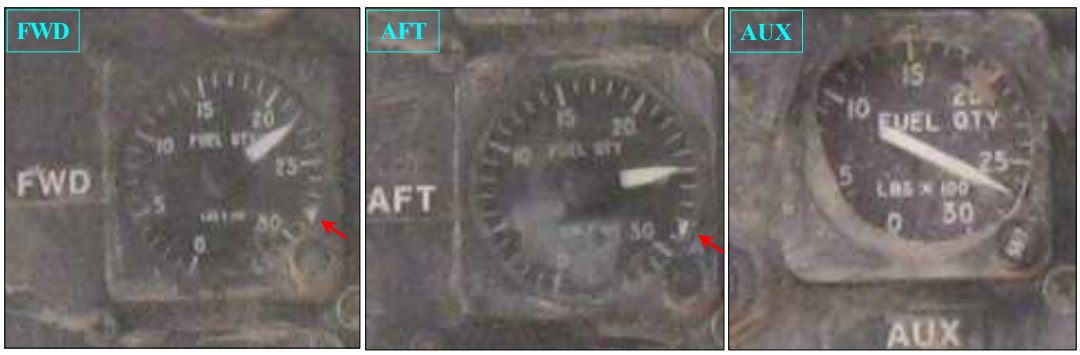
1.12.4.2 Cockpit

As shown in [Figure 6], part of the cockpit instrument panel and the floor was covered with mud, and the right pilot seat's attitude indicator and the both seats' N_2NR indicators were damaged by an external force.

Most of the indications were unreliable, but the fuel quantity indicator indicated the fuel quantity before power disconnection.

[Figure 6] Cockpit Instrument Panel Immediately after the Recovery

The fuel quantity of the fuel quantity indicator was reliable, considering the position of the Burg[58] and the flight time after refueling. As shown in [Figure 7], 2,210 lbs, 2,500 lbs, and 2,700 lbs of fuel remained in the forward tank, aft tank, and auxiliary tank, respectively.



[Figure 7] Position of Burg on Fuel Quantity Indicator (red arrow) and Remaining Fuel

58) A triangular mark in the fuel quantity indicator that can be set by a knob. The aircraft is filled with the quantity of fuel set by the Burg.

As shown in [Figure 8], switches of the forward and rear booster pumps were at the "on" position, whereas the cross feed switch was at the "off" position. The transfer pump switch of the auxiliary tank located at the top left of the instrument panel was at the "off" position.

[Figure 8] Fuel Control Panel Switches and Aux Fuel Pump Switch (arrow)

The decision height set in the radio-altimeter[59] at the right of the instrument panel could not be confirmed since the device was submerged in water after crash. When it was dried and checked for circuit at the lab of Korean Air, then supplied with power, however, the decision height was set at 250 ft. Please refer to [Figure 9].

59) A radio-altimeter measures absolute altitude (distance between the aircraft and the underlying terrain) by using a radio range finder and indicates two categories: absolute altitude and decision altitude. Decision altitude is set by the use of the altitude control knob by a pilot, and when the aircraft's altitude is below the decision altitude during flight, an audible alarm warning is given.

[Figure 9] Decision Height Set in the Radio-Altimeter

1.12.4.3 Tail Boom and Tail Rotor Blades

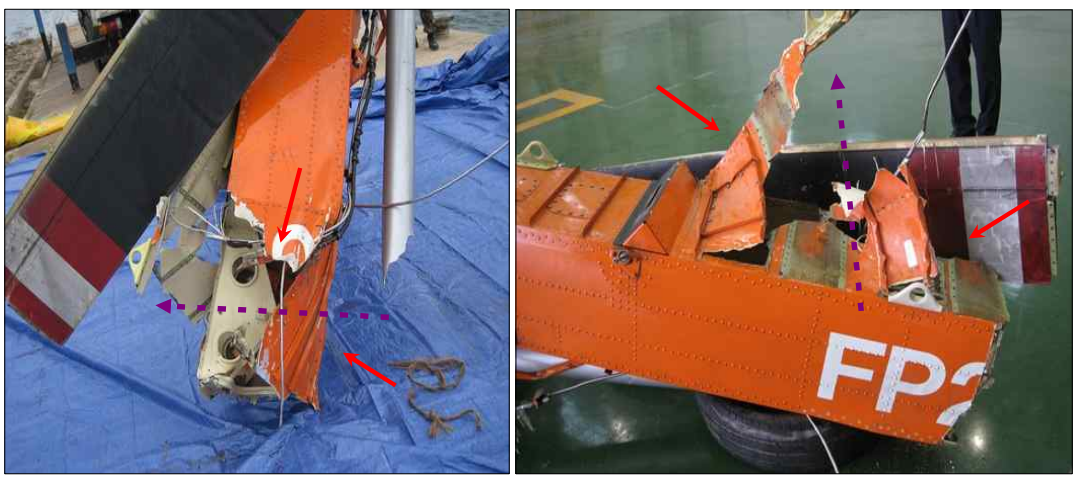
The tail boom was severed at two locations: the point at the junction aft of the auxiliary tank in the forward fuselage (Station 600 inch) was bent from left to right and fractured as shown in [Figure 10]; and the point where the tip of the tail rotor contacted the tail boom (Station 780 inch) was fractured by impact forces caused by the tail rotor blades.

The fracture surface of the forward severed portion displayed no damage by an external force, and the tail rotor driveshaft was also severed at the same location when it was bent from left to right without torsion caused by a rotational force.

[Figure 10] Tail Boom Fractures and Fracture Surface of the Forward Portion

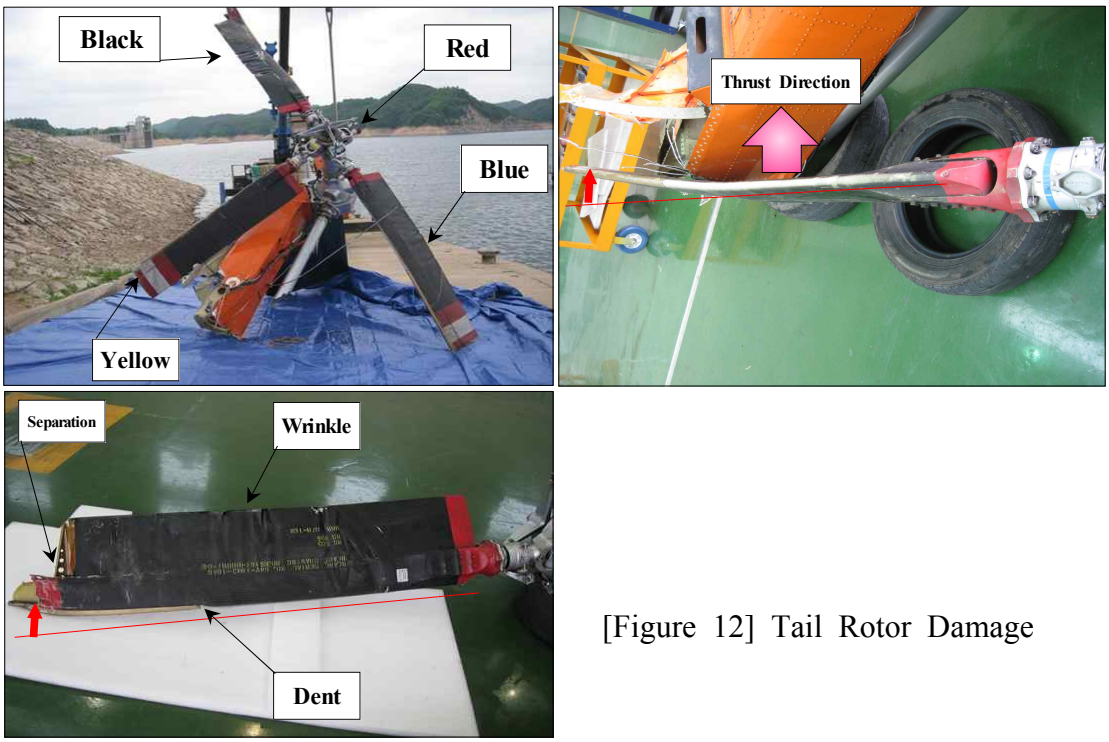
As shown in [Figure 11], the aft portion of the tail boom was severed at the point where it contacted the tip of the tail rotor. As the tail boom was struck by the rotating tail rotor, its metal skin and frame were torn or ripped off in the rotational direction of the tail rotor.

The aft portion of the tail boom driveshaft was not directly struck by the tail rotor, but it was fractured by a strong rotational force caused by the separation of the tail boom.



[Figure 11] Fracture Surface of the Aft Portion of the Tail Boom (red arrow) and Fracture Direction (purple arrow)

As shown in [Figure 12], three of the four tail rotor blades (black, yellow, blue) were bent in the thrust direction and in the opposite direction to the rotation. The tip and the leading edge of the tail rotor blades were separated, scraped, and dented by impact from the tail boom while the trailing edge exhibited wrinkles (red arrow) when it was bent in the opposite direction to the rotation. One tail rotor blade (red) was separated from its feathering hinge.



[Figure 12] Tail Rotor Damage

1.12.4.4 Main Rotor Blades

As shown in [Figure 13], out of the six main rotor blades, five (yellow, blue, red, black, white) were damaged but still attached to the mast after the accident, whereas one (green) was separated from the hub as it was raised upwards.

[Figure 13] Damage to Main Rotor Blades (during recovery)

All main rotor blades were bent upwards (in the direction of lift) by strong flapping or at the hub (yellow, black, white). In addition, their leading edge exhibited dents caused by impact from the fuselage and engines, while the trailing edge was separated or wrinkled.

Main rotor blades were mostly damaged by impact from the surface of the water, and it is determined that dents on the leading edge were caused by impact from the engines and the upper portion of the right pilot seat.

[Figure 13-1] Damage to Main Rotor Blades (upper side)

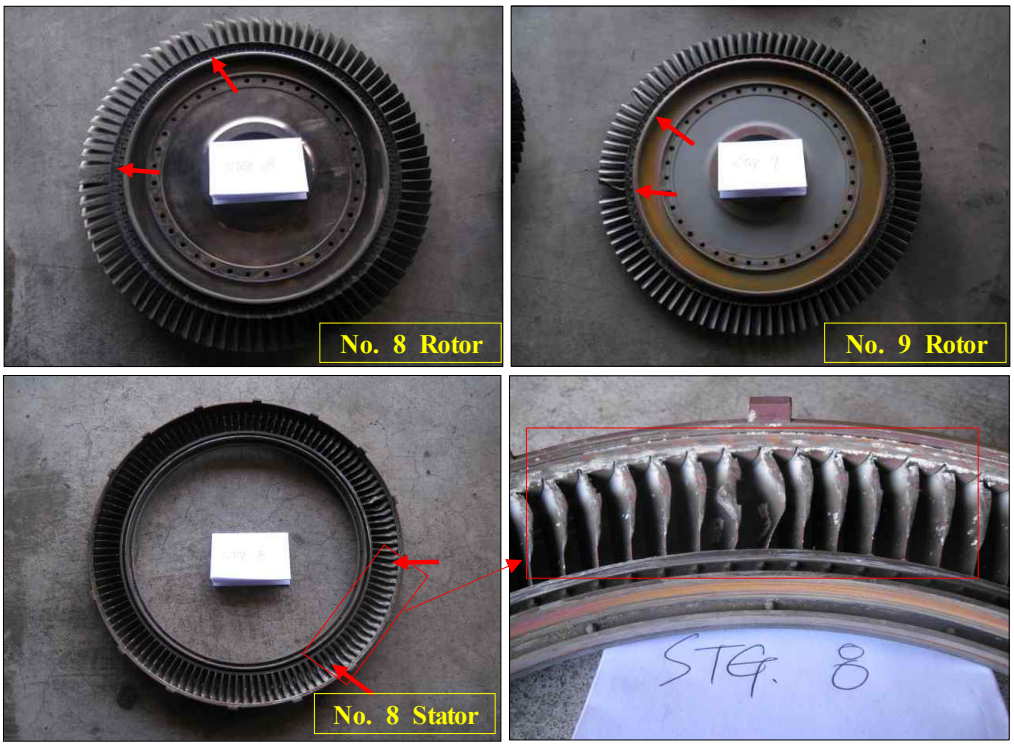
1.12.4.5 Engines

HL9467 was equipped with two engines on top of the fuselage. Post-accident wreckage examination revealed that, as shown in [Figure 14], the LH engine did not exhibit any significant external damage, whereas the right side of the RH engine's air inlet bellmouth (red arrow) was crushed by an external force.

As the engine was fractured both at the flange attachment to the compressor inlet case (blue arrow) and at the attachment to the diffuser case (light blue arrow), 8th and 9th stages of the compressor blades were exposed, and the whole RH engine was twisted to the left. Further, 8th and 9th stages of the compressor blades were damaged as shown in [Figure 14-1].

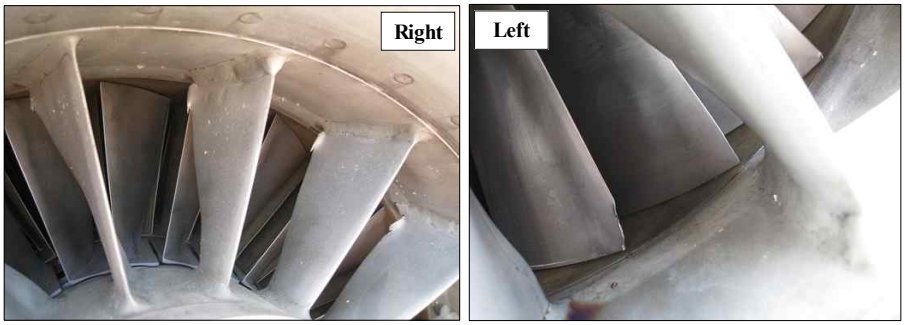
60) Counterclockwise rotation in order of green, yellow, blue, red, black, and white.

[Figure 14] External Damage of RH Engine



[Figure 14-1] Damage to 8th and 9th Stages of the Compressor Rotor and Stator

As shown in [Figure 15], the compressor inlet sustained damage as evidenced by the fact that the tip of the compressor blades was bent when the 1st stage of the compressor blades rubbed against the case.



[Figure 15] Damage to Guide Vanes and Compressor Rotor

1.13 Medical and Pathological Information

Any of the pilots' medical and pathological evidence, including ethanol, drugs, fatigue, or stress, that could have affected this accident was not found.

1.14 Fire

There was no fire after the crash of HL9467.

1.15 Survival Aspects

1.15.1 General

Aboard the aircraft were three crew members, and the captain, the FO, and the aircraft mechanic took the right, left, and back seat, respectively. The captain and the FO were fatally injured, while the mechanic sustained serious injuries, and one 119 rescue worker[61] was also fatally injured during underwater search operations.

61) A diver (male, fire sergeant) affiliated with Youngju 119 Rescue Service was missing at 18:20, and his body was found underwater at 18:54.

At the time of the accident, water temperature was 5℃. The captain and the FO were found at the spot 25 meters and 29 meters from the crash point to the land, respectively, with the depth of about 17 meters.

An autopsy was not performed on the bodies of the crew members and the 119 rescue worker, so the exact cause of the death was not determined. Yet the medical doctor in charge of the emergency room in Andong Hospital, who conducted a postmortem examination on them, determined that the captain and the FO had been "drowned to death", and that the 119 rescue worker had been fatally injured by the "causes other than drowning[62)]".

A total of three seats on HL9467 were equipped with 4-point seat belts, and post-accident on-scene investigation confirmed no functional[63)] defects in the belts.

1.15.2 Emergency Response

Approximately 09:38 on the day of the accident, FAH found that the flight track of HL9467 stopped on the "Safety Information System" and dispatched its aircraft[64)] to the final point of flight track for aerial searching. Approximately 10:12, the search aircraft found floating debris and a band of oil near the point and thus, notified the occurrence of the accident to related agencies approximately 10:29.

Apart from this, upon the receipt of the accident notification by the AFAO about 10:35, Gyeongbuk 119 All-Source Situation Room directed Andong 119 Rescue Service to respond to the accident. About 10:58, the command center

62) The airway and lungs of the rescue worker were free of water.
63) Locking and release of buckles, strength of fasteners, tension of belts and their state, and inertia lock.
64) KA-32A (FPA No. 618).

and the rescue unit of Andong 119 Rescue Service first arrived on scene, followed by Gyeongsangbuk-do Fire Service Headquarters' Special Rescue Service, Uiseong and Youngju 119 Rescue Services, and National 119 Rescue Headquarters, which joined[65] the search for the missing pilots and aircraft wreckage.

Immediately after the accident, FAH dispatched a staff member of the "AFAO" to the scene to support emergency response efforts. He was subsequently joined by staff members of "Andong Police Station" and "Southern Regional Office of the Korea Forest Service" to search for the missing pilots and deal with the aftermath.

At the request of the emergency headquarters[66], the "Coast Guard's Special Rescue Unit[67]" arrived on scene about 15:00 to join search and rescue operations. The "Navy's Ship Salvage Unit (SSU)[68]" attended the meeting hosted by the emergency headquarters about 19:00 and was dispatched to recover the aircraft wreckage next day about 06:00.

1.15.3 Search and Rescue

The post-accident search for the missing pilots and wreckage was conducted together by Gyeongbuk 119 Rescue Service, National 119 Rescue Headquarters, and Coast Guard, starting about 11:20 on the day of the accident. As a result, the aircraft was located by a rescue worker of Andong 119 Rescue Service about 11:45, then confirmed[69] by an "underwater camera" of Gyeongbuk Fire

65) A total of 69 rescue workers (Andong 119 Rescue Service: 35, Gyeongsangbuk-do Fire Service Headquarters' Special Rescue Service: 17, National 119 Rescue Headquarters: 17), 2 rotorcraft, 1 rescue boat, etc.
66) An organization temporarily established on scene to search for missing pilots and recover aircraft wreckage. The head of the headquarters is Deputy Minister of the Korea Forest Service.
67) 20 rescue workers.
68) 24 sea-rescue workers, 2 rescue boats, a float for wreckage recovery, etc.
69) Forward fuselage with the tail boom separated, and tail rotor.

Service Headquarters' Special Rescue Service and marked by a buoy. The bodies of the captain and the FO were found[70] about 17:30 on 11 May and about 12:30 on 12 May, respectively.

Immediately after the location, the bodies of the pilots were recovered by 119 Rescue Service and transported to Yuri Oriental Medicine Hospital in Andong-si, Gyeongsangbuk-do.

The wreckage was recovered by the "Navy's SSU" in the first- and second-phase operations[71], but the separated tail boom[72] and snorkel could not be searched and collected due to obstacles including underwater trees in the submerged area.

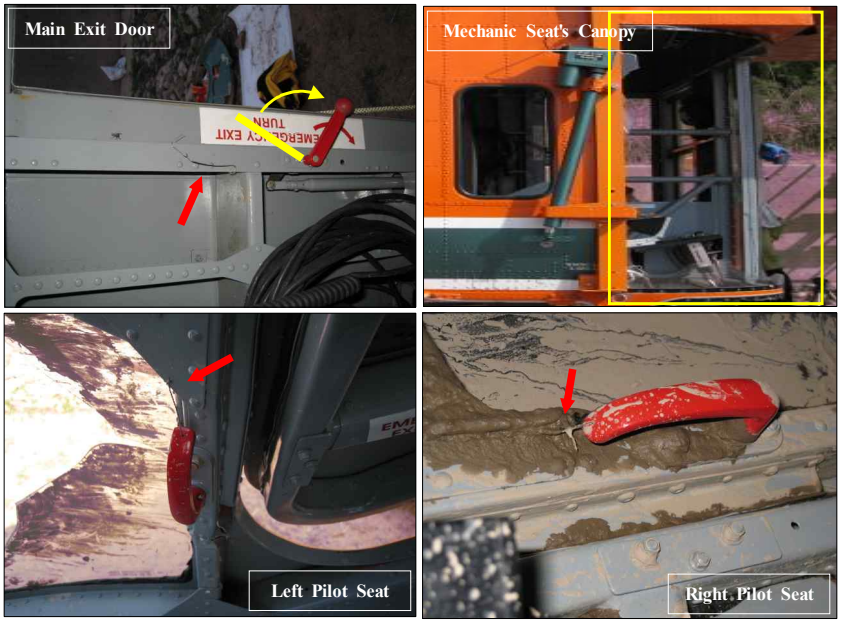
After on-scene examination, the main rotor was removed from the fuselage for land transport, and the forward fuselage was cut off aft of the cockpit (STA 170 inch) and transported[73] to the ARAIB's analysis lab.

1.15.4 Emergency Exit Door

The crash impact damaged the left and right exit doors, the forward portion of the right pilot seat, and the canopy of the mechanic seat; separated the main exit door of the cockpit; and severed the safety wire installed on the emergency release handle of the main exit door.

As shown in [Figure 16], however, safety wires installed on the emergency release handles of the left and right emergency exit doors were intact.

70) CAP: 25 m from the helicopter wreckage, 17 m deep, FO: 29 m from the helicopter wreckage, 17 m deep.
71) First-phase (12 May, about 12:53): forward fuselage, Second-phase (11 Jun., about 18:20): tail rotor.
72) Station 600 - 780 inch.
73) 16 May 2013 (Thu).



[Figure 16] Emergency Handles, Safety Wires, and the Mechanic Seat's Canopy

1.15.5 119 Rescue Service's Rescue Activities

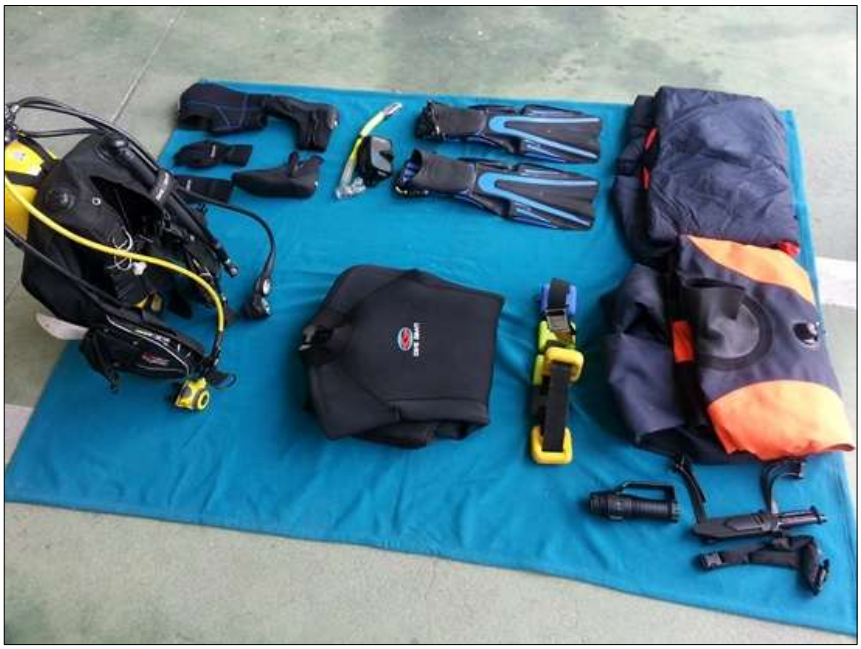
The rescue worker of Youngju 119 Rescue Service who was deployed to search and rescue the missing pilots after the accident was fatally injured during his mission, so rescue workers affiliated with Youngju and Uiseong 119 Rescue Services withdrew from the accident site. The remaining rescue workers from Gyeongbuk Fire Service Headquarters, Coast Guard's Special Rescue Unit, and National 119 Rescue Headquarters together continued to perform rescue operations until the recovery of the missing pilots.

In response to a fatal accident involving the rescue worker, the ARAIB examined[74] the underwater rescue operational readiness of "Gyeongbuk Fire Service Headquarters' Special Rescue Service" and "Youngju 119 Rescue Service". As a result of the examination, the ARAIB concludes that Gyeongbuk Fire Service Headquarters was inadequately prepared[75] for rescuing persons in

74) 10 Apr. 2014, 14:00 - 17:30 (Gyeongbuk Fire Service Headquarters' Special Rescue Service), 11 Apr. 2014, 10:00 - 11:30 (Yeongju 119 Rescue Service).

deep water in case of an accident in the freshwater lakes[76] within its jurisdiction.

Both agencies were equipped with the divers[77] capable of conducting rescue operations in water about 10 meters deep and relatively various underwater rescue equipment[78], without deep-sea diving equipment as shown in [Figure 17]. In addition, the divers were regularly trained, but mainly in shallow waters 10 meters deep, without deep-sea diving training.



[Figure 17] Diving Equipment Owned by Youngju 119 Rescue Service

1.15.6 Emergency Locator Transmitter

The emergency locator transmitter (ELT) mounted[79] on HL9467 is C406NHM

75) Operational environment analysis (underwater terrain analysis, water temperature, water depth, water storage, main obstacles, etc.); staffing of deep-sea divers; securing of the necessary equipment; familiarization with diving limitations such as diving time change according to depth, and consideration of countermeasures; and adequate training.

76) 4 multipurpose dams (Andong/66.5 m, Imha/60 m, Gunwi/37 m, Buhang/46 m), 4 water-storage dams (Youngcheon/31.8 m, Angye/25.9 m, Gampo/31.7 m, Unmun/44.6 m), ※ by maximum reservoir capacity at full water level (source: K-water, Daegu-Gyeongbuk Regional Division).

77) Out of 191 divers (skin-scuba divers), 135 divers were trained and 1 diver completed his deep-sea diving training offered by Korea Underwater Diving Association.

78) Rescue boat, underwater camera, jet ski, SONAR, underwater communications equipment, etc.

manufactured[80] by the US ARTEX in accordance with the operational requirements of the COSPAS/SARSAT system[81]. It operates on the 406.025 Mhz frequency and is installed at body station 123.

On-scene examination revealed that the ELT did not exhibit external damage caused by physical impact, except the signs of waterlogging. At the time of the accident, the ELT's distress signal was not detected by the situation room of the Coast Guard.

1.16 Tests and Research

There were no separate tests or research conducted in the course of the investigation.

1.17 Organizational and Management Information

1.17.1 Follow-up Measures in Response to Safety Recommendations

The ARAIB issued a safety recommendation, "AAR0905-03"[82], to FAH in relation to the rotorcraft accident involving HL9413 operated by FAH in "Lake Youngam," Jeollanam-do on 23 November 2009.

In response to this safety recommendation, FAH entrusted[83] the "ROK Navy's

79) 15 Dec. 2007.
80) Certification No.: 135, Part No.: 453-5061.
81) The COSPAS/SARSAT system is an international satellite system coordinated by the US, Russia, etc. to detect alert transmissions.
82) Secure the equipment like life vests necessary for crew survival in case of aircraft crash; train crew members in how to use the equipment; and enhance related regulations to get crew members to wear or carry the equipment during flight operations.
83) 160 in total, and 98 graduates before the accident.

6th Aviation Group" with underwater escape survival training, which was given to its pilots and aircraft mechanics from 6 January 2010 to 30 September 2012. Also, FAH purchased[84] life vests required additionally and distributed them to each individual.

"FAH's Operations Regulation" valid at the time of the accident was amended to require crew members engaged in fire suppression duties to carry and wear life vests, but failed to provide separate instructions or training on this.

Accordingly, although the flight crew of HL9467 were given life vests, they neither carried nor wore them on the day of the accident. Also, when they reported for flight duty, they failed to be given any comment or check on not wearing their life vests. They thought that they had to wear life vests only during maritime flight. In addition, the captain and the FO failed to complete their underwater escape survival training[85].

1.17.2 Management of Pilot Qualification Certificates

In accordance with FAH's Operations Regulation, Article 3.1 (Certification of Qualification), any person who desires to perform duties as the S-64E captain shall complete his/her captain training, be evaluated by a "pilot examiner" designated by the aviation safety department, then be given a captain's license for S-64E.

Under this Article, the captain training shall consist of 21 hours of ground training[86] and 5 hours of flight training[87], and qualifications required for the

84) 196 life vests required, 35 already in possession, and 161 additionally purchased.
85) FAH has gradually offered underwater escape survival training according to its own training program, but the captain and the FO did not complete the training at the time of the accident.
86) Ground Inspection Procedures and Trial Run Procedures: normal operating procedures (2); emergency procedures (2); operator manual (7); cargo air-transport (2); troubleshooting (3); firefighting procedures (2); knowledge evaluation (1); and 21 hours in total.

instructor pilot are as follows: ① among pilots in possession of the "pilot training certificate", a pilot who accumulated more than 100 total flight hours in the same type aircraft and was appointed by the head of FAH; ② a pilot in possession of the overseas "pilot training certificate", who made a transition to the domestic pilot training certificate and met the requirements under ①; and ③ among pilots who obtained the "pilot training certificate" after completing instructor training[88] on the recommendation of the head of Forest Aviation Office or the forest aviation director and with the approval of the head of FAH, a pilot who met the requirements under ①.

Further, a "pilot examiner" is appointed by the head of FAH on the recommendation of the forest aviation director, among "instructor pilots" who accumulated more than 300 total flight hours in the same type aircraft. Qualifications required for the pilot examiner are as follows: a pilot in possession of the "pilot training certificate" acknowledged by the Minister of Land, Infrastructure and Transport, who has never been subject to not more than a "minor disciplinary action" for less than 1 year and whose expected period of appointment is more than 1 year.

In accordance with FAH's Operations Regulation, Article 3.1.2.5 (Maintenance of Certification), proficiency of the pilots shall be evaluated by a "pilot examiner" of the same type aircraft not less than once a year, and in case of the pilots with not less than two type ratings, it shall be biennially evaluated per type.

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87) Cargo air-transport (1), firefighting procedures (2), emergency procedures (1), flight test (1): and 5 hours in total.

88) **Ground Training Courses:** aviation laws and regulations (10); review of the subject on aerial work pilots (40); firefighting procedures (5); aerial application flight (5); cargo air-transport (5); emergency procedures (5); aviation general knowledge (5); flight instruction methods (12); educational psychology (35); human factors (5); flight safety theory (5); evaluation (3); and 135 hours in total.
Flight Training Courses: preflight inspection procedures and operation procedures (1); normal operating procedures (2); firefighting procedures (2); aerial application flight (2); cargo air-transport (3); nonnormal and emergency procedures (2); night flight (1); instrument flight (1); flight test (1); and 15 hours in total.

The captain, who had obtained the instructor pilot license in accordance with the aforementioned regulations, properly maintained his certification of qualification through the proficiency check by FAH's pilot examiner. Also, the FO, after making transition to the same type rating, obtained his certification of qualification, was evaluated in proficiency, and completed his annual duty training[89] in compliance with the regulations.

1.17.3 Related Regulations on CRM

FAH's Operations Regulation, Article 5.3 (Flight Crew Duty) specified the roles of the captain and the FO except those of the pilot flying (PF) and the pilot monitoring (PM) during flight. It also failed to stipulate specific in-flight CRM procedures for flight crew.

1.18 Additional Information

1.18.1 Statement of the On-board Aircraft Mechanic

Verbal statements were taken from the on-board aircraft mechanic in the patient room[90] in "Andong Hospital" in Andong-si, Gyeongsangbuk-do on 15 May 2013 and by telephone on 15 June 2013.

- ○ He sat on the aircraft mechanic seat aft of the FO seat at the time of the accident.
- ○ During preflight inspection, no defects in the aircraft were found.

- ○ Before reaching Imha Dam during return to base, the captain said, "Let's

89) Subjects: forest fire suppression, cargo air-transport, flight hours: 1 - 2 hours/person.
90) Room #621.

rinse a water tank."

- ○ The aircraft descended to draw water at Lake Imha, and he felt that a speed of descent was faster than other times as the aircraft kept sinking without pause.
- ○ When the aircraft's main landing gear first contacted the surface of the water with a nose-up attitude, he heard engine noise increase, sensed impact vibration, saw the snorkel kink and separate from the aircraft, and felt like riding a roller-coaster.
- ○ The helicopter did not sink into the water immediately after crash. He could not remember where he escaped through.
- ○ After gathering his senses, he found himself out of the aircraft. As he could not swim, he held tight to floating debris (seat cushion) and swam to the closest shore with strokes.
- ○ When he escaped, he identified two pilots, and one of them was swimming to the shore, about 10 meters ahead of him.
- ○ He completed his underwater escape survival training in the ROK Navy's 6th Aviation Group[91] in March 2011.
- ○ He recalled that he was neither instructed to wear or load a life jacket nor called his attention to wearing a life jacket when he reported for duty (During maritime flight, life jackets should be worn and a lifeboat be loaded on the aircraft, but during general firefighting activities, they need not be loaded).
- ○ It is assumed that the captain was on the controls at the time of the accident (there was no communication about the transfer of the flight control between the captain and the FO).
- ○ According to the visual observation, weather conditions on the day of the accident were ceiling and visibility O.K.

91) Republic of Korea Navy, 6th Aviation Group, 609th Squadron, Underwater Escape Survival Battalion (Pohang).

1.18.2 Glassy Water Effect

When the pilots, who attempt to land at or take off from a wide and quite lake or sea with no visual reference points nearby, approach the water at shallow angles, they will have difficulty perceiving exact depth of it because nearby terrain and sky are reflected in the water as shown in [Figure 18], which is called the "glassy water effect."

[Figure 18] Reflection on the Quite Water (Glassy Water)[92)]

If the pilot mistaken about the altitude approaches the surface of the glassy water while performing decelerating and hovering maneuvers at a high altitude, there will be no special danger, but if he performs the same maneuvers at an extremely low altitude, it is likely that the aircraft's tail rotor will first hit the water due to its tail low attitude, and that the pilot will fail to perform decelerating maneuvers, thereby causing the aircraft to crash straight into the water.

92) Source: Erickson Air-Crane.

Accordingly, Erickson Air-Crane's S-64E ATM, 4.3.2 (Pond Snorkel) and 4.3.5 (Sea Snorkel) specified risks of and precautions against snorkel operations under glassy conditions. Also, the company's chief pilot issued the Operations Memo 26[93] to all flight crews and warned them of the risk of fresh water sea snorkel operations under glassy conditions. He recommended that an alternate water source should be used if it is not possible to adequately disrupt the surface of the water with the aircraft rotor wash.

1.18.3 Variation of Submergence Duration by Water Level

Air consumption rates on a dive vary depending on who it is, but a diver typically uses about 20 liters of air in 1 minute of diving at 1 atmospheric pressure (oxygen partial pressure of 0.21 ha). In addition, if a diver uses an oxygen bottle with 2,200 liters of oxygen capacity[94], he can dive for 110 minutes at 1 atmospheric pressure.

As the depth of the water increases by 10 meters on a dive, atmospheric pressure increases by 1. In this regard, a diver uses about twice and three times the amount of air at 10 and 20 meters at 2 (oxygen partial pressure of 0.42 ha) and 3 atmospheric pressure, respectively, and under these conditions, the diver can dive for 55 and 36 minutes, respectively.

On the assumption that the water level in Imha Dam is 30 meters, the diver uses about four times the amount of air since atmospheric pressure increases to 4 (oxygen partial pressure of 0.84 ha), thereby capable of diving for about 27 minutes.

93) Subject: Resumption of Fresh Water Sea Snorkel Operation (29 July 2008).
94) Oxygen capacity of the oxygen bottle used by Youngju 119 Rescue Service at the time of the accident.

Yet actual submergence duration will be more reduced since decompression time[95] required for surfacing should be considered. Decompression time at 30 meters deep is calculated by adding ① 2 minutes required for surfacing to 12 meters and ② about 3 - 5 minutes required for surfacing to about 10 meters, thereby totaling about 7 minutes. As a result, a diver can stay at 30 meters deep for about 20 minutes.

95) Time required for releasing saturated nitrogen absorbed by the body. It takes 1 minute for a diver to surface 9 meters, and within 10 meters deep, 3 - 5 minutes.

2. Analysis

2.1 General

The flight crew of HL9467 held all qualification certificates required for operation, and any of the captain's medical and pathological evidence that could have affected the flight was not found in the course of the investigation.

The HL9467 aircraft was legally certified for aircraft registration, airworthiness, operating limitations, and radio station operation in accordance with the procedures prescribed by the Aviation Act of the Republic of Korea.

The aircraft was operated within the allowable range of weight and balance.

2.2 Meteorological Factors

At the time of the accident, the weather on site was above Visual Meteorological Condition (VMC), so meteorological factors did not affect this accident.

2.3 On-site Investigation and Wreckage Analysis

On-site investigation and wreckage analysis revealed that the tail boom was severed at two locations: the point at the junction aft of the auxiliary tank; and the point where the tip of the tail rotor contacted the tail boom.

The forward severed portion of the tail boom was fractured when it was bent to right. Its aft severed portion was separated when it was struck by an external

force in the rotational direction of the tail rotor.

Considering the fracture patterns above, it is determined that the forward portion of the tail boom was fractured when the tail boom severely yawed to the right due to the tail rotor's strong thrust produced when HL9467's tail rotor hit the surface of the water during the final deceleration, and that the aft portion was fractured when the tail rotor, which was bent to the right by the strong thrust from its impact with the surface of the water, struck the tail boom.

This determination was based on the following as shown in [Figure 19]: ① the LH metal skin at the forward severed portion of the tail boom was fractured when pulled to the right, exhibiting no signs of external force; ② rivets at the attachment were fractured by a strong tensile force, and the metal skin was torn in the right direction (red arrow); ③ the rotorcraft is put into a tail low attitud e[96] when performing deceleration maneuvers during the final approach; and ④ the tail rotor's thrust is in the right direction.

[Figure 19] Forward Severed Portion of the Tail Boom and the Tail Rotor's Thrust Direction

As shown in [Figure 20], it is determined that the aft portion of the tail boom was fractured by impact with the tail rotor on the basis of the following: ① the aft portion was severed at the point contacting the tip of the tail rotor;

96) Nose-high attitude. If a pilot pulled back on the cyclic to reduce speed, the main rotor's plane of rotation will move upwards, whereas the tail boom downwards.

② the aft portion was severed by impact with the tail rotor in its rotational direction; ③ the tail rotor was bent in the thrust direction, and the tip of it contacted the tail boom; and ④ the leading edge of the tail rotor was dented or scraped by impact with the tail boom.

[Figure 20] Aft Severed Portion of the Tail Boom and Tail Rotor Damage

The RH engine and the upper portion of the right pilot seat were damaged when the aft main rotor blades of HL9467 first struck the water and strongly flapped upwards due to the aircraft's tail low attitude, thereby causing the forward main rotor blades over the nose to flap downwards in reaction and hit the RH engine and the upper portion of the right pilot seat.

As shown in [Figure 21], the aforementioned determination is on the basis of the following: ① the RH engine and the upper portion of the right pilot seat were aligned in a horizontal position to the main rotor hub; and ② the RH engine and the upper portion of the right pilot seat were damaged by impact from right to left.

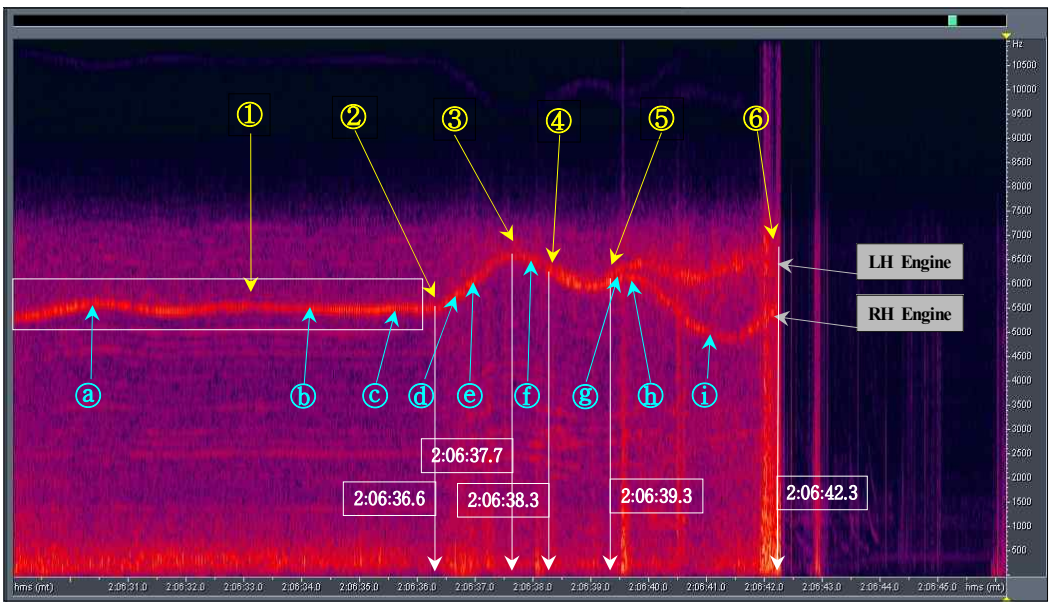
[Figure 21] Damage to RH Engine and Upper Portion of Right Pilot Seat

The main rotor blades were bent or twisted upwards and in the opposite direction to the rotation due to the water's strong resistance caused when the blades impacted it. As a result, the upper side of the main rotor blades were wrinkled, and their trailing edge was bent or separated when it was bent upwards.

In addition, it is determined that two engines' guide vanes and 1st-stage rotor exhibited rubbing marks caused when water flowed into the rotating engine.

2.4 CVR Analysis Result

As shown in [Figure 22], the spectrum image of the engine sound recorded in HL9467's CVR is marked with changes in the engine sound (yellow) at major points and important voice communications (light blue) in chronological order in order to analyze the CVR recording.



[Figure 22] Changes in Engine Sound and Major Voice Communications

According to [Figure 22], an audible alarm warning indicating 100 ft was

generated at 09:38:27.8 (ⓐ) and 09:38:34.0 (ⓑ), and the engine sound within a box "①" exhibited a stable wave form at about 5.5 KHz. Considering this, HL9467's engines were relatively in normal operation without fluctuation in power when the aircraft was passing 100 ft.

At 09:38:33.0 (ⓒ), the FO shouted, "Sinking! Sinking!", and 1 second later at 09:38:34.0 (②), the captain increased power by raising the collective lever to reduce the aircraft's sink rate. At nearly the same time, the aircraft mechanic fel t[97] like the aircraft would crash into water, so yelled "Ah! (ⓓ)", and 0.7 seconds later, the sound of the engine grew fainter (③).

The reason for the lower engine sound is likely that, as HL9467's tail boom and water tank struck the water due to the aircraft's sinking momentum, the pilots, in reaction, leaned forward and instantaneously lowered the collective lever, which thereby lowered the engine sound.

It is determined that the sound of impact recorded at 09:38:35.4 (ⓕ) was generated when the main rotor blades at the back struck the water[98] and strongly flapped upwards due to the aircraft's tail low attitude, thereby causing the forward main rotor blades over the nose to flap downwards in reaction and hit the RH engine and the upper portion of the right pilot seat.

As the forward main rotor blades impacted the RH engine, the sound of it grew fainter a little[99] from 09:38:35.7 (④), and 1 second later at 09:38:36.7 (⑤), started to grow fainter significantly and separated, which indicated that the RH engine maintained a normal sound of the engine in the early stage of the impact with the main rotor blades, but became unfunctional as a balance was

97) Statement of the aircraft mechanic.
98) Before crash, the aircraft impacted the water with a tail low attitude, which resulted from the pilot's maneuvering to reduce a speed of advance and sink rate.
99) The wave form of the engine sound got thicker.

disrupted when the parts of the engine were damaged and separated.

It is determined that the sound of the secondary impact recorded at 09:38:36.9 (ⓖ) was generated when HL9467's tail boom was bent to the right (thrust direction) and separated due to the tail rotor effect[100] at a time the tail boom initially impacted the water, and the fuselage that lost the tail rotor's anti-torque function dramatically turned right, thereby generating a centrifugal force, which caused the snorkel to rotate and impact the bottom section of the fuselage.

It is assumed that the captain's sound of sigh recorded at 09:38:37.1 (ⓗ) was caused by the aircraft's strong right-handed centrifugal force due to torque, and that the sound of impacting water recorded at 09:38:38.5 (ⓘ) was generated when the aircraft struck the water while turning over. It is determined that 1.2 seconds later at 09:38:39.7 (⑥), a lot of water that was flowed into the engines' compressor shut down the engines.

The engine sound recorded by the CVR during crash is analyzed in chronological order, as shown in [Table 7].

Time		Content	Engine Sound Analysis
KST	CVR		
09:38:27.8	2:06:30.4	ⓐ **Beep**! (0.5 sec)	※ 100 ft Alarm Warning
09:38:31.6	2:06:34.2	ⓑ **Beep**! (0.5 sec)	① **Consistent Engine Sound**
09:38:33.0	2:06:35.6	ⓒ **Sinking! Sinking**! (FO)	
09:38:34.0	2:06:36.6		② **Engine Sound Increase** (collective up)
09:38:34.1	2:06:36.7	ⓓ **Ah**! (aircraft mechanic)	

100) When the tail rotor that maintains an anti-torque pitch angle during flight strikes the water, its thrust suddenly increases due to the resistance of the water.

Time		Content	Engine Sound Analysis
KST	CVR		
09:38:34.4	2:06:37.0	ⓔ **Beep**! (2.4 sec)	
09:38:35.1	2:06:37.7	※ Tail Boom's Impact with the	③ **Engine Sound Decrease** (collective down)
09:38:35.4	2:06:38.0	ⓕ **Bang**! (initial impact: main rotor blades' impact with the engine)	
09:38:35.7	2:06:38.3		④ **RH Engine Sound Decrease** (sign of abnormality)
09:38:36.7	2:06:39.3		⑤ **Engine Sound Separation** (RH engine's loss of function)
09:38:36.9	2:06:39.5	ⓖ **Bang**! (secondary impact: snorkel's impact with fuselage/fuselage rotation)	
09:38:37.1	2:06:39.7	ⓗ **Ah**! (Captain)	
09:38:38.5	2:06:41.1	ⓘ **Sound of Impact with Water** (fuselage rollover)	
09:38:39.7	2:06:42.3		⑥ **Termination of the Engine Sound** (engine shutdown)

[Table 7] CVR Transcript & Engine Sound Analysis During the Final Leg

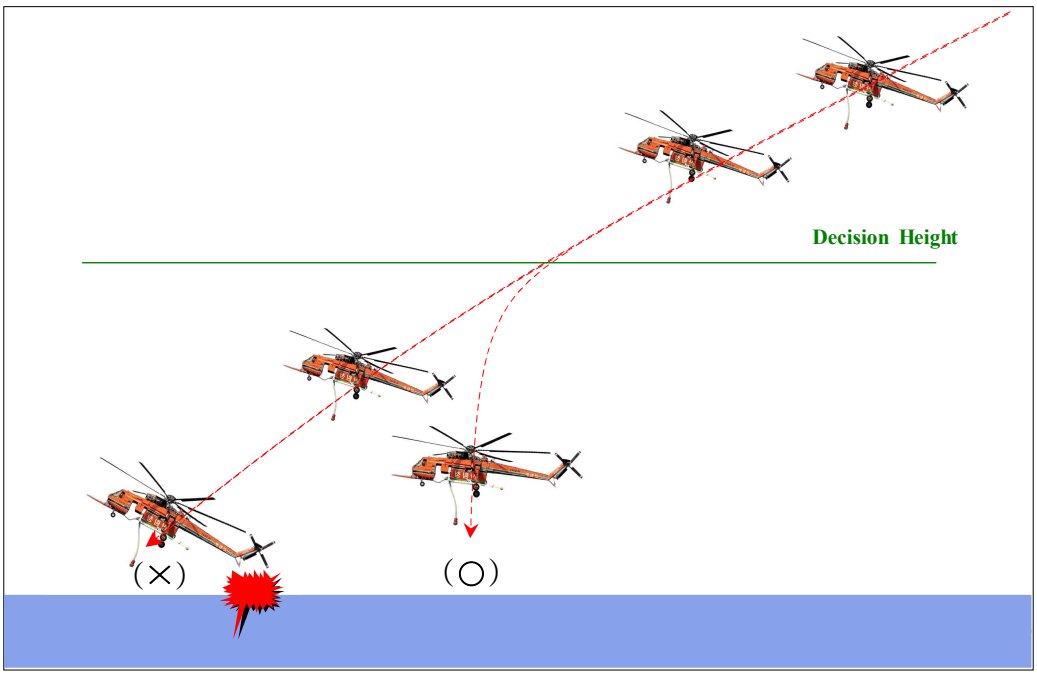
Given the findings above, it is determined that HL9467 was in normal operation before crash into water, that the captain increased power by raising the collective lever when very close to the water, 1.1 seconds before impact with the water while descending at about 667 ft/min[101], and that, he failed to control the aircraft's sinking momentum resulting from a delayed use of the collective, thereby crashing into the water.

2.5 Analysis of the Captain's Flight

According to the S-76E "Rotorcraft Flight Manual[102]", standard approach procedures during the approach and landing phases, as shown in [Figure 23], are

101) Determined on the basis of the fact that it took 20.8 seconds from 250 ft to crash.
102) S-64E RFM PRRT Ⅰ, Section 2 Normal Procedure (Land Procedure).

as follows: there are no limitations until 200 ft AGL, but the pilot should maintain a descent rate of less than 800 ft/min at an altitude of less than 200 ft. According to the statement of the FAH instructor pilot in the same type aircraft, the pilot should perpendicularly descend hovering, with almost no speed of advance, from 200 ft AGL to the ground.



[Figure 23] Normal Approach of S-64

Yet the captain, as evidenced by the analysis of the CVR engine sound, continued to descend at a consistent sink rate until 1.1 seconds before the crash, in that the engine sound did not change until this moment after passing a decision height of 250 ft set on the radio altimeter indicator as well as 100 ft.

On the basis of these findings, the captain is likely to have been mistaken about the altitude between the aircraft and the surface of the water during the final approach phase on the day of the accident. It is determined that this caused him to significantly delay increasing power and thereby fail to control

the aircraft's sinking momentum, resulting in the crash into water.

It is determined that the captain was mistaken about the altitude from the water surface, on the basis of the following: ① at the time of the accident, the weather condition at Imha Dam was ceiling and visibility O.K. with a calm wind, resulting in a quite lake; ② a wide and quite lake with no visual reference points are likely to produce the "glassy water effect" of making the pilots mistaken about the altitude because nearby terrain and sky are reflected in the water; ③ it is highly unlikely that the captain's poor maneuvering skills caused the accident, considering his flight experience; and ④ the general pilots apply power in advance according to deceleration, with a good margin for time and altitude during the final approach phase.

Yet the captain did not respond to a 250 ft altitude alarm warning from the radio altimeter during the approach to the water, nor did he respond immediately to a 100 ft altitude alarm warning by increasing power[103]. In addition, he increased the engine power 1 second after the FO shouted, "Sinking! Sinking!".

Also, the flight manual[104] specified that the auxiliary pump switch should be "on" before takeoff, but the flight crew of HL9467 failed to comply with this procedure.

On the basis of these findings, they seemed to have a tendency to make poor use of the check list or not to perform an instrument cross-check during flight. Further, the captain likely had a tendency to fly based only on his own judgement because he did not check or ignored the altitude on the radio altimeter despite its alarm warning.

103) He raised the collective lever 5.2 seconds after a 100 ft altitude alarm warning and increased power.
104) S-64E Operator's Manual, Check List for S-64E (Before Take-off Check) 6. Fuel Quantity - Check (Aux Pump On).

It is assumed that there was an inadequate CRM within the cockpit based on the following: ① the captain stopped the FO from assuming the flight control, saying "Don't hold the column! Don't hold it!" when the FO felt something wrong[105] and tried to perform correction maneuvers during the approach to water to rinse a water tank after the transfer of the control to the captain; ② under these circumstances, the FO failed to give any advice[106] until he felt danger[107] when the aircraft closely approached the water and shouted "Sinking! Sinking!"; and ③ given that the FO received his type transition training for the same type from the captain (instructor), he likely felt uncomfortable with the captain who was his training instructor as well as senior, and the captain likely failed to willingly accept the FO's advice.

2.6 FAH's Response to Safety Recommendations

According to the statement of the aircraft mechanic, he held tight to the floating debris and swam to the shore as he could not swim at the time of the accident. At that time, he saw the captain and the FO swimming to the shore, about 10 meters ahead of him.

A little later, however, they disappeared from his view and 2 - 3 days later, rescue workers found them dead underwater between the crash point and the shore.

The captain and the FO likely rapidly ran out of physical strength due to cold water temperature in that they failed to swim to the shore and were drowned, but the aircraft mechanic succeeded, depending on the floating debris.

105) Assumption based on the circumstances at the time.
106) Actions like making callouts about the current altitude or approach speed or checking instruments to make the captain aware of indications.
107) Assumption based on the fact that he hurriedly shouted "Sinking! Sinking!" 2.1 seconds before the impact with the water.

If the captain and the FO had worn their life vests, they would have made it safe to the shore. Yet they neither wore them nor made use of the floating debris, so ran out of physical strength while swimming to the shore and were drowned to death.

In the accident investigation report on HL9413, the ARAIB recommended FAH to offer underwater escape survival training to its crew members boarding firefighting helicopters, require them to carry or wear life vests during each mission, and to enhance related regulations. Later, FAH responded to the ARAIB through its document[108] saying that the agency had implemented the recommendations.

FAH offered underwater escape survival training[109] to some crew members[110], and purchased[111] and distributed life vests to each individual. Although the Headquarters amended related regulations to require crew members to wear life vests during their firefighting mission before the accident, however, it failed to instruct, train, and supervise them separately concerning this.

As a result, the flight crew and the aircraft mechanic of HL9467, although they were given their life vests, failed to wear them during their firefighting mission, and thus, the captain and the FO lost their opportunity to survive at the time of the accident.

108) Aviation Safety Department-95 (26 Jan. 2012), Notification of follow-up measures in response to the safety recommendations issued as a result of the investigation into the KA-32 accident.
109) The aircraft mechanic, except the captain and the FO, was given the training (the FO completed the training during military service).
110) The training was given to 27 out of 160 crew members eligible for training (including the aircraft mechanic, and excluding the captain and the FO).
111) Existing 35 life vests, and newly purchased 161, totalling 196 (distributed to all the flight crew and aircraft mechanics).

2.7 Pilot Training

As described in the Analysis of the Captain's Flight, the captain failed to recognize the actual altitude between the aircraft and the surface of the water due to the "glassy water effect" during the approach to the water, and continued to descend, thereby crashing into the water.

The risk of the "glassy water effect" was emphasized in the Operations Memo 26 issued by the manufacturer's chief pilot, ATM 4.3.2, and 4.3.5, but FAH has never emphasized or informed the flight crew of the risk until the accident.

In addition, the ARAIB determines as follows: the captain had a habit of not using the check list based on the CVR transcript[112] and on the fact he took off with the "auxiliary fuel pump" not in operation; the captain failed to properly allocate his attention due to overreliance on himself in that he ignored the altitude alarm warning and continued to approach; and the flight crew exhibited inadequate CRM skills in that the FO failed to make callouts, including an earlier callout about warning altitude, to ensure a safe flight.

In addition, FAH's Operations Regulation failed to specify the roles of the PF and the PM, let alone offer the related training, which thereby likely affected the pilots' inadequate CRM skills.

Accordingly, it is necessary for FAH to include the risk of the "glassy water effect" and related avoidance procedures in its training curriculum as well as train all the pilots repeatedly on them, and to reinforce regulations to require the PM to make callouts about major flight parameters[113] during each flight in order to raise the PF's awareness as well as train the pilots on the reinforced regulations.

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112) There were no actions determined that he used the check list from engine start to takeoff.

113) Decision height, state of and distance from obstacles, a significant change in attitude and speed, dangerous situation, other safety issues, etc.

In addition, it seems that the captain's unique flight habit had been formed for a long period of time because he had not undergone any regular instructor training or evaluation from FAH's "pilot examiner" or the government's "check airman" since appointed as instructor.

Therefore, it is necessary for FAH to reinforce related regulations to require its instructor pilots to undergo a regular annual evaluation from its own "pilot examiner" or the government's "check airman" in order to standardize their airmanship and to correct their unique flight habits[114]. Also, the Headquarters should improve evaluation procedures to require its pilot examiners to assess the instructor pilots' unique flight habits carefully and keep records of their evaluation results.

2.8 Survival Aspects

Firefighting helicopters should be necessarily operated over water at a low altitude to draw water. Accordingly, accidents involving the crash into water during firefighting frequently occur, mostly in the dry season during winter and spring.

In this season, the water temperature of the inland waters is maintained at about 5℃, so in the event of the crash into water, the pilots, although they can swim well, tend to rapidly run out of their physical strength due to cold water temperature and fail to reach the land, thereby resulting in fatalities.

Consequently, it is necessary for all occupants including the flight crew to wear life vests at all times when helicopters are operated on the sea as well as the inland waters[115]. Yet the Enforcement Rule of the Aviation Act, Appendix

114) Excessive maneuvering, sudden maneuvering, negligence in allocating attention, non-compliance with procedures, no use of the check list, disregard of CRM, etc.

21 (Emergency Equipment, etc. to Be Mounted on the Aircraft) stipulates that the emergency equipment shall be mounted on the aircraft flying on the sea, and thus, all the aircraft owned by State agencies, etc. and aerial work operators are not equipped with the emergency equipment when they fly on the inland waters.

Therefore, related regulations should be reinforced to require all the occupants to wear at least life vests when the helicopters fly on the inland waters.

115) Operated at an altitude or in a way that, in case of emergency, the aircraft cannot reach the ground by using auto-rotation.

3. Conclusions

3.1 Findings

1. The flight crew of HL9467 held all qualification certificates required for operation.

2. The HL9467 aircraft was legally certified for aircraft registration, airworthiness, operating limitations, noise standards, and radio station operation in accordance with the procedures prescribed by the Aviation Act of the Republic of Korea.

3. Any of the flight crew's medical and pathological evidence that could have affected the flight was not found in the course of the investigation.

4. The aircraft was operated within the allowable range of weight and balance.

5. At the time of the accident, the captain, the FO, and the aircraft mechanic took the left, right, and back seat, respectively.

6. At the time of the accident, the weather on site was above Visual Meteorological Condition (VMC), so meteorological factors did not affect this accident.

7. There were no defects found in the airframe and flight control system before and during flight.

8. Damage to the main rotor and the tail rotor, and the separation of the tail boom resulted from the crash into water.

9. The flight crew neither carried nor wore their life vests during the accident flight. Also, when reporting for flight duty, they failed to be given any order to correct this.

10. As a result of the rotorcraft accident involving HL9413 in Lake Youngam on 23 November 2009, the ARAIB recommended to FAH that the Headquarters should "secure the equipment like life vests necessary for crew survival in case of aircraft crash during flight operations over water; train crew members in how to use the equipment; and reinforce related regulations to require crew members to wear or carry the equipment during flight operations." Accordingly, FAH amended the related regulations but failed to offer life vest training to and supervise the crew members.

11. FAH purchased and distributed life vests to its crew members, and entrusted the ROK Navy with underwater escape survival training.

12. The Enforcement Rule of the Aviation Act, Appendix 21 (Emergency Equipment, etc. to Be Mounted on the Aircraft) stipulates that the emergency equipment shall be mounted on the aircraft flying on the sea, falling short of regulating the aircraft conducting its mission on the inland waters.

13. The captain increased power to reduce a sink rate at 09:38:34.0, and the aircraft initially crashed into the surface of the water 1.1 seconds later at 09:38:35.1.

14. While on approach to the water surface of Lake Imha, the captain was likely mistaken about the altitude due to the "glassy water effect", which caused him to delay increasing power and fail to control the aircraft's sinking momentum, thereby crashing into the water.

15. Pilots exhibited inadequate CRM skills in that the FO failed to make callouts about altitude, sink rate, airspeed, etc. or give any other advice to help the captain aware of a situation until the crash into water.

16. FAH's Operations Regulation failed to specify the roles of the PF and the PM as well as CRM procedures during both flight preparation and flight, let alone offer the related training.

17. HL9467's decision height set on the radio altimeter was 250 ft, and according to the "CVR" transcript, the altitude alarm warning sounded at 250 ft and 100 ft, respectively.

18. The captain likely had a habit of not using the "check list" and has a tendency not to "allocate his attention" properly, in that he took off with the "auxiliary fuel pump" not in operation, and ignored the altitude alarm warning during the approach to the water and continued to descend.

19. Immediately after the crash, all the crew members succeeded in escaping the aircraft, but the captain and the FO were drowned between the crash point and the shore while swimming, and the aircraft mechanic came safe to land, using the seat cushion.

20. The risk of the "glassy water effect" has been emphasized in the Operations Memo 26 issued by the manufacturer's chief pilot, and the manufacturer's ATM, but the subject on the "glassy water effect" was neither included in FAH's training curriculum nor taught.

21. After appointed as FAH's instructor in the same type aircraft, the captain received his proficiency check from FAH's "pilot examiner" as well as his annual duty training (forest fire suppression and cargo air-transport).

22. Gyeongbuk Fire Service Headquarters' Special Rescue Service and Andong/Youngju 119 Rescue Service had an inadequate life-saving system (manpower, equipment, training, etc.) for rescuing persons according to the depth of the water in Lake Imha.

23. The rescue worker of Youngju 119 Rescue Service conducting the underwater search for the missing pilots was fatally injured by "the causes other than drowning".

3.2 Causes

The Aviation and Railway Accident Investigation Board determines the cause of the HL9567 accident as follows:

"While on approach to the water surface of Lake Imha, the captain ignored the altitude alarm warning, and was mistaken about the altitude due to his failure to properly allocate attention and the "glassy water effect", which caused him to delay increasing power and fail to control the aircraft's sinking momentum, thereby crashing into the water."

Contributing to this accident was as follows:

"Pilots exhibited a lack of CRM skills in that the FO failed to call out major flight parameters such as approach altitude and sink rate until the aircraft crashed into the water, thereby failing to help the captain aware of a situation."

4. Safety Recommendations

As a result of the investigation of the accident that occurred to HL9467 on 9 May 2013, the Aviation and Railway Accident Investigation Board issues the following safety recommendations.

To the Civil Aviation Office

1. Consider reinforcing related regulations to require all crew members to wear life vests when performing flight operations, including forest fire suppression, on the inland waters (AAR1304-1).

To the Forest Aviation Headquarters

1. Improve your training and evaluation system in order to standardize your pilots' airmanship and correct their wrong flight habits, by conducting research into various training and evaluation methods and applying them (AAR1304-2).

   ○ Consider including "annual recurrent training" in your training program.
   ○ Design subjects and contents of training according to FAH's duty environment and pilots' qualifications.
   ○ Provide annual recurrent training and evaluation for your main type aircraft.
   ○ Require your pilot examiners to specify flight habits of examinees and related corrective measures when keeping records of evaluation results, to manage these records, and to integrate them in future training and

evaluation.

- ○ Include the subject on the glassy water effect (risk, avoidance procedures, etc.) in your training curriculum.
- ○ Improve qualifications of your pilot examiners by requiring them to complete the manufacturer's commissioned instructor training per each type aircraft.

2. Reinforce your current Operations Regulation and training, including the following (AAR1304-3):

- ○ Specify CRM procedures.
- ○ Specify the roles of the PF and the PM during flight.

3. Comply with the safety recommendations (AAR1304-4).

- ○ Require all crew members to wear or carry life vests when performing flight operations on the inland waters.
- ○ Confirm and supervise crew members' wearing and carrying survival equipment when they report for flight duty.

To the National Emergency Management Agency and Fire Service Headquarters of Local Autonomous Bodies

1. Establish a life-saving system for rescuing persons according to the depth of the water in the freshwater lakes within jurisdiction (AAR1304-5).

- ○ Analyze the duty environment by freshwater lake (water depth, underwater obstacles, water temperature, water storage, etc.).

○ Identify rescue missions based on the analysis of the anticipated accidents and disasters.

○ Secure appropriate personnel and equipment and offer training (deep sea diving) based on the identified rescue missions.