AIRCRAFT ACCIDENT REPORT

CRASH WHILE MOVING FOR AIRLIFT OPERATIONS
HONGIK AIR SERVICE CO. LTD.
B214B-1, HL9131
SAMMUN-RI, JANGYU-MYEON, GIMHAE-SI,
GYEONGSANGNAM-DO
OCTOBER 19, 2011

SEPTEMBER 12, 2013

AVIATION AND RAILWAY ACCIDENT INVESTIGATION BOARD
MINISTRY OF LAND, INFRASTRUCTURE AND TRANSPORT

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 text shall prevail.

Aircraft Accident Report

Aviation and Railway Accident Investigation Board. *Crash While Moving for Airlift Operations, Hongik Air Service Co., Ltd., HL9131, B-214B-1, Sammun-ri, Jangyu-myeon, Gimhae-si, Gyeongsangnam-do, October 19, 2011*. Aircraft Accident Report ARAIB/AIR1107. Sejong 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 Moving For Airlift Operations

- ○ Operator: Hongik Air Service Co., Ltd.
- ○ Manufacturer: Bell Helicopter Textron Inc.
- ○ Type: B214B-1 (Rotorcraft)
- ○ Registration Mark: HL9131
- ○ Place: Sammun-ri, Jangyu-myeon, Gimhae-si, Gyeongsangnam-do
  (Latitude: N35°12'11.04", Longitude: E128°46'24.17")
- ○ Date & Time: October 19, 2011, about 14:10 (Korean Standard Time[1])

Synopsis

On October 19, 2011, about 14:10, a B214B-1 helicopter, registered as HL9131, operated by Hongik Air Service Co., Ltd., crashed while moving for airlift operations in Sammun-ri, Jangyu-myeon, Gimhae-si, Gyeongsangnam-do. The HL9131 aircraft was a rotorcraft for aerial work operating under visual flight rules (VFR). Aboard the aircraft were one captain and one co-pilot. Two pilots were seriously injured, and the aircraft was destroyed by the crash impact.

The Aviation and Railway Accident Investigation Board (ARAIB) determines that the probable cause of this accident was 「the sling strap attached to the belly hook got into the tail rotor blade since the captain decelerated more greatly than normal and descended at the same time while flying at approximately 70 kts.」 Contributing to the accident are (1) Hongik Air Service Co., Ltd. provided its pilots with inadequate flight procedures training in airlift operations; and (2) the flight route the captain took on the day of the accident was inadequate since there were many obstacles.

1) Unless otherwise indicated, all times in this report are Korean Standard Time (GMT +9).

As a result of this accident investigation, the ARAIB addresses safety recommendations to the manufacturer (Bell Helicopter Textron), to the Ministry of Land, Infrastructure and Transportation (MOLIT), to the Seoul Regional Aviation Administration, and to Hongik Air Service Co. Ltd.

1. Factual Information

1.1 History of Flight

On October 19, 2011, about 14:50, a B214B-1 helicopter, registered as HL9131 (hereafter referred to as HL9131), operated by Hongik Air Service Co. Ltd. (hereafter referred to as Hongik Air Service), was given a mission to airlift construction materials for the construction of the power-line tower #12 between Gimhae and Noksan.

Hongik Air Service made a contract with Sambu Construction Co., Ltd. under which Hongik Air Service agreed to move construction materials to the construction site of three power-line towers[2] which were a part of 345 kv power-line construction between Gimhae and Noksan. To abide by the contract, Hongik Air Service planned to commence airlifting construction materials beginning October 13.

On October 15, about 08:00, HL9131, operated by two other pilots affiliated with the company, departed Gimpo International Airport, aircraft station, and arrived at Goeje, Gyeongsangnam-do at 10:30 where it conducted airlift operations for hiking trail repair work. On October 16, about 09:00, the aircraft moved from Goeje to Yangsan, Gyeongsangnam-do, then connected high voltage power lines in the morning, and moved to the power line construction site in Gimhae[3] (hereafter referred to as the Gimhae site) in the afternoon.

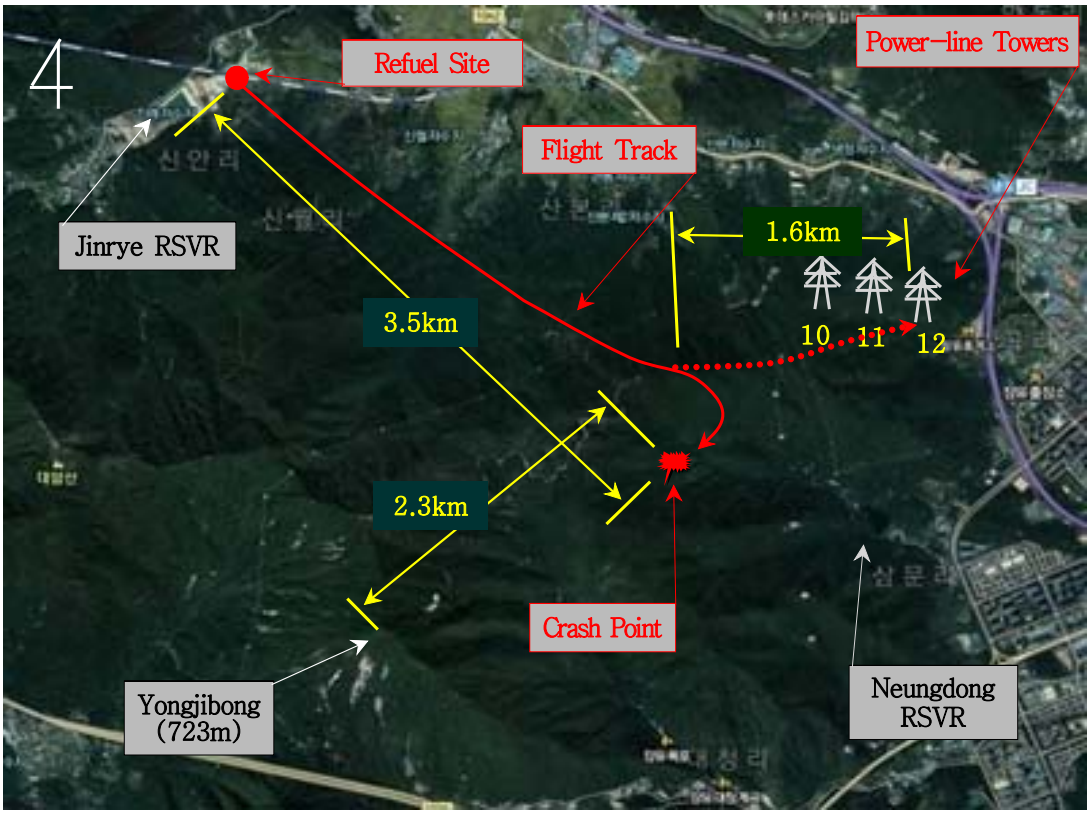
On the same day, the captain and the co-pilot moved from Gimpo International Airport to the Gimhae site on HL9116, the same type as HL9131.

After arriving at the Gimhae site, the captain and the co-pilot operated

2) #10 (N34°17'29", E128°47'10"), #11 (N34°17'20", E128°47'12"), #12 (N34°17'04", E128°47'17").
3) Construction site where the accident occurred.

HL9131 and on October 17, commenced airlifting cargo at the Gimhae site. They moved to Mungyeong on HL9131 in the afternoon on October 18, and on October 19, from 09:00 until 11:30, transported temple facelift materials to Simwonsa in Mungyeong. At 12:20, they departed Mungyeong and arrived at the Gimhae site at 13:10.

On the day of the accident, HL9131's airlift operations at the Gimhae site were planned to commence at 14:00. After completing pre-flight preparation, the captain on the left pilot seat and the co-pilot on the right pilot seat started the engine about 14:00 and took off from a refuel site[4] about 14:05.



[Figure 1] Crash Point and Flight Track of HL9131

As shown in [Figure 1], the captain stated that while flying to the power-line

4) Open area adjacent to the road east of Jinrye reservoir (N35°13'39.91" E128°44´38.02").

tower #12 after departure from the refuel site, he heard a sudden loud "bang" and a sound of rubbing and vibration from the back over the accident site,[5] then the aircraft slowly yawed to the right and experienced vibration at the same time.

Accordingly, after confirming that all instruments were in normal operation except for the illumination of the 90° gearbox warning light, the captain slowly lowered the collective and began descending. At this time, the aircraft's rate of turn increased.

The captain who determined that it would be impossible to return to the refuel site selected the closest area as an emergency landing site[6] and tried to fly there, but failing to reach the site, he attempted to land on an upslope with a lot of trees.

The captain fully pulled the collective when flying on top of the trees, and accordingly, the aircraft's sink rate dropped. He pulled the cyclic to make a level landing, however, the aircraft crashed into the ground in nose down and left bank attitude.

1.2 Injuries to Person

Injuries	Crew	Passengers	Other
Fatal	0	0	0
Serious	2	0	0
Minor/None	0/0	0/0	0/0
Total	2	0	0

5) The captain initially stated that the aircraft was descending at approximately 500 ft/min at an altitude of 1,200 ft MSL or 300 - 400 ft AGL and a speed of 70 kts over the intersection between a red dotted line and a solid line in [Figure 1].

6) Open area in the valley near the crash point.

1.3 Damage to Aircraft

As shown in [Figure 2], HL9131 was destroyed by the crash impact.

The HL9131 aircraft was covered under hull insurance[7] and pilot and passenger accident insurance[8], which were valid[9] at the time of the accident.

[Figure 2] Aircraft at the Crash Point and its Surroundings

1.4 Other Damage

The crash point is a valley slope of about 10 degrees where scrub from 20 - 40 years of age was densely growing, and about 20 trees were broken by the crash impact. Also, as oil and fuel leaked from the aircraft, water in the valley flowing downwards to an orchard was contaminated.

7) 3 billion Korean won (including third party damage).
8) Pilot: 400 million Korean won/person, Passenger: 250 million Korean won/person.
9) Hyundai Marine & Fire Insurance Co., Ltd., Insurance Policy No.: S-2011-0057-895/889/893, Term of Validity: May 20, 2011 - May 19, 2012.

1.5 Personnel Information

1.5.1 The Captain

The captain (male, age 51) has accumulated 6,022.9 total flight hours, including 4,202 hours[10] during military service and 943 hours[11] as Gyeonggi Provincial Fire and Disaster Headquarters pilot. Since hired by Hongik Air Service on August 1, 2008, he had flown 877.9 hours[12], including 875.2 hours[13] in the same type aircraft, before the day of the accident.

Before the accident flight, the captain had flown 4.3 hours and 78.7 hours in 24 hours and 90 days, respectively. He obtained all the qualification certificates[14] necessary for the applicable flight.

After the captain was hired by Hongik Air Service, his type transition training for the same type aircraft was conducted as two categories, new pilot training[15] and captain training[16], in accordance with Hongik Air Service's own type transition training program[17].

He received the aviation physical examination[18] in accordance with the provisions of the Aviation Act, Article 31 (Certification of Aviation Physical Examination), and the result was "suitable"[19].

10) OH-23: 45 hrs, UH-1H: 4,040 hrs, 500MD: 50 hrs, FH-20: 34 hrs, PA32: 33 hrs, total 4,202 hrs.
11) AS-365: 418 hrs, KA-32: 297 hrs, Bell206: 228 hrs, total 943 hrs.
12) B214: 875.2 hrs, BK117: 2.7 hrs, total 877.9 hrs.
13) Captain: 300.7 hrs, F/O: 573 hrs, Trainee Pilot: 1.5 hrs, total 875.2 hrs.
14) Commercial Pilot License: License No. 2929 (Acquisition Date: Jan. 17, 1997), Type Rating: Rotorcraft/Single Engine Land (Jan. 17, 1997), B214 (Dec. 29, 2009), Radio Operator License: Registration No. 923400161 (Issue Date: May 20, 1992).
15) Hongik Air Service Doc 5 (Apr. 16, 2009), Report on the initial type rating training results/ground training for 20 hrs, flight training for 20 hrs.
16) Hongik Air Service Doc (Dec. 4, 2009), Report on the captain training results/ground training for 10 hrs, flight training for 7:25 hrs.
17) Hongik Air Service Doc (Jul. 31, 2008), Report on the new pilot training plan.
18) Term of Validity: Aug. 11, 2011 - Aug. 31, 2012, Issue No.: 122-1319.
19) Limitation: Must wear corrective glasses during qualified duty; possess a reserve pair of corrective glasses.

1.5.2 The co-pilot

The co-pilot (male, age 46) had accumulated 2,556.3 total flight hours, including 2,145.9 hours[20] during military service. Since hired by Hongik Air Service on January 11, 2010, he had flown 410.4 hours[21], including 396.3 hours[22] in the same type aircraft, before the day of the accident.

Before the accident flight, the co-pilot had flown 4.3 hours and 106.5 hours in 24 hours and 90 days, respectively. He obtained all the qualification certificates[23] necessary for the applicable flight.

The co-pilot's type transition training[24] for the same type aircraft was conducted in accordance with Hongik Air Service's own type transition training program from December 1, 2010 until January 19, 2011. He acquired the type rating of the same type aircraft through the in-house personnel order[25].

He received the aviation physical examination[26] in accordance with the provisions of the Aviation Act, Article 31 (Certification of Aviation Physical Examination), and the result was "suitable".

1.6 Aircraft Information

1.6.1 General

20) AH-1: 337.1 hrs, UH-1H: 72.1 hrs, OH-23: 40 hrs, 500MD: 343.2 hrs, UH-1H(simulation): 399.3 hrs, UH-60: 843.7 hrs, total 2,405.8 hrs.
21) B214B-1: 175.8 hrs, KA-32: 462.7 hrs, S-64E: 59.3 hrs, total 697.8 hrs.
22) Captain: 32.6 hrs, F/O: 363.7 hrs, total 396.3 hrs.
23) Commercial Pilot License: License No. 7252 (Acquisition Date: Aug. 28, 2009), Type Rating: Rotorcraft/Single Engine Land (Jun. 22, 2009), H369D (Jul. 30, 2009), B214 (Feb. 1, 2011), Radio Operator License: Registration No. 09-34-4-0010 (Issue Date: Apr, 6, 2009).
24) Ground Training 19 hrs (Dec. 1, 2010 - Jan. 19, 2011), Flight Training 11.5 hrs (Dec. 1, 2010 - Jan. 19, 2011).
25) Hongik Personnel Order No. 2011-02001 (Feb. 1, 2011) B214 Type Transition.
26) Term of Validity: Jul. 13, 2011 - Jul. 31, 2012, Issue No.: 122-1188.

The HL9131 aircraft was manufactured[27] by Bell Helicopter Textron Inc. on July 5, 1970 and registered on August 9, 1996. It had been operated for 10,890.5 total hours (TSN)[28] before the day of the accident.

The aircraft was equipped with one turboshaft engine[29] of T5508D model manufactured by the U.S. Honeywell, and the total service time of the engine before the day of the accident was 2,800.7 total hours (TSO)[30]. The fuel for the aircraft was Jet A-1.

The tail rotor gearbox[31] was installed on June 9, 2004 and had been operated for 2,049.1 hours (TSO)[32].

The HL9131's aircraft's registration certificate[33], airworthiness certificate[34], radio station license[35], and operating limitations specification[36] were all verified valid.

1.6.2 Aircraft Maintenance

Most recently, 25-hour scheduled maintenance and 100-hour/90-day scheduled maintenance were carried out on September 9 and 28, 2011 and August 26, 2011, respectively. From August 30 until October 18, 2011, four parts were replaced[37].

27) Serial No.: S/N28010.
28) Time Since New.
29) Serial No. (Manufacture Date): S/N LE31912 (Sep. 30, 1975), Installation Date: Aug. 4, 2011.
30) Time Since Overhaul, TSN (Time Since New): 8,845.6 hrs.
31) Part No.: 214-040-011-007, Serial No.: AMF00501.
32) Time since Overhaul, TSN (Time Since New): 7,032.0 hrs.
33) Certificate No.: 2008-003 (Registration Date: Jan. 7, 2008), Registration Mark: HL9131.
34) Certificate No.: AS07005 (Issue Date: Jan. 8, 2007).
35) License No.: 46-1996-10-0000046 (Issue Date: Jan. 17, 1997).
36) Designation No.: ASOL07005 (Issue Date: Jan. 8, 2007).
37) ① Aug. 30, 2011: Main Rotor Hub Grip/yoke/T.T Strap Replacement and Main Rotor Vibration Inspection, ② Sep. 1, 2011: Liner Actuator Replacement, ③ Sep. 27, 2011: Elevator Horn Replacement, ④ Oct. 18, 2011: Dual Power Actuator Replacement.

Inspections were conducted in accordance with procedures and methods prescribed by the manufacturer's manual and Hongik Air Service's maintenance regulations, and as a result of the inspections, there were no defects found in HL9131. The replacement of the parts was performed as a normal procedure due to part failure.

1.6.3 Weight and Balance

At the time of the accident, aboard HL9131 were two pilots, and 1,900 lbs of fuel. The aircraft was started at 14:00 and took off from the refuel site at 14:05, and the accident occurred at 14:10, which means that HL9131 flew for approximately 10 minutes. Based on this fact, weight and balance of HL9131 at the time of the accident were determined as follows:

Own Weight ····· 7,655 lbs
Fuel Weight ····· 1,900 lbs
Oil Weight ····· 16 lbs
Pilots (2 persons) ····· 380 lbs

Takeoff Weight ····· 9,951 lbs

The maximum takeoff weight of HL9131 was 12,500 lbs, and the takeoff weight during the last flight before the accident was 9,951 lbs. Considering the fuel consumption of 281 lbs at the time of the crash after 10-minute flight, the aircraft weight right before the crash was determined to be 9,937 lbs. Accordingly, HL9131 had a margin of 2,563 lbs at the time of the accident.

1.7 Meteorological Information

The captain stated that he referred to weather conditions observed by himself with the naked eye at the refuel site before the accident and to weather conditions observed by the aircraft mechanic on the power-line tower #12 with the naked eye about 13:40. The weather conditions observed by them are shown in [Table 1].

Category	Observation Time	Wind Direction /Speed (kn)	Visibility (mi)	Cloud Amount[38] /Ceiling	Temp (℃)	Remarks
Captain	13:30	Ceiling and Visibility O.K. with a Calm Wind and Visibility more than 7 miles				Refuel Site
Aircraft Mechanic	13:40	Ceiling and Visibility O.K. with a Calm Wind and Visibility more than 7 miles				Power-line Tower
Aerodrome Meteorological Office	14:00	070/13	6	SCT/4,000	22/09	Gimhae Airport

※ METAR RKPK 190500Z 07013KT 9999 SCT040 22/09 Q1023 NOSIG=(Gimhae Airport)[39]

[Table 1] Weather Conditions in Gimhae Area at the Time of the Accident

1.8 Aids to Navigation

On the day of the accident, HL9131 did not use aids to navigation for flight.

1.9 Communications

No technical communications problems were reported.

38) Clear (CLR): cloud amount 1/8 and less, Scatter (SCT): cloud amount 1/8 - 4/8, Broken (BKN): cloud amount 5/8 - 7/8, Overcast (OVC): cloud amount 8/8.

39) Flatland 14 km SEE of the accident site. Weather conditions in Gimhae Airport are different from those at the accident site.

1.10 Heliport Information

No problems with the heliport used by HL9131 were reported.

1.11 Flight Recorders

HL9131 was not equipped with flight recorders.

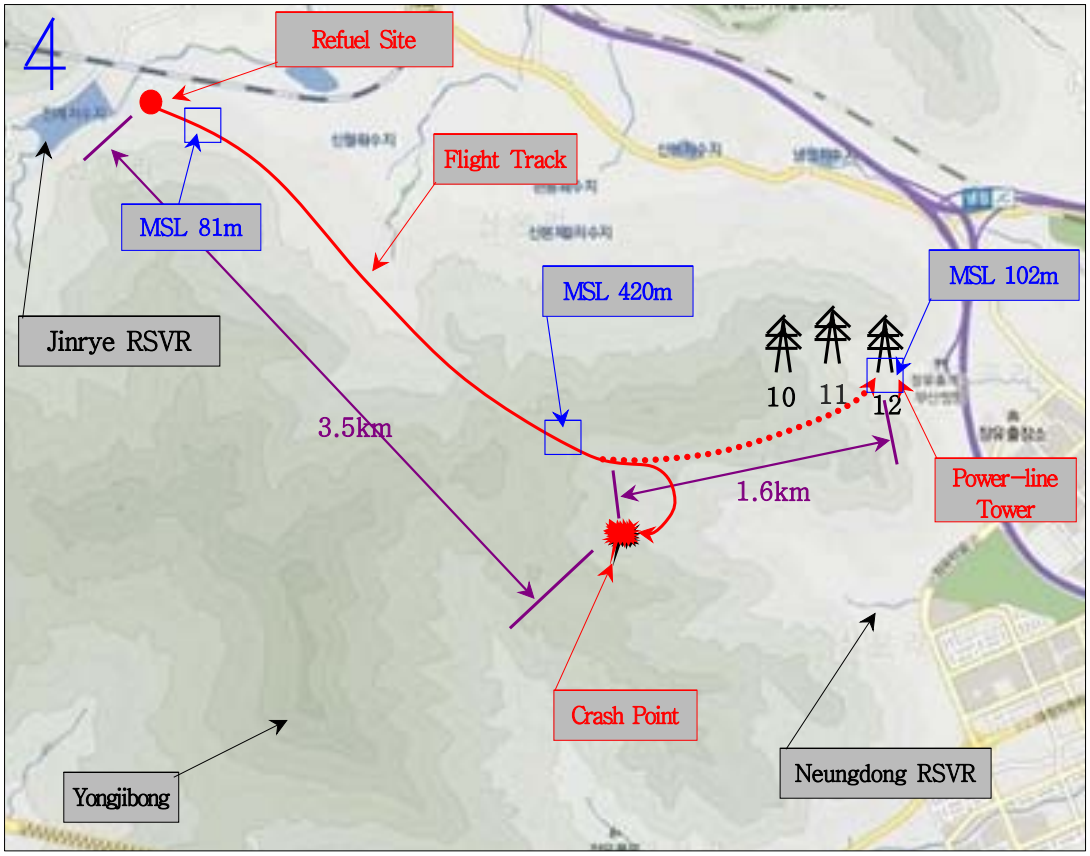
1.12 Wreckage and Impact Information

1.12.1 Terrain of the Accident Site

The accident site is located approximately 2.3 km northeast of Yongjibong, highest mountain peak in the area, as shown in [Figure 3]. Also, it is a valley located in the south and middle of the ridge which is approximately 5 km long and connected to the top of Yongjibong in the east-north-east direction.

The refuel site is located approximately 3.5 km north of Yongjibong. HL9131's flight track between the refuel site and the power-line tower #12 shows that the aircraft departed from the flatland at 81 m MSL and had to fly over the ridge at 420 m MSL to reach the power-line tower #12 at 102 m MSL.

At the crash point, oak trees aged 20 - 40 years and scrub (20 - 40 cm in diameter) were densely growing. On the waterway in the valley were rocks approximately 1 m in diameter. No water flowed on the floor of the valley, but there were some puddles of water which oozed from the floor. The terrain was a slope of about 10 to 40 degrees.



[Figure 3] Periphery of the Crash Point and the Flight Track

1.12.2 Distribution of the Wreckage

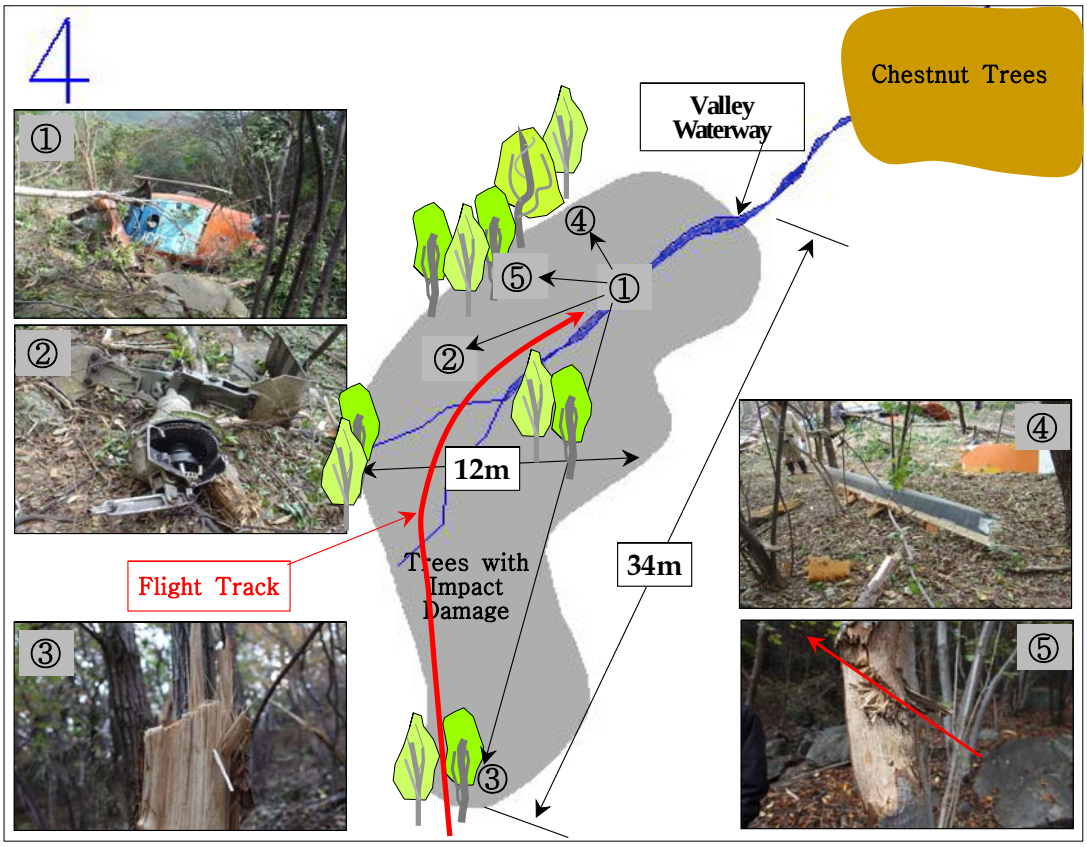
The HL9131 aircraft was found tilted to its left at about 110 degrees on top of the rock. Its tail boom was fractured at the connecting point with the forward fuselage but still attached to the forward fuselage with its upside down. The heading of the forward fuselage was at 160 degrees.

The aircraft wreckage was mainly distributed within a 30-meter radius of the crash point. The main rotor blades sustained fractures at their root when contacting the trees during the crash sequence. The sling strap wrapped around the mast of the fuselage counterclockwise six times.

The damage to the tail boom was predominantly on the left side. The tail rotor 90° gearbox with fractures was separated from the tail boom and found

10.9 m from the main fuselage at a bearing of 270 degrees. The severed portion of the one tail rotor blade was not located despite four rounds of search operations at the accident site[40].

As shown in [Figure 4], the tree 23 cm in diameter in ⑤ sustained impact damage by the main rotor blades, about 1 m from the ground at approximately a 45-degree angle, and around the tree there were about 30 big and small trees severed or fallen by the main rotor blades and tail boom. The wreckage distribution chart of HL9131 is shown in [Figure 4].



No.	Distance	Wreckage Name	No.	Distance	Wreckage Name
①	0 m	Fuselage	④	8.4 m	Main Rotor Blades
②	10.9 m	Tail Rotor Assembly	⑤	7.8 m	Tree with Impact Damage
③	27 m	Tree with Impact Damage			

[Figure 4] Wreckage Distribution Chart

40) Area within a 2 km radius of the crash point.

1.12.3 Main Rotor Blades

During the crash sequence, both main rotor blades contacted trees, resulting in multiple fractures of the composite material of the trailing edge, which was scattered around along the entry track. The leading edge of the blades was severed during the final crash sequence, resulting in one resting beside the fuselage and the other in ④ location as shown in [Figure 4].

1.12.4 Drive System

The wreckage examination revealed that the drive continuity of the tail rotor and main drive systems was confirmed without any seizure or resistance, except for the tail rotor driveshaft fractured by an external force.

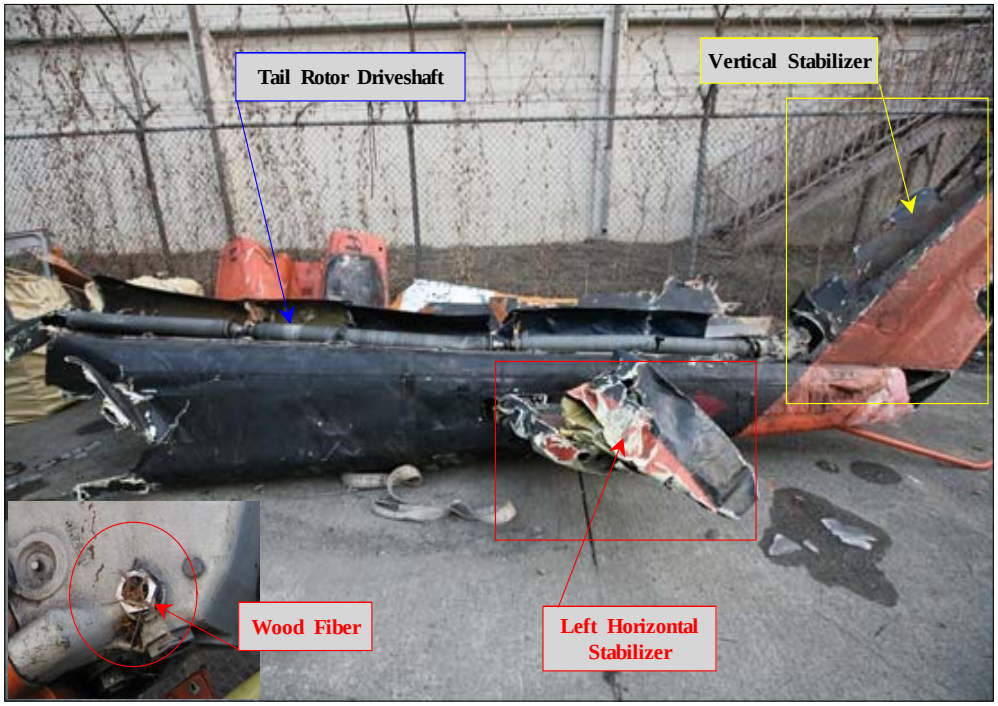
1.12.5 Tail Boom

As shown in [Figure 5], the tail boom was fractured and separated at the portion connected to the forward fuselage. The left side of the separated tail boom was substantially damaged, whereas the right side of it sustained relatively minor damage. Wood fiber was jammed in the damaged portion of the tail boom.

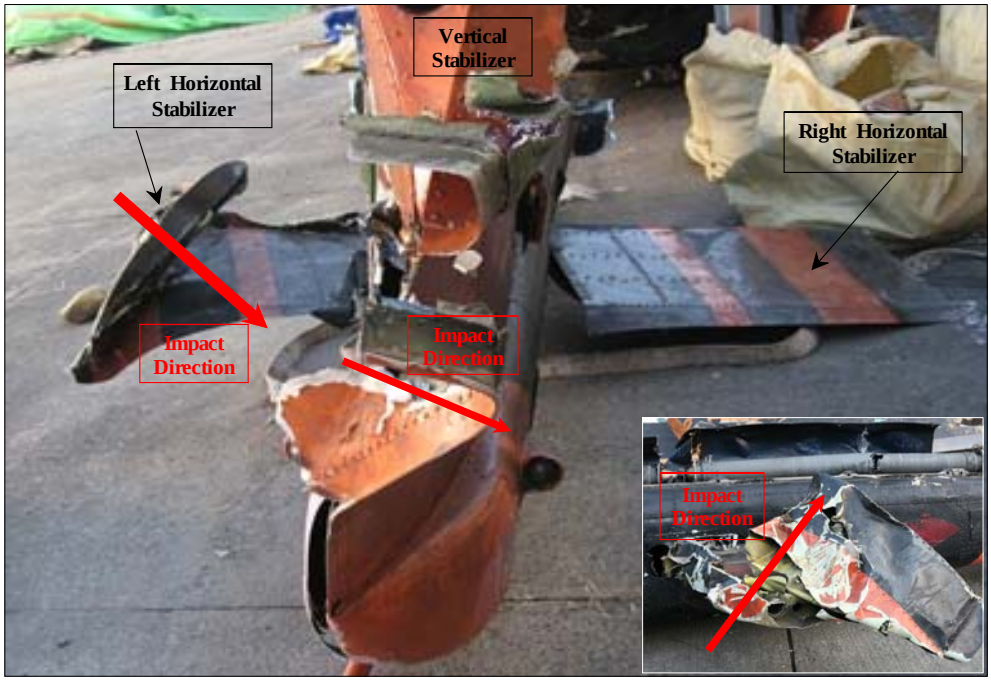
As shown in [Figure 5], the tail rotor driveshaft cowling sustained crushing damage by an external force from left to right. The cowling was punctured at two points as it made contact with the inner rotating driveshaft fractured, resulting in rotational wear.

As shown in [Figure 6], the left horizontal stabilizer was damaged by an external force from bottom left froward to upper right backward. The right horizontal stabilizer was intact without external damage. The bottom portion of

the vertical stabilizer was damaged by an external force from left to right based on the nose.



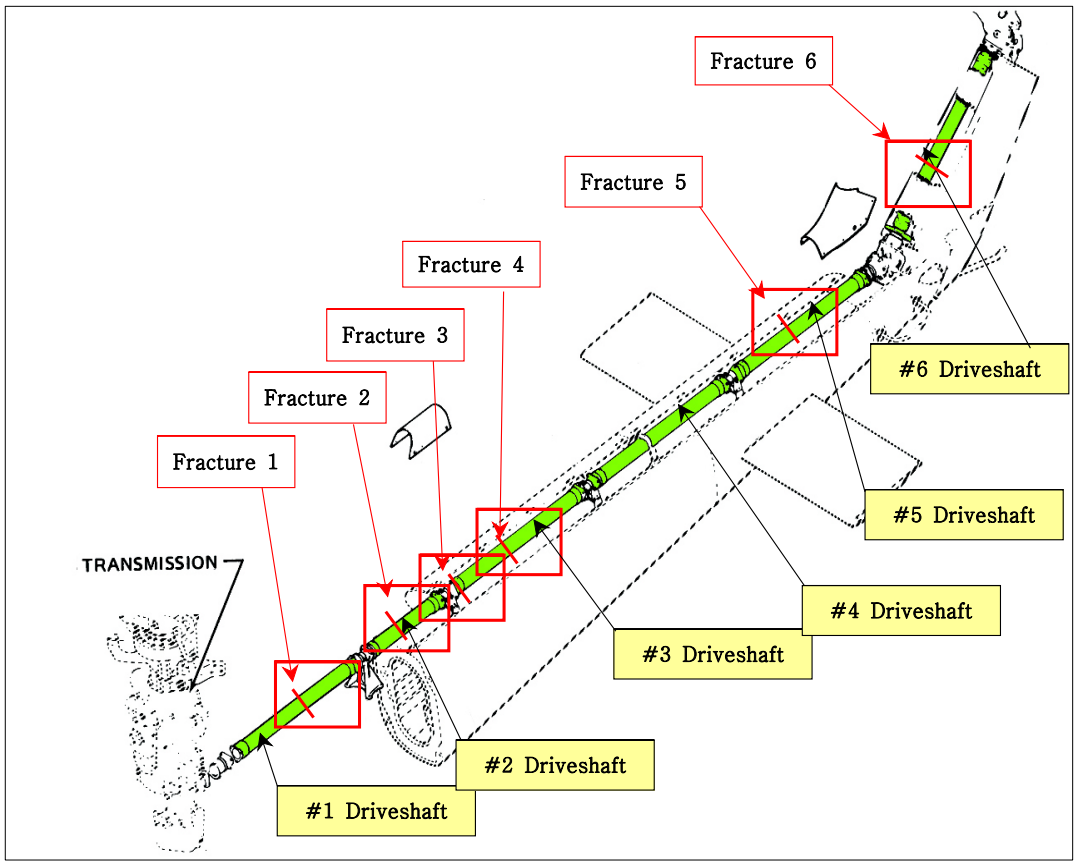
[Figure 5] Left Side of the Fractured Tail Boom



[Figure 6] Damage to Left/Right Horizontal Stabilizer and Vertical Stabilizer

As shown in [Figure 7], the tail rotor driveshaft displayed separation at six different locations[41] as a result of strong rotational resistance in the direction of the tail rotor. One location displayed counterclockwise twisting[42].

Also, there was circumferential scoring throughout the driveshaft, and the fracture surfaces[43] of the #1 driveshaft in both directions of the gearbox and the tail rotor showed the inner diameter of the driveshaft expanded outwards due to the impact and wear.



[Figure 7] Tail Rotor Driveshaft Fractures and Their Locations

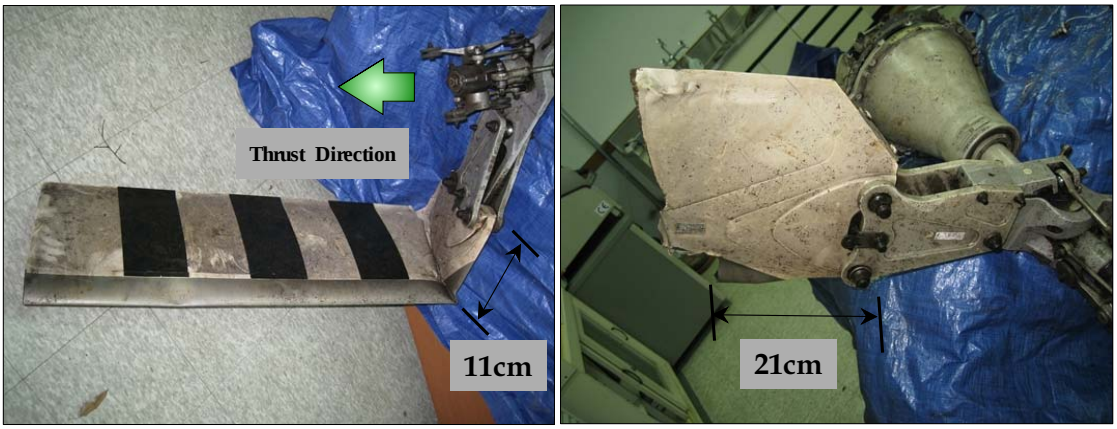
41) #1 Driveshaft: 2 locations, #2 Driveshaft: 2 locations, #5 Driveshaft: 1 location, #6 Driveshaft: 1 location.
42) Fracture #6 in [Figure 8].
43) Fracture #1 in [Figure 8].

[Figure 8] Fracture Surfaces of the Tail Rotor Driveshaft

1.12.6 Tail Rotor Blades

As shown in [Figure 9], one of the two tail rotor blades was fractured 21 cm from the installation bolt in the rotational direction. The other tail rotor blade was bent 11 cm from the installation bolt, at approximately 90 degrees in the thrust direction.

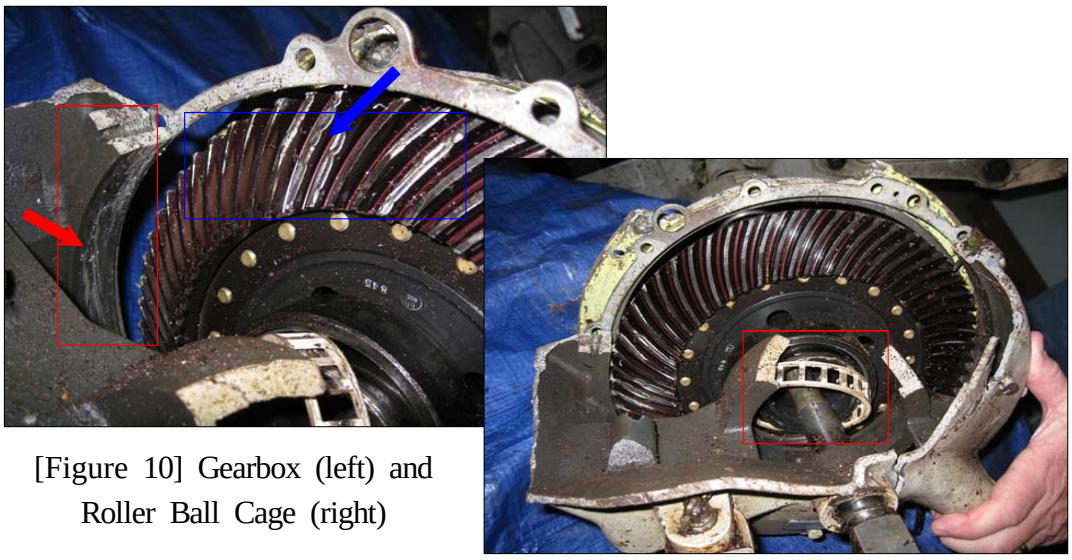
The surface of the tail rotor blade displayed no severe rotational damage, such as dents or scratches caused by striking a hard object like a tree at the crash point.



[Figure 9] Tail Rotor Blades Damaged

1.12.7 90° Gearbox

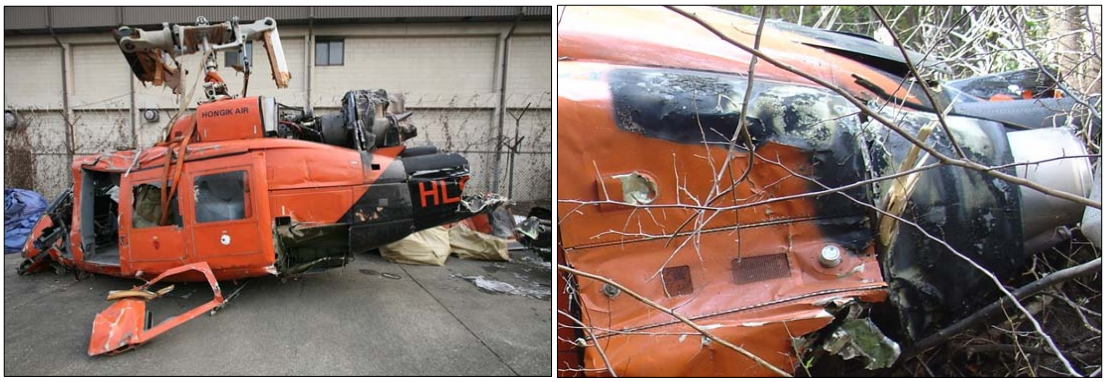
As shown in [Figure 10], the 90° gearbox sustained damage as the tail rotor blades experienced instantaneous strong rotational resistance. On the inside surface of the gearbox there was circumferential damage by the gears rub. The roller ball cage did not display any heat distress.



[Figure 10] Gearbox (left) and Roller Ball Cage (right)

1.12.8 Fuselage

The left side of the fuselage was severely dented, bent, and fractured as it contacted tress and rocks during the crash sequence. The paint on the engine cowling burned black due to the engine exhaust gas[44] shortly after the crash.



[Figure 11] Left Side of the Fuselage (left) and the Engine Cowling (right)

1.12.9 Sling Strap

At the time of the accident, the sling strap[45] was attached to the belly hook of the HL9131 aircraft for airlift operations. As shown in [Figure 12], the on-site investigation revealed that the sling strap wrapped around the mast counterclockwise six times. One of the two pitch-control rods fractured was wrapped by the sling strap, whereas the other was not.

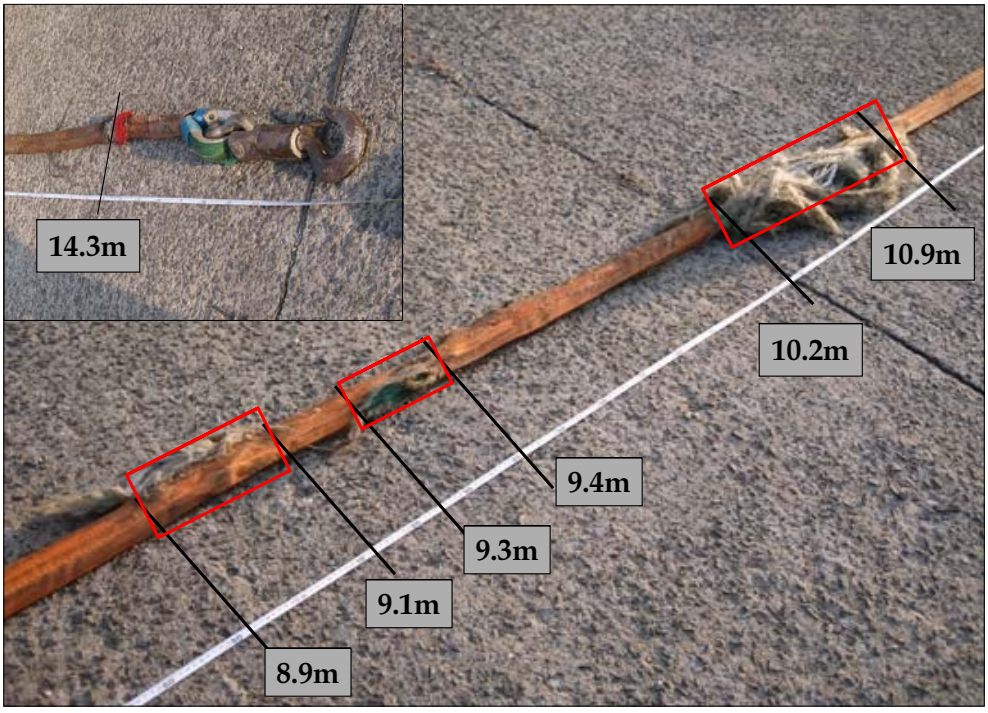
As shown in [Figure 13], the fiber of the sling strap was damaged by an external force in three locations, which were 8.9~9.1 m, 9.3~9.4 m, and 10.2~10.9 m from the belly hook.

The sling strap was cut 14.3 m from the belly hook at a right angle by a

44) The engine shut down since the captain shut off the fuel shutoff valve and BAT switch after crash.
45) Synthetic fiber, with the maximum tension of 4 tons, 15 m in length and 15 kg in weight.

rescue worker to perform rescue missions.

[Figure 12] Sling Strap Wrapped Around the Mast and the Fractured Pitch-control Tubes



[Figure 13] Damage Locations of the Sling Strap

1.13 Medical and Pathological Information

There was no evidence indicating that the captain had medical and pathological factors which could have affected this accident.

1.14 Fire

After the crash, the engine cowling of HL9131 was burned by the exhaust gas from the engine exhaust duct, and a fire occurred to dry grass besides the exhaust duct but was immediately extinguished by the co-pilot, resulting in the stoppage of the damage from spreading.

1.15 Survival Aspects

On October 19, 2011, about 14:48, the situation room of the Gyeongsangnam-do Fire Department received an accident report from a witness and instructed the Busan and Ulsan Fire Departments to dispatch helicopters for search operations and the Gimhae Fire Station to rush to the accident site about 15:05. Accordingly, the Jangyu 119 Safety Center within the jurisdiction of the Gimhae Fire Station, about 5 km from the crash point, was dispatched to the accident site about 15:05 and arrived there about 15:42.

When the firemen and rescue workers[46)] arrived at the accident site, the co-pilot with a minor injury already escaped from the accident aircraft by himself and the captain with a serious injury was found captured by the wreckage, with his right leg jammed between the pedal and the instrument panel

46) Vehicles and Personnel Dispatched: 2 ambulances, 1 command vehicle, 2 rescue vehicles, and 32 persons.

collapsed by the crash impact.

At the time, the captain who was conscious was lying down between the left and right pilot seat. He was rescued by rescue workers about 16:20 and transported to the e-Joeun Jungang Hospital in Gimhae-si along with the co-pilot about 16:55.

The helicopter[47] affiliated with the aviation unit of the Busan Fire Department was dispatched at 15:06, checked the accident site at 15:45, and returned[48] to the base after search operations at 16:20. The helicopter[49] affiliated with the aviation unit of the Ulsan Fire Department was dispatched at 15:30 and returned to the base after search operations at 16:30.

On the day of the accident, HL9131 was equipped with the Emergency Locator Transmitter (ELT)[50], but its available frequency was 121.5 MHz and 243.0 MHz which could not be received by the situation room of the Coast Guard. As a result, HL9131's distress signal failed to be detected.

1.16 Tests and Research

Tests and research were not conducted for the accident investigation.

1.17 Organizational and Management Information

1.17.1 Training of the Pilots

In accordance with the operation regulations of Hongik Air Service, Chapter 5

47) 2 pilots, 2 rescue workers, and 1 aircraft mechanic.
48) There was neither an urgent patient to be transported nor a place to land near the accident site.
49) 2 pilots, 1 aviation commander, 1 rescue worker, and 1 aircraft mechanic.
50) Manufacturer: US Pointer Avionics Ltd, Model No.: 3000AP, Serial No.: 331423.

(Airman Training), 5-4 (Pilot Training), the pilot training is categorized as follows: ① initial training[51], ② type transition training[52], ③ recertification training, ④ recurrent training; ⑤ captain training; and ⑥ instructor training. The initial training is again subdivided into initial type rating training[53] and familiarization training[54].

After hired by Hongik Air Service, the captain received the initial type rating training as part of the initial training and the captain training for B214 flight as pilot-in-command. Hongik Air Service's operation regulations and new pilot training plan prescribe that the initial type rating training and the captain training should offer 20-hour ground training[55] and 20-hour flight training[56] and 10-hour ground training[57] and 5-hour flight training[58], respectively.

The initial type rating training results report of the captain showed that he received 20-hour ground training and 22-hour flight training. Yet, the documented evidence[59] showed that the details of the ground training could not be verifie d[60] and that the captain had 17 hours and 25 minutes[61] of flight training.

As part of the captain training, he received 10-hour ground training and 6-hour flight training, whereas he was supposed to have 10-hour ground training and 5-hour flight training. The ground training was carried out in a way that a

51) Training for newly-hired pilots with basic type rating, categorized as the initial type rating training and familiarization training.
52) Training for pilots who wish to fly types other than the currently operated type.
53) Training for pilots who need to obtain initial type rating.
54) Training for pilots who hold type rating but have no flight experience for the last 3 - 6 months.
55) Aviation Act for 2 hours, operation regulations for 2 hours, aviation meteorology for 2 hours, air traffic control for 2 hours, crew resource management for 3 hours, security for 3 hours, dangerous goods identification and transportation for 3 hours, flight manual for 8 hours, and review and evaluation for 1 hour.
56) Subjects are selected according to the manufacturer's curriculum. 20 hours including a checkride.
57) Aviation Act for 1 hour, flight manual for 8 hours, and appraisal for 1 hour.
58) 5 hours in total including normal procedures, non-normal procedures, and appraisal.
59) Copies of the flight log and the ground training log.
60) The related document was destroyed since it exceeded its retention period of three years (document with the three-year retention period).
61) Without specifying training subjects, the log just mentioned the "training flight".

trainee taught himself, prepared a ground training log, and obtained an approval from his instructor. During the approval process, the instructor answered his questions.

As part of the flight training, training flights were separately arranged, but sometimes they were incorporated into other flight missions. Still, at this time, a trainee prepared[62] his flight training log and obtained an approval from his instructor.

1.18 Additional Information

1.18.1 Statements of the Pilots

The captain initially stated[63] after the accident that his emergency training as part of initial type rating training and captain training was carried out in a way that during ground training, he studied the operator manual by himself, prepared his flight training log, and obtained an approval from his instructor and that during flight training, the instructor mostly demonstrated and verbally explained emergency procedures during simulated engine shutdown.

Also, the captain stated that he did not remember having flight training for "emergency procedures in case of in-flight tail rotor failure". Further, he was not acquainted with them, either. When his statement was taken second time[64], however, he was relatively well-aware of them.

The captain stated that before the accident, he flew at a pressure altitude of

62) There was disagreement between the log preparation date and the training flight date. The log was recorded by translating the English flight manual into Korean language.
63) On Oct. 25, 2011, at 14:30 in Sujiho Hospital in Pungdeokcheon-dong, Suji-gu, Yongin-si, Gyeonggi-do.
64) On Dec. 6, 2011, at 12:45 in a coffee shop in Suji-gu, Yongin-si, Gyeonggi-do.

about 1,700 ft and a speed of about 70 kts and that as he flew over the ridge, reduced a speed, and descended at about 500 ft/m, failure occurred along with a sudden loud "bang" sound.

The co-pilot stated that he heard the engine sound even after the crash and that a fire occurred to the grass near the engine exhaust duct due to engine exhaust gas but he extinguished it at an early stage by smothering it with soil.

After hired by Hongik Air Service, the co-pilot completed his B214 type transition training. He stated that his ground training was carried out in a way that he studied relevant subjects[65] by using a teaching plan, manuals, Internet, etc. by himself, prepared his ground training log, and obtained an approval from his instructor and that as part of flight training, he had practical flights with a focus on basic airmanship[66].

He added that in his emergency training, he just observed his instructer demonstrating the power recovery procedure and the terminated with power procedure and that his mission training[67] was also completed by observing his instructor's demonstration.

Yet, the flight training appraisal forms of the captain and the co-pilot showed that their emergency actions in case of tail rotor failure were evaluated as competent. Also, when questioned about emergency procedures in case of tail rotor failure, the co-pilot stated general emergency actions for rotorcraft[68] rather than specific ones for B214.

65) Operator manual (English), aviation regulations (Act, Enforcement Decree, Enforcement Rule), Flight Safety Regulations, aviation meteorology, aviation safety, mission familiarization (forest fire suppression, cargo transportation), aircraft manual, etc.
66) Ground inspection procedure, instrument handling procedure, engine starting procedure, hovering at 3 - 5 ft, normal takeoff and landing, takeoff and landing in a compound.
67) Forest fire suppression and cargo transportation.
68) Maintain a speed at 60 kts and over, maintain the heading by lowering the collective or controling the throttle, and make a cushion landing (on flat ground) by using running landing.

1.18.2 Emergency Procedures for B214B-1

In accordance with the emergency procedures in case of tail rotor failure[69] specified in the B214B-1 operator manual, 3-13, the pilots should reduce the throttle, lower the collective pitch, and maintain a slightly faster speed than normal autorotation speed.

In addition, the manual also mentioned that for reference, if an altitude is permitted at a speed of 60 kts, flight with power can be resumed to some extent by applying the throttle and pitch smoothly, however, if the aircraft yaws in the opposite direction, autorotation should be used again until landing.

At this time, if the nose yaws to the right when power is reduced, the collective pitch should be slightly raised to correct the heading or if the nose yaws to left, the throttle should be slightly rolled to correct the heading.

At the final stage of landing, after confirming that all power to rotors is shut off, the pilots should gently decelerate, take a slight nose-high attitude by smoothly raising the collective, then land with the aft portion of the skids contacting the surface first by using running landing.

Also, according to the manual, in case of B214B-1's directional control failure, emergency procedures vary depending on various situations[70], and accordingly, blindly applying general rotorcraft's emergency procedures for tail rotor failure to all cases is wrong since it can cause fatal consequences.

69) DIRECTIONAL CONTROL FAILURE - COMPLETE LOSS OF TAIL ROTOR THRUST - (Level Flight or Powerdive)

70) Complete thrust loss of the tail rotor (ascending, hovering, level and descending flight, descending with low power/no power, landing at min. ground speed), tail rotor component loss (pitch control stuck, hovering, forward movement, right pedal)

2. Analysis

2.1 General

The pilots of HL9131 held valid qualification certificates necessary for the same type aircraft operation in accordance with the Aviation Act. Also, any of their medical and pathological evidence that could have affected flight was not found throughout the investigation.

In accordance with the provisions stipulated in the Aviation Act, the HL9131 aircraft was duly registered, certified for airworthiness and operational limit designation, obtained the noise certificate and the radio station license, and was approved for the flight operations.

The aircraft weight and balance were within the prescribed limits. Further, on-site investigation and wreckage analysis found no evidence indicating defects in the aircraft's power transmission system or engine before the accident.

2.2 Weather Factors

At the time of the accident, the weather in the mission area of HL9131 was better than the visual meteorological conditions and thus, did not affect the accident.

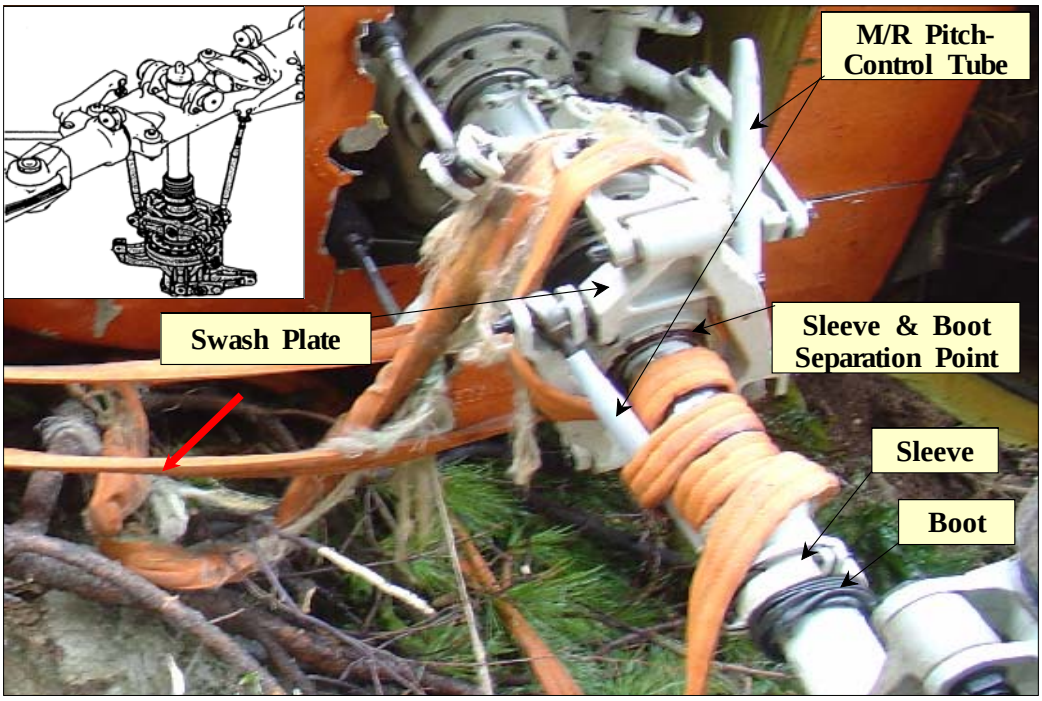
2.3 On-site Investigation and Wreckage Analysis

The on-site investigation and wreckage analysis revealed that the drive continuity of the tail rotor and main drive systems was confirmed without any

seizure or resistance, except for the fractured tail rotor driveshaft. The sling strap wrapped around the mast after HL9131 contacted trees on the ground, and the pitch-control tubes were fractured by the crash impact generated when the main rotor blades struck tress.

As shown in [Figure 14], the sling strap wrapped around[71] one of the two fractured pitch-control tubes. If the pitch-control tubes were fractured by the sling strap during flight, the sling strap should have wrapped around both pitch-control tubes or the pitch-control tubes should have bent towards the mast, however, evidence indicating both was not found.

Also, the sling strap should have covered the sleeve and boot, or the sleeve and boot should not have been pushed upwards since the sling strap had wrapped around them before they got fractured and separated.



[Figure 14] Sling Strap Wrapping around the Mast and the Surrounding Wreckage Damaged

71) After wrapping around the mast twice, the sling strap wrapped around the pitch-control tube once.

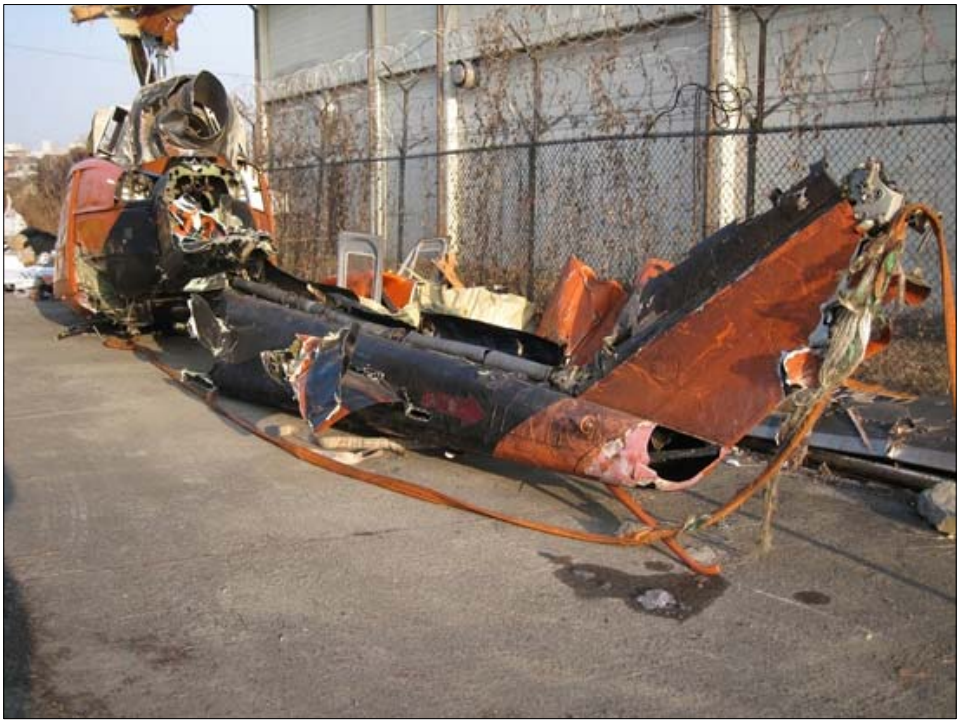
In addition, the only portion in the mast capable of damaging the sling strap is the area between the fixed swashplate and the rotational swashplate. Accordingly, it is determined that the damage to the sling strap was not caused by its wrapping around the mast considering the followings: the damaged portion of the sling strap was also found in a location (red arrow) other than the portions of the strap wrapping around the mast; and a slack portion of the sling strap still remained except for the portion wrapping around the mast six times.

It is determined that while turing right, the aircraft crashed with its tail rotor blade almost stopping rotating and with one tail rotor blade already separated before crash, considering the followings: one of the two tail rotor blades was bent at approximately 90 degrees in the thrust direction, without rotational damage by impact with trees; the other tail rotor blade was not found near the accident site; and the tail boom sustained impact damage by striking tress from left to right.

The gear in the 90° gearbox sustained damage by instantaneous impact, and the portions around the gearbox displayed no heat distress[72] by resistance. The driveshaft between 42° gearbox and 90° gearbox was twisted by strong resistance to rotation in the tail rotor direction.

As shown in [Figure 15], it was confirmed that the damaged portion of the sling strap is exactly consistent with the location of the rail rotor, and the captain stated that failure occurred after he heard a sudden loud "bang" while descending at a rate of approximately 500 ft/m at 70 kts and 1,200 ft before the accident.

72) When the gear inside the gearbox or bearing is seized up, heat damage is caused by frictional heat, but the fact that such damage was not found constitutes the evidence that resistance to rotation in the tail rotor direction was not caused by seizure.



[Figure 15] Comparison of the Damaged Location of the Sling Strap with the Location of the Tail Rotor

Accordingly, the ARAIB assumed based on these facts that when HL9131 decelerated and descended after flying over the ridge right before the crash point, the sling strap got closer[73] to the tail rotor, then struck it, thereby resulting in damage to the sling strap, separation of the tail rotor blade, fractures of the tail rotor driveshaft, and impact damage to the 90° gearbox.

At the time, it appears that although the tail rotor driveshaft was fractured, power from the gearbox was continuously supplied, and accordingly, as fracture surfaces rubbed against each other, power was still partially transmitted to the tail rotor. With the lapse of time, however, fracture surfaces of the driveshaft were worn out, resulting in the gradual loss of power of the tail rotor. Eventually, the tail rotor almost stopped rotating at the time of the crash, and

73) When descending and decelerating, the tail rotor dropped as the aircraft takes a nose-high attitude.

the remaining tail rotor blade was bent in the thrust direction when it contacted trees due to the aircraft's yawing to the right.

Subsequently, the HL9131 aircraft was in a left bank attitude as it severely yawed to the right, and at this time, its main rotor blades contacted trees, resulting in the fracture of the pitch-control tubes and damage to the sleeve and boot. Then, as the sling strap got caught in the main rotor, it wrapped around the mast about six to ten times and came to a halt.

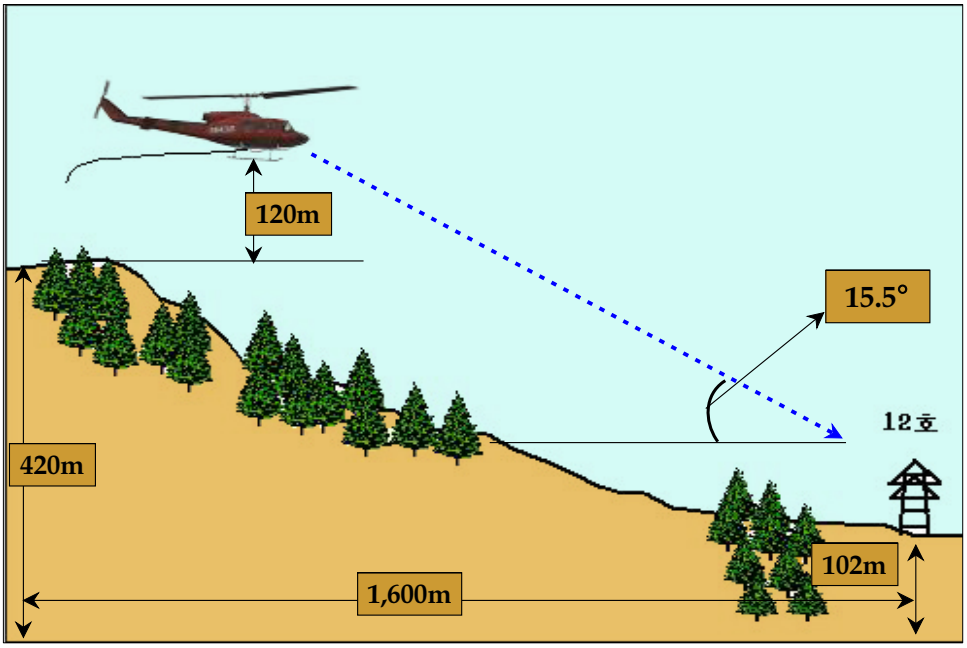
2.4 Analysis of the Flight

The captain stated that before the accident, he flew over the ridge at 70 kts and 1,200 ft, maintained approximately 300 - 400 ft AGL, then descended at a rate of approximately 500 ft/min to approach the power-line tower #12. He also added that the distance between the power-line tower #12 and the location where he descended was about 800 - 900 m.

In this regard, the analysis of these facts indicated that the captain actually flew at approximately 540 m (1,770 ft)[74] given that the altitude of the ridge was 420 m (MSL, 1,377 ft) and that he flew at 90 - 120 m (300 - 400 ft) above the ridge. In addition, the altitude difference between the descending point and the power-line tower was actually approximately 438 m (1,453 ft) since the power-line tower #12 was located at 102 m (MSL, 335 ft).

As the descending point was located 1.6 km from the power-line tower, HL9131 approached at an angle of approximately 15.5 degrees as shown in [Figure 16], which is slightly deeper than the rotorcraft's normal approach angle, 8 - 12 degrees.

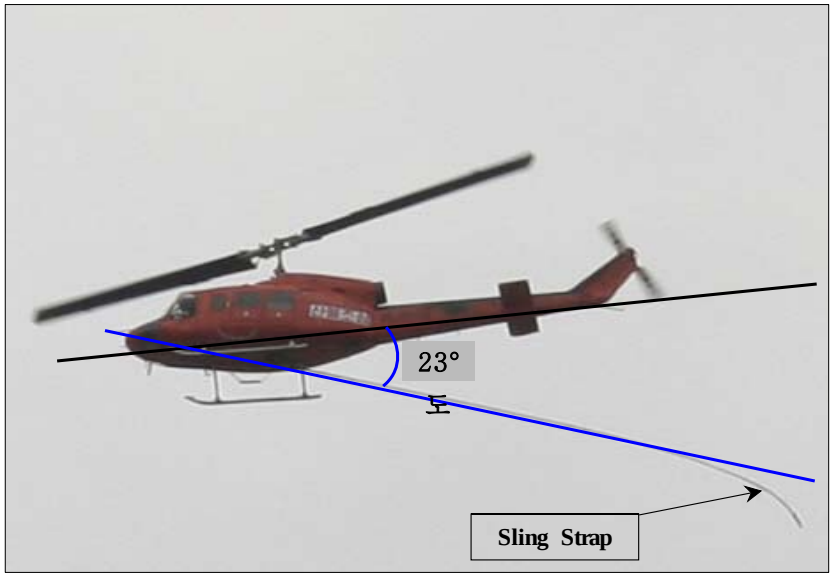
74) 1 m = 3,28 ft.



[Figure 16] Topography between the Descending Point and the Power-line Tower #12 and the Estimated Approach Angle

Against this backdrop, to hover and land on the destination, the captain had to decelerate more greatly than normal. Furthermore, if the captain recognized the distance to the destination as 800 - 900 m, which means shorter than real, he was highly likely to decelerate much more greatly.

As shown in [Figure 17], if the aircraft has a level flight with the sling strap attached at a speed of 70 kts, the angle between the fuselage and the sling strap is about 23 degrees. The angle between the sling strap and the aircraft fuselage per speed is shown in [Table 3].



[Figure 17] Angle between the Sling Strap and the Fuselage during Level Forward Flight

Category	50 kts	60 kts	70 kts	80 kts
Angle	28°	25°	23°	20°
Remarks	No Wind, Cloud 3,000 OVC, Visibility 7 miles			

[Table 3] Angle between the Sling Strap and the Fuselage per Speed

Just before the accident, although HL9131 flew at 70 kts, its sling strap got closer to the fuselage since it ascended to fly over the ridge, then descended at approximately 500 ft/min. More specifically, as the aircraft took a nose-high altitude while decelerating, the sling strap got closer to the tail boom, eventually resulting in impact with the tail rotor.

As a result, the ARAIB determines that the probable cause of this accident was 「the sling strap attached to the belly hook got into the tail rotor blade since the captain decelerated more greatly than normal and descended at the

same time while flying at approximately 70 kts.」

Currently, the B214B-1 operator manual stipulates a speed limit during airlift operations but failed to specify restrictions on the flight with an empty string strap attached to the belly hook of the aircraft. 「Rotorcraft Airlift Operations Manual」 partially specifies the risk of the flight with an empty sling strap and its risk mitigation measures[75], but flight restrictions were not included.

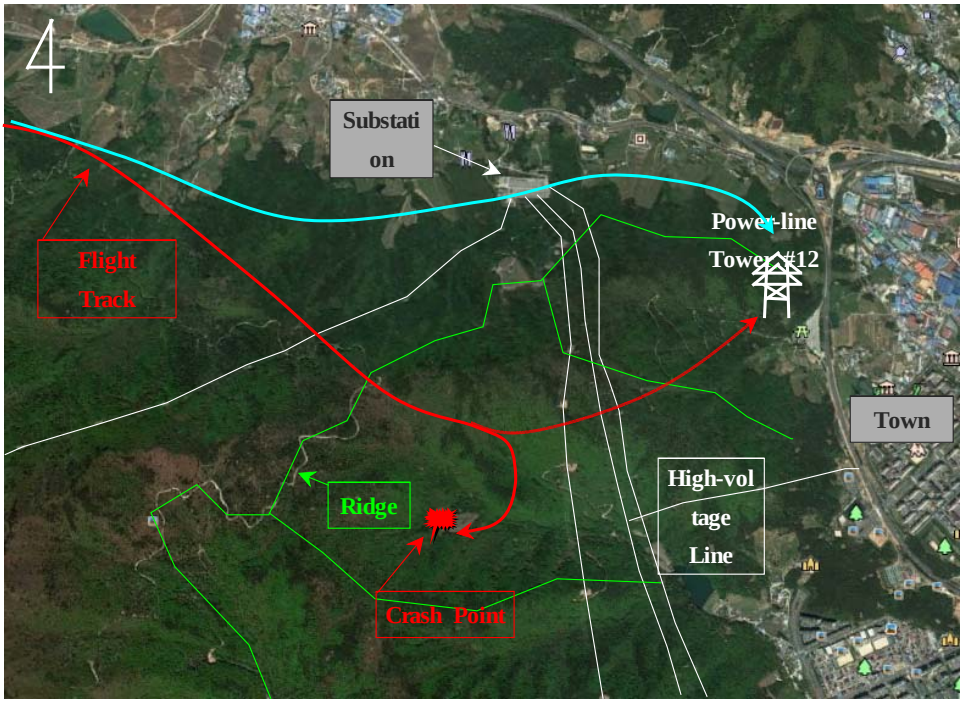
In this regard, to prevent similar accidents, relevant procedures need to be enhanced by specifying, in the manual, limitations to the aircraft speed and the sink rate in case of the flight with an empty sling strap attached.

The captain stated that after hearing a sudden loud "bang" during descent, he confirmed the illumination of the 90° gearbox warning light, then the aircraft yawed to the right with vibration.

Accordingly, the captain surveyed the circumstances as he lowered the collective and sought to maintain the attitude, and as a result, he determined that he had to land as soon as possible since the tail rotor was abnormal.

Yet, the aircraft already entered the valley after flying over the ridge, and moreover, on the periphery of the aircraft, there were high-voltage lines ahead and a town beyond them as shown in [Figure 16]. Thus, the captain determined that circular or straight flights were impossible.

75) Rotorcraft Airlift Operations Manual (Oct. 2006, Airworthiness Division of the Safety Operation Bureau under the Seoul Regional Aviation Administration) recommends that more than 5 kg of ballast weight be attached to the remote hook or that the length of the sling strap be half the diameter of the rotor.



[Figure 16] Crash Point and the Surrounding Obstacles

Subsequently, while approaching the point he considered relatively flat in his vicinity, HL9131 crashed into the valley.

Therefore, the captain should have planned the flight route[76] on which there were more flat areas with fewer obstacles so that he could have performed emergency procedures in case of aircraft failure. In reality, there was a better flight route[77] beyond the ridge north of the route he had taken.

The fact alone that there were flat areas when emergency procedures were performed cannot guarantee the prevention of the accident, but it could raise the possibility of successful emergency procedures and reduce damage. Therefore, the captain should have planned the flight route on which there were fewer obstacles and more available areas for emergency landing.

76) On the day of the accident, the captain planned his flight route on which there were no houses to avoid damage by cargo separation in case of emergency during airlift operations.
77) Blue line in [Figure 16], flat area in which there are no houses and few obstacles, unnecessary to fly over the ridge.

2.5 Training of the Pilots

The ARAIB examined the same type training of the captain and the co-pilot to grasp the exact condition of the training about airlift operations procedures and emergency procedures for tail rotor failure since they are considered related to this accident.

As part of the initial type rating training, the captain had flight training of 17 hours and 25 minutes, short of 20 hours required by the operation regulations, but his training results report showed that he received 22-hour flight training.

Likewise, the co-pilot received flight training of seven hours, short of 10 hours required by the operation regulations, but his training results report[78] specified 10 hours and 30 minutes.

During training, the pilots of Hongik Air Service prepare the "ground training log" for ground training subjects and the "flight training log" for flight training, but they mostly record the contents of the flight manual in both logs. Moreover, the contents in the logs is not organized by each subject required by the operation regulations, so there is no knowing whether the required subjects and hours were properly met.

The copies of the flight log presented as the evidence of the flight training specified just "training flight" in the remarks column to describe the contents of the flight training, or left the column empty and counted flights with an instructor as flight training hours. Accordingly, it was impossible to verify which subject was taught for how many hours or whether training flight was performed during all the flight hours or only some.

78) Hongik Air Service Doc (Jan. 28, 2011) Report on the pilot training results.

In particular, on January 22, 2009, during the period of the initial type rating training, the captain had flight training with an instructor pilot for one hour and 30 minutes in Pohang-si. Yet, the flight log on this day showed that the maintenance flight was performed due to the oil leaking from the right dual power actuator and the balancing of the main and tail rotors.

In accordance with the operation regulations of Hongik Air Service 5-5-3 (Other Regulations), flight training, except for the initial type rating training and type transition training, can be combined with ferry flights. In this regard, Hongik Air Service failed to comply with its operation regulations dictating that during the captain's initial type rating training, training flight cannot be combined with maintenance flight.

In addition, he completed his emergency procedures flight training just by watching his instructor's demonstration once or twice, and thus, it cannot be said that he experienced emergency procedures. Yet, his flight training appraisal form showed that the subject of tail rotor failure was included and that the applicable appraisal was performed.

It is a well-known fact that the operator's internal training is difficult to be conducted at the same level as that of professional training agencies. Still, as stated above, Hongik Air Service reported that its training met the basic requirements prescribed by the operation regulations although it failed to do so. Also, its flight training was not consistent with the operation regulations, and its training curriculum was not properly taught by subject.

Based on the facts above, the ARAIB determined that Hongik Air Service provided its pilots with inadequate training, resulting in the captain's failure to recognize the risk that the sling strap could get into the tail rotor blade during rapid attitude change and descent with an empty sling strap attached to the belly

hook, which was accordingly considered contributory to this accident.

Hongik Air Service's operation regulations and training plan report only showed that flight training subjects of initial type rating training are designed according to the same type manufacturer's curriculum, i.e. they specified just 20 total flight hours without the standard for which subject should be taught for how many hours and related training details.

Therefore, the agency supervising training of Hongik Air Service needs to review the flight safety regulations and operation regulations of the company, reexamine the appropriateness of training curriculum, time allocation, and training methods, come up with specific measures to improve the quality of training as much as possible, and enhance its supervision of whether the company implements the measures or not.

2.6 Emergency Locator Transmitter

The Aviation Act, Article 40 (Compulsory Wireless Apparatus) and the Enforcement Decree of the same Act, Article 122 (Wireless Apparatus), Paragraph 1, Subparagraph 8, prescribes that "the signal of the emergency locator transmitter (ELT) shall be transmitted on frequency 406 MHz."

Given that the frequency of the ELT installed on HL9131 was 121.5 MHz and 243.0 MHz, however, it failed to meet the requirement above. Furthermore, it is unserviceable equipment since the receiving frequency of the distress signal receiver in the situation room of the Coast Guard is 406 MHz.

The HL9131 aircraft is a single engine rotorcraft for aerial work which is operated in all inland regions in Korea except for marine and international

flights. Accordingly, Enforcement Decree of the Aviation Act, Article 122 (Wireless Apparatus), Paragraph 1, Subparagraph 8the subject to Item 2, "5) Aircraft flying in the air above the land designated by the Ministry of Land, Infrastructure and Transport, such as "mountainous areas making search and rescue operations particularly difficult" and "remote areas," but this provision is unapplicable since the "mountainous areas making search and rescue operations particularly difficult" and "remote areas" are not stipulated.

The ELT is critical equipment for the pilot survival since it can transmit the location of the aircraft in case of emergency, such as aircraft in distress, so that search and rescue operations can be rapidly initiated. Therefore, related regulations should be complemented so that valid ELTs can be installed and operated on all aircraft.

3. Conclusions

3.1 Findings

1. The pilots of HL9131 held valid qualification certificates necessary for the same type aircraft operation.

2. In accordance with the provisions stipulated in the Aviation Act, the HL9131 aircraft was duly registered, certified for airworthiness and operational limit designation, obtained the noise certificate and the radio station license, and was approved for flight operations.

3. The maintenance logbook of the HL9131 aircraft showed no defects which might have affected its operation. On the preflight inspection and during flight, no evidence indicating defects in the aircraft's airframe and power transmission system was found.

4. On the day of the accident, HL9131 was given a mission to airlift construction materials for the construction of the power-line tower #12. To this end, the aircraft used a 15-meter synthetic fiber sling strap.

5. At the time of the accident, the captain on the left seat and the co-pilot on the right seat were the pilot flying and the pilot monitoring, respectively.

6. At the time of the accident, the weather in Jangyu-myeon, Gimhae-si, Gyeongsangnam-do was better than the visual meteorological conditions and thus, did not affect the accident.

7. Right before the accident, HL9131, with an empty sling strap attached to

its belly hook, flew over the ridge right before the accident site at approximately 70 kts and 1,770 ft, then started descending at approximately 500 ft/min. At this time, a sudden loud "bang" was heard, followed by aircraft vibration, noise, illumination of the 90° gearbox warning light, and aircraft yawing to the right.

8. The synthetic fiber of the sling strap was damaged by an external force in three locations: 8.9 - 9.1 m; 9.3 - 9.4 m; and 10.2 - 10.9 m from the belly hook of the aircraft.

9. One of both tail rotor blades was not found at the accident site, whereas the other was bent at 90 degrees in the thrust direction when it contacted trees due to the aircraft's yawing to the right

10. The pitch-control tubes were fractured by the crash impact generated when the main rotor blades struck trees.

11. External damage to the HL9131 aircraft was mostly caused when the aircraft crashed into the ground while yawing to the right. The sling strap wrapped around the mast when the mast was rotating after crash into the ground.

12. The drive continuity of the tail rotor and main drive systems was confirmed without any seizure or resistance, except for the tail rotor drive-shaft fractured by an external force.

13. The wreckage examination revealed that the tail rotor drive-shaft displayed separation at six different locations. The drive-shaft between 42° gearbox and 90° gearbox was twisted by instantaneous resistance to rotation in the tail rotor direction. The gear in the 90° gearbox also sustained damage by

instantaneous resistance in the tail rotor direction.

14. Hongik Air Service failed to meet the requirements for pilot training stipulated in the operation regulations and provided its pilots with inadequate airlift operations training.

15. Hongik Air Service's operation regulations, 5-4-3 (training curriculum and hours), and its training plan report only specified that flight training subjects of initial type rating training are designed according to the same type manufacturer's curriculum, thereby failing to stipulate the standard for specific subjects and training methods.

16. The distress signal of the ELT was not received by the situation room of the Coast Guard since its transmitting frequency was different from 406 MHz stipulated in the Aviation Act.

17. On the Enforcement Decree of the Aviation Act, Article 122 (Wireless Apparatus), Paragraph 1, Subparagraph 8the subject to Item 2, as for the case of installing 1 ELT, it is written as "Aircraft flying in the air above the land designated by the Minister of Land, Infrastructure and Transport", such as "mountainous areas making search and rescue operations particularly difficult" and "remote areas", However, mountainous and remote areas are not designated as separately, ELT installation criteria are ambiguous to apply for the aerial work aviation.

18. The accident site was a valley surrounded by the mountains, and on its periphery, there were high-voltage lines ahead and a town beyond them. Thus, it was inadequate to perform emergency procedures at the site.

19. At the time of the accident, the captain took the inappropriate flight route

where there were many obstacles and the ridge to fly over although there was another flight route with fewer obstacles and more flat areas in the north.

20. The manufacturer issued 'Operational Safety Note' for all Bell 214 operators in 1988 and in 1992 respectively. But the OSNs have not been applied and or maintained by the Hongik Air Service since it introduced the HL9131 in August 1999.

3.2 Causes

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

1. The sling strap attached to the belly hook got into the tail rotor blade since the captain decelerated more greatly than normal and descended at the same time while flying at approximately 70 kts.

Contributing to this accident are as follows:

1. Hongik Air Service provided its pilots with inadequate flight procedures training in airlift operations.

2. The flight route the captain took on the day of the accident was inadequate since there were many obstacles.

4. Safety Recommendations

As a result of the investigation of the accident that occurred to HL9131 on October 19, 2011, the ARAIB issues the following recommendations.

To the Bell Helicopter Textron

1. Include, in its flight manual, risk factors that require attention and flight restrictions in case of flight with an empty sling strap attached to the belly hook of the aircraft (AAR1107-1).

To the Ministry of Land, Infrastructure and Transport

1. Required to examine the relevant Act and regulations regarding the ELT installation criteria for the aircraft for Aerial Work whether or not to supplement them appropriately (AAR1107-2).

To the Seoul Regional Aviation Administration

1. Examine the appropriateness of the curriculum, hours, and methods of the training program specified in the operation regulations of Aviation Companies; remedy related regulations; and enhance supervision to ensure substantial training (AAR1107-3).

To Hongik Air Service

1. Devise the measures to remove the risk factors accompanied by the flying with an empty loaded sling, and give the affiliated pilots the guide referred above and reinforce the supervision over the pilots (AAR1107-4).

   A. Measures to winch up the sling strap after completion of de-loading.

B. Measures to operate the length of sling short enough not to contact with tail rotor.

C. If unavoidable, measures to increase weight of the ballast and the method of flying in restrictive with increased weight of the ballast.

2. Train, guide, and supervise the pilots to plan their flight routes where there are few obstacles and it is easy to perform emergency procedures in case of emergency (AAR1107-5).

3. Specify the details of training subjects, training hours, and training methods in the operation regulations (AAR1107-6).

4. Complement the training program with the following measures (AAR1107-7).

a. Prepare a fight training log and a ground training log daily per subject, and after the completion of each training, have them recorded and signed by an instructor.

b. After flight training, record a training subject, training hours, and brief training content in the remarks column of the flight log.

5. Develop a specific emergency procedure training plan, including the use of a flight simulator (AAR1107-8).