AA2018-8

AIRCRAFT ACCIDENT INVESTIGATION REPORT

NAGANO FIRE AND DISASTER PREVENTION AVIATION CENTER
J A 9 7 N A

October 25, 2018

Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board and with Annex 13 to the Convention on International Civil Aviation is to determine the causes of an accident and damage incidental to such an accident, thereby preventing future accidents and reducing damage. It is not the purpose of the investigation to apportion blame or liability.

Kazuhiro Nakahashi
Chairman
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

AIRCRAFT ACCIDENT
INVESTIGATION REPORT

COLLISION WITH TREES AND CRASH
MT. HACHIBUSE, MATSUMOTO CITY,
NAGANO PREFECTURE
AT AROUND 13:41 JST, MARCH 5, 2017

NAGANO FIRE AND DISASTER PREVENTION AVIATION CENTER
BELL 412EP (ROTORCRAFT), JA97NA

September 28, 2018

Adopted by the Japan Transport Safety Board

Chairman	Kazuhiro Nakahashi
Member	Toru Miyashita
Member	Toshiyuki Ishikawa
Member	Yuichi Marui
Member	Keiji Tanaka
Member	Miwa Nakanishi

SYNOPSIS

<Summary of the Accident>

On Sunday, March 5, 2017, at 13:33 Japan Standard Time (JST: UTC + 9 hours; all times are indicated in JST on a 24-hour clock), a Bell 412EP, registered JA97NA, operated by the Nagano Fire and Disaster Prevention Aviation Center took off from Matsumoto Airport and was flying toward a temporary helipad in the mountains, Shiojiri City, Nagano Prefecture to conduct rescue training. At around 13:41, it collided with trees and then crashed onto the mountain's slope on Mt. Hachibuse, Matsumoto City, Nagano Prefecture.

There were nine persons on board the helicopter, consisting of a captain, eight others and all of them suffered fatal injuries.

The helicopter was destroyed, but there was no outbreak of fire.

<Probable Cause>

It is highly probable that in the accident occurred, while flying in a mountainous region, the helicopter collided with trees and crashed, because the helicopter did not take avoidance maneuver even getting closer to the ground.

Regarding the helicopter's not taking avoidance maneuver even getting closer to the ground while flying in a mountainous region, it is somewhat likely that the captain could not recognize the dangerous situation because the captain was in a state where the arousal level was lowered, however, it was not possible to clarify whether he actually fell into such a state.

<Statement of Opinions>

In the accident, it is highly probable that the captain had a past medical history and a surgical history and he was under treatment with medication. However, it is certain that he had obtained the aviation medical certificate without making a self-report on those medical information. In the examination for the Aviation Medical Certificate, it is difficult to make an appropriate judgment on whether to conform to the standards of Aviation Medical Examination unless applicants declare their medical history and information accurately.

Therefore, in view of the identified matters of the accident investigation, in order to ensure the safety of aviation, the Japan Transport Safety Board submit proposals pursuant to the provision of Article 28 of the Act for Establishment of the Japan Transport Safety Board to the Ministry of Land, Infrastructure, Transport and Tourism as follows:

It is necessary that the Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism thoroughly instruct aircrews to accurately make a self-report on their medical information to apply for the aviation medical certification, and if non-conformity is suspected, they must not engage in the performance of aviation duties, and must receive instructions from the designated aviation medical examiners and others, even if his/her aviation medical certificate is still within validity period.

The main abbreviations used in this report are as follows:

AGL	: Above Ground Level
ALT	: Altitude
AP	: Auto Pilot
ATT	: Attitude
CGB	: Combine Gear Box
CMM	: Component Maintenance Manual
CRM	: Crew Resource Management
DFCC	: Digital Flight Control Computer
ELT	: Emergency Locator Transmitter
FAA	: Federal Aviation Administration
ITT	: Inter Turbine Temperature
ICAO	: International Civil Aviation Organization
MR	: Main Rotor
MRB	: Main Rotor Blade
N1	: Compressor Turbine RPM
N2	: Power Turbine RPM
Nr	: Main Rotor RPM
NTSB	: National Transportation Safety Board
NPAU	: Nagano Police Aviation Unit
OAT	: Outside Air Temperature
RPM	: Revolutions Per Minute
SAS	: Stability Augmentation System
SMS	: Safety Management System
TB	: Tail Boom
TR	: Tail Rotor
TRB	: Tail Rotor Blade
VMC	: Visual Meteorological Condition

Unit Conversion List:

1 ft	: 0.3048 m
1 in	: 25.40 mm
1 nm	: 1,852 m
1 lb	: 0.4536 kg
1 kt	: 1.852 km/h (0.5144 m/s)

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1. PROCESS AND PROGRESS OF THE AIRCRAFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident

On Sunday, March 5, 2017, at 13:33 Japan Standard Time (JST: UTC + 9 hours; all times are indicated in JST on a 24-hour clock), a Bell 412EP, registered JA97NA, operated by the Nagano Fire and Disaster Prevention Aviation Center took off from Matsumoto Airport and was flying toward a temporary helipad in the mountains, Shiojiri City, Nagano Prefecture to conduct rescue training. At around 13:41, it collided with trees and then crashed onto the mountain's slope on the Mt. Hachibuse, Matsumoto City, Nagano Prefecture.

There were nine persons on board the helicopter, consisting of a captain, eight others and all of them suffered fatal injuries.

The helicopter was destroyed, but there was no outbreak of fire.

1.2 Outline of the Accident Investigation

1.2.1 Investigation Organization

On March 5, 2017, the Japan Transport Safety Board designated an investigator-in-charge and two other investigators to investigate this accident. One investigator was added on March 13, 2017.

1.2.2 Representatives from the Relevant States

An accredited representative and an advisor of United States of America, as the State of Design and Manufacture of the helicopter involved in this accident, and an accredited representative and an advisor of Canada, as the State of Design and Manufacture of the engine of the helicopter participated in the investigation.

1.2.3 Implementation of the Investigation

March 6 to 8, 2017	Interviews, helicopter examination and on-site-investigation
March 14 and 15, 2017	On-site-investigation by drone
March 22, 2017	Interviews
April 10, 2017	Helicopter examination and on-site-investigation
May 9, 2017	On-site investigation
May 14 and 15, 2017	Helicopter examination
June 5 to 7, 2017	Helicopter examination
June 6 and 7, 2017	Autopilot computer examination (The examination was conducted by the autopilot computer's manufacturer in the presence of the NTSB.)
April 10 and 11, 2018	Interviews, investigation by the same type of the helicopter (BELL 412EP)

1.2.4 Comments from the Parties Relevant to the Cause of the Accident

Comments were invited from the parties relevant to the cause of the accident.

1.2.5 Comments from the Relevant States

Comments were invited from the relevant States.

2. FACTUAL INFORMATION

2.1 History of the Flight

On March 5, 2017, a Bell 412EP, registered JA97NA (hereinafter referred to as “the helicopter"), operated by the Nagano Fire and Disaster Prevention Aviation Center (hereinafter referred to as “the Center"), took off from Matsumoto Airport (hereinafter referred to as “the Airport” at 13:33 with the captain in the right pilot seat and mechanic A in the left pilot seat and seven rescuers sitting directly on the floor in the cabin to conduct rescue training.

The flight plan for the helicopter was outlined below:

Flight rules:	Visual flight rules (VFR)
Departure aerodrome:	Matsumoto Airport
Estimated off-block time:	13:40
Cruising speed:	100 kt
Destination aerodrome:	Takabotchi temporary helipad
Total estimated elapsed time:	0 hr 20 min
Fuel load expressed in endurance:	1 hr 30 min
Persons on board :	9

The flight history up to the time of the accident is outlined below, based on statements of relevant parties and the images of a video camera that was worn by a rescuer.

2.1.1 Statements of Parties Relevant to the Accident

(1) Statements of the Center’s aviation chief, pilot A, and rescuer A

At the time of the accident, rescuer A and the aviation chief were providing ground support for the helicopter, and pilot A was working as the flight control officer who handled radio communications with the helicopter. The aviation chief, a mechanic, conducted a preflight inspections check on the helicopter on the day of the accident.

The rescue training had been planned for the morning but was rescheduled for the afternoon as they were dispatched upon receiving an emergency call in the morning. The noontime break was taken as scheduled between 12:00 and 13:00, and a detailed discussion concerning the training began at 13:00. In this meeting, there was no briefing on the engine data check to be conducted during the flight.

The rescue training to be conducted by the helicopter was the final test in hoist operator[1] training for rescuer B, who had been assigned to the Center in April 2016. The other rescuers on board were there to comprehensively verify that rescuer B could be entrusted with the work of a hoist operator in terms of his cooperativeness, decision-making ability, ability to communicate with other crew members, and so on. The specific training plan was to first drop off a rescuer to watch out for intrusion by outsiders after landing at Takabotchi temporary helipad (hereinafter referred to as “the Helipad” at an elevation of 1,580 m) and then to conduct training using a hoist on the western slope of Mt. Maehachibuse (hereinafter referred to as “the Training site”). The helicopter had 1,400 lbs of onboard fuel and a fuel consumption

*[1] “Hoist operator” refers to a person who operates the cable of a hoist that is capable of raising and lowering a person or goods with a wire cable while guiding the helicopter (See Photo 6: the helicopter [provided by the Center]).

rate of 680 lb/hour. The entire flight time for the training was 1 hour and 20 minutes. The aft seats had been removed in accordance with special operations for rescue, search, or training for those purposes noted in the Flight Manual Supplement.

The captain, mechanic A, rescuer B, and another rescuers wore flight helmets equipped with a microphone and speakers. The remaining five rescuers wore rescue helmets attached a headset having a speaker for only one ear. The captain and mechanic A had their helmet visors raised at the time of takeoff. Rescuer B was shooting video camera attached to his helmet to verify his own eye level and the monitoring conditions.

The helicopter took off from the Airport and headed to the Helipad, and pilot A was waiting for a communication from the helicopter, "landing at the Helipad." The flight to the Helipad should normally take about ten minutes, however, as there was no communication from the helicopter even after about 15 minutes had passed since its takeoff, pilot A went out into the corridor and outside with binoculars to search for the helicopter along the ridgeline near the Helipad and the Training site, but could not locate it. He called to the helicopter by radio multiple times but did not receive any response from the helicopter. At 14:37, the aviation chief asked the Nagano Police Aviation Unit (hereinafter referred to as "NPAU") by telephone to gather information on the helicopter. (See Photo 1: flight helmet, Photo 2: rescue helmet, and Photo 3: video camera)

Photo 1: flight helmet

Photo 2: rescue helmet

Photo 3: video camera

(2) Statement of the air traffic services flight information officer of the Airport

The helicopter took off from Runway 36 at 13:33 and headed to the Helipad. The air traffic services flight information officer asked the helicopter to notify when it arrived at the Helipad and got the read back from the helicopter; however, there was no subsequent communication from the helicopter. Before beginning search and rescue, the officer called to the helicopter four times but did not receive a reply. The first call was made at 14:12:20, the second at 14:12:50, the third at 14:18:20, and the fourth at 14:24:20. At 14:14, the Center informed that the contact with the helicopter had been lost. The officer contacted the Tokyo Rescue Coordination Center while continuing to call to the helicopter.

At 15:13, he had a report from NPAU's helicopter, which was searching for the helicopter, saying that it had found the helicopter crashed. There was no information concerning the receipt of a radio signal issued from the helicopter's emergency locator transmitter (ELT).

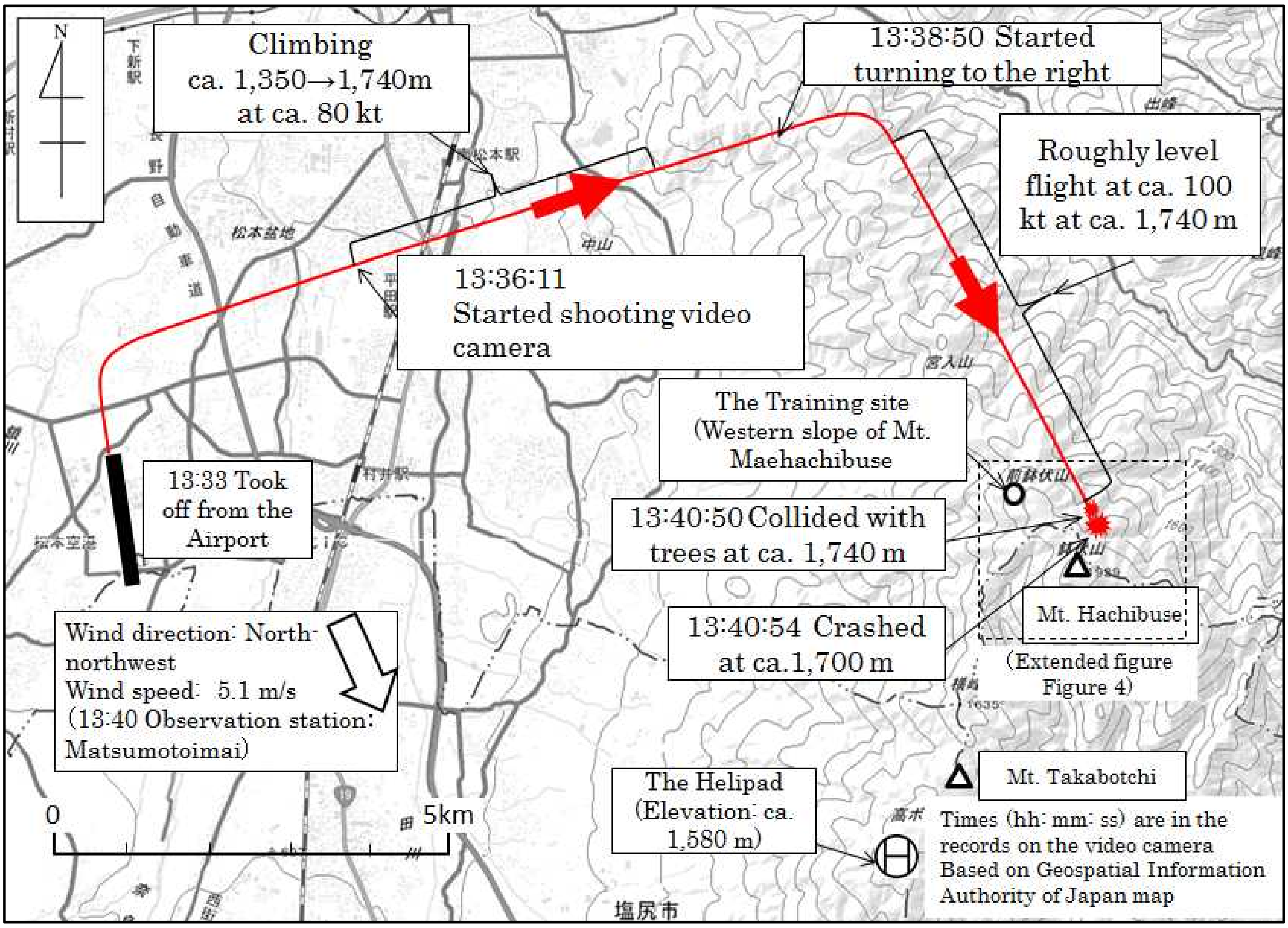

Figure 1: estimated flight route

2.1.2 Information from the Video Camera

The images and onboard sound were recorded on the video camera worn by rescuer B, which mentioned in 2.1.1(1), from around 13:36:11, when the helicopter was flying above the city approximately five km northeast of the Airport, until 13:40:54, when the helicopter collided with trees and crashed.

The helicopter's flight route, estimated from the images showing the outside the helicopter and the operating engine data table (to be described in 2.7 and 2.12.2), is as shown in Figure 1 and Figure 2. After taking off from the Airport, the helicopter climbed at a speed of approximately 80 kt while heading northeast from the area above the city to over the mountains located about 9 km northeast of the Airport. The helicopter leveled off at about 1,740 m (5,700 ft), then turned right over the mountains and headed toward Mt. Hachibuse, continuing roughly level flight at a speed of about 100 kt and at an altitude of about 1,740 m. The higher the mountains' elevation got, the lower the helicopter's altitude above ground level (AGL) became, despite the tree-covered mountainside that was looming ahead, the helicopter collided with trees while maintaining attitude and speed. Branches and leaves scattered throughout the interior and about four seconds later, recording the video images stopped.

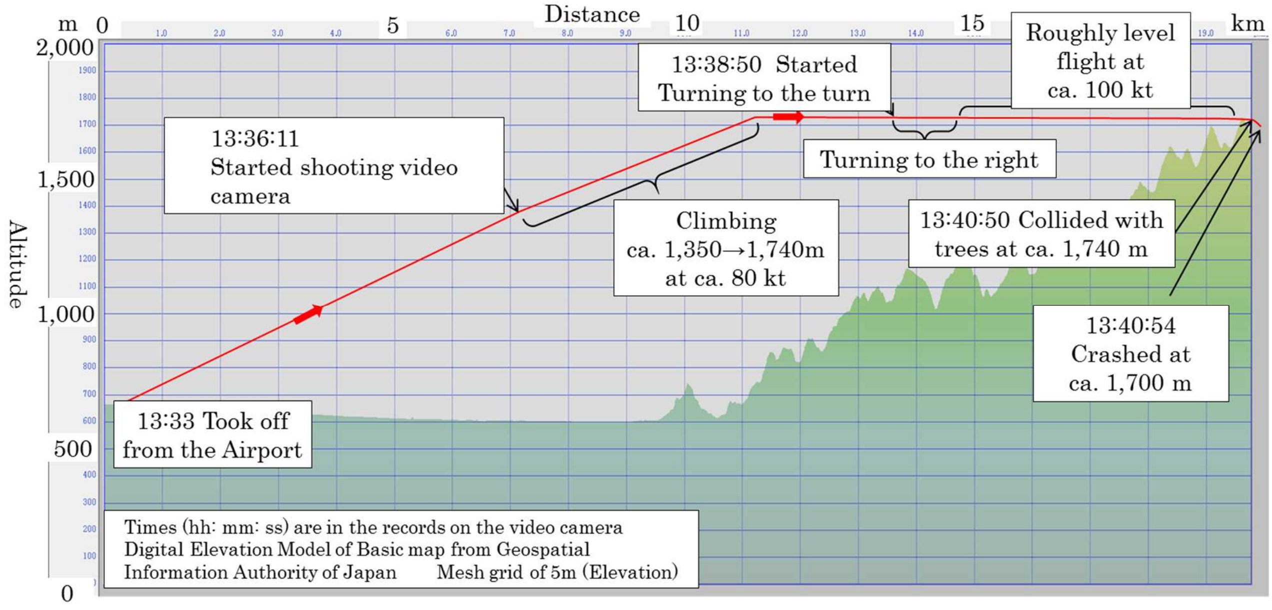

Figure 2: vertical cross section chart of the estimated flight route

The situation within the interior (audio and visual) and the situation of the helicopter at that time were as shown in Table 1. It should be noted that warning sounds indicating problems with the helicopter and abnormal sounds were not recorded.

The times (hours: minutes: seconds) are based on the time on the video recording, and times [minutes (') and seconds (")] are based on the time when the helicopter collided with trees (the same applies to the times provided in Photo 4, Photo 5, and Photo 7).

This accident occurred in a mountainous area of Mt. Hachibuse, Matsumoto City, Nagano Prefecture (36°10'09"N, 138°03'45"E) at around 13:41 on March 5, 2017.

Photo 4: mountain surface covered with trees

(See Figure 1: estimated flight route, Figure 2: vertical cross section chart of the estimated flight route, Photo 4: mountain surface covered with trees, and Photo 5: movement of captain's upper right arm (-1'30").

Table 1: situation in the interior and situation of the helicopter

Times (hh : mm: ss) Time (m ['] s ["]) up until the collision	Situation in the interior (audio or video images)	Situation of the helicopter
13:36:33 -4'17"	Mechanic A: Minus 2 (-2)	Climbing above the city
13:36:48 -4'02"	Captain: It is too big as usual.	Climbing above the city
13:36:49 -4'01"	Mechanic A, holding a data sheet, extends a hand to the right pilot seat.	Climbing above the city At an altitude of 4,900 ft (about 1,490 m)
13:36:50 -4'00"	Mechanic A: <u>It needs more Trim Control, over there.</u>	Climbing above the city

13:36:52 -3'58"	Captain: Split is much.	Climbing above the city
13:37:09 -3'41"	Mechanic A: I return it.	Climbing above the city
13:38:50 -2'00"	Rescuer B: Right rear clear.	Just commenced turning right above the mountains
13:39:20 -1'30"	The captain right upper arm moved.	Almost level flight above the mountains
13:40:50~54 0'00" to 0'04"	(Violent noises)	After collision with trees

- Underlined sentences show poorly-heard conversations.

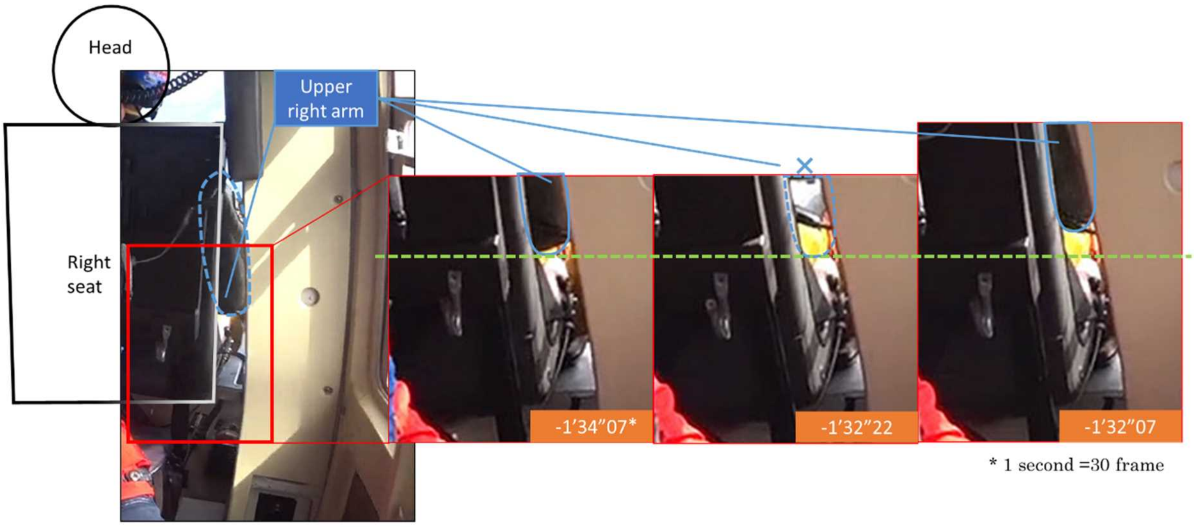

Photo 5: movement of captain's upper right arm (-1'30")

2.2 Injuries to Persons

There were nine persons on board the helicopter, consisting of the captain and eight others (one mechanic and seven rescuers), and all of them suffered fatal injuries.

2.3 Damage to the Helicopter

2.3.1 Extent of Damage

Destroyed.

2.3.2 Damage to the Helicopter Components

Fuselage: Damaged
Main rotor (MR): Damaged
Tail boom (TB): Broken and damaged
Tail rotor (TR): Damaged
Engine: Damaged
Transmission: Broken and damaged
Control system: Broken

2.4 Personnel Information

Captain Male, Age 56

Commercial pilot certificate (Rotorcraft)	August 3, 1989
Specific Pilot Competence Expiry of practicable period for flight	February 17, 2018
Rating for multi-turbine engine (land): Bell 212	April 3, 1996
Class 1 aviation medical certificate	
Validity	September 29, 2017
Total flight time	5,117 hrs. 01 min.
Flight time in the last 30 days	6 hrs.40 min.
Total flight time on the same type of the Helicopter (Bell 412EP)	More than 3,425 hrs. 49 min.
Flight time in the last 30 days on the same type of the Helicopter	6 hrs.40 min.

2.5 Aircraft Information

2.5.1 Aircraft

Type	Bell 412EP
Serial number	36135
Date of manufacture	August 8, 1996
Certificate of airworthiness	Dai 2016-203
Validity	July 12, 2017
Category of airworthiness	Rotorcraft Transport TA or TB, or Special aircraft X
Total flight time	5,559 hrs. 09 min.
Flight time since last periodical check (300 hours/12-month inspection carried out on February 26, 2017)	3 hrs. 19 min.

(See Photo 6: the helicopter [provided by the Center] and Appendix 1: three angle view of a Bell 412EP)

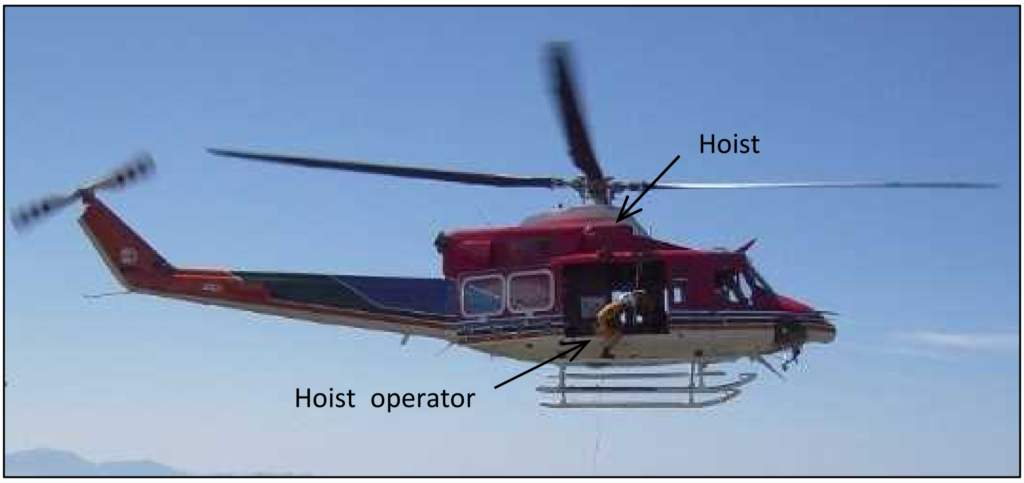

Photo 6: the helicopter (provided by the Center)

2.5.2 Weight and Balance

At the time of the accident, the weight of the helicopter is estimated to have been 10,582 lb, the position of the front-back center of gravity is estimated to have been 136.24 aft of the base plane (20 in aft of the leading tip of the nose), and the left-right center of gravity is estimated to have been 0.21 in to the right of the fuselage's symmetric plane. It is highly probable that each was within the allowable ranges (maximum weight of 11,900 lb, position of front-back center of gravity with respect to the helicopter's weight at the time of the accident of 133.0 to 142.5 in, and position of left-right center of gravity of between 4.5 in left and 4.5 in right). The positions of center of gravity were calculated by considering that the rescuers, who sat directly on the cabin floor, would sit in the seats of the same positions as on those positions on the floor.

2.6 Meteorological Information

2.6.1 Regional Aviation Weather Report

The 06:00 aeronautical weather summary for the Kanto and Chubu regions that was announced by the Tokyo Aviation Weather Service Center at 06:30 on March 5, 2017, was as follows:

There is a high-pressure system in Japan's south that is moving east. An underlayer of warm and moist air moving around the edge of the high-pressure system is flowing in, and radar echoes are observed from offshore of the Kii Peninsula to the southern part of the Izu Islands. Atmospheric conditions are becoming unstable.

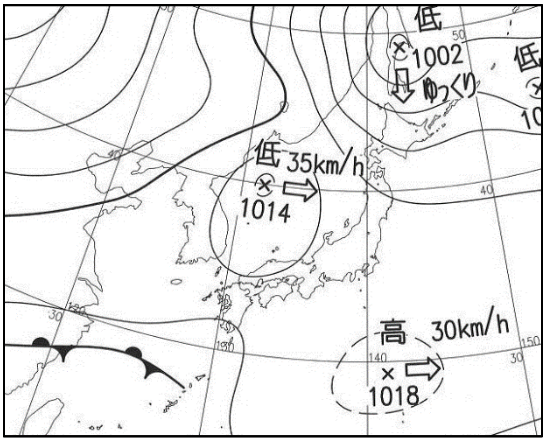

Figure 3: portion of preliminary weather map [12:00 on March 5, 2017]

Ground report: VMC (visual meteorological conditions) at all airports in area in charge.

(See Figure 3: portion of preliminary weather map [12:00 on March 5, 2017])

2.6.2 Weather Observations at the Airport

Aviation weather observations around the time when the accident occurred at the Airport, located approximately 10 km west of the crash site, were as follows.

13:00 Wind direction 360°; Wind velocity 4 kt; Wind direction variation 300° to 070°; Prevailing visibility 30 km

Cloud: Amount 1/8, Type cumulus, Cloud base 6,000 ft
Amount 6/8, Type unknown, Cloud base unknown

Temperature 12°C; Dew point -2°C; Altimeter setting (QNH) 29.85 inHg

14:00 Wind direction 350°; Wind velocity 9 kt; Prevailing visibility 30 km

Cloud: Amount 1/8, Type cumulus, Cloud base 6,000 ft
Amount 7/8, Type unknown, Cloud base unknown

Temperature 13°C; Dew point -3°C; Altimeter setting (QNH) 29.82 inHg

Additionally, observations around the time when the accident occurred at Matsumoto-Imai Regional Weather Station located at the Airport, were as follows.

13:40 Wind direction North-northwest; Wind velocity 5.1 m/s; Maximum instantaneous speed 7.2 m/s; Temperature 13.2°C; Precipitation 0 mm

2.6.3 Information on the Weather Ascertained from the Video Camera Images

The ridgeline of the mountains near the flight route is visible in the images of the video camera worn by rescuer B that was described in 2.1.1 (1), and visibility was good without any phenomena that impeded visibility nearby.

(Photo 7: video camera image (-0'50"))

Photo 7: video camera image (-0'50")

2.7 Accident Site and Wreckage Information

The crash site was an approximately 40-degree north-facing slope covered with snow at an elevation of approximately 1,700 m, approximately 700 m north-northeast from the summit of Mt. Hachibuse (elevation: 1,928.8 m). The helicopter was turned upside-down with the nose pointing southwest. The TB had broken off from its base to be under the fuselage. The four MR blades (MRB), which were severely fractured and bent, were located near the fuselage. Trees situated north-northwest of the crash site were broken. There was no sign of fire.

There are marks indicating the helicopter collided with approximately ten-meter-high trees on a ridge of an elevation of approximately 1,730 m, approximately 140 m north-northwest of the crash site. Several trees were cut off, and the left cockpit door, the lower fuselage parts, the MRB parts, and other items of the helicopter were scattered nearby. Pieces of the MRB and the fuselage, the left pilot seat's collective pitch control lever (hereinafter referred to as "the CP Lever") head and other items were scattered within approximately 40 m wide from the site of the collision with the trees to the crash site. Around the helicopter, log papers reading "In flight engine data table" and captain's camera (his name was written on it) were scattered.

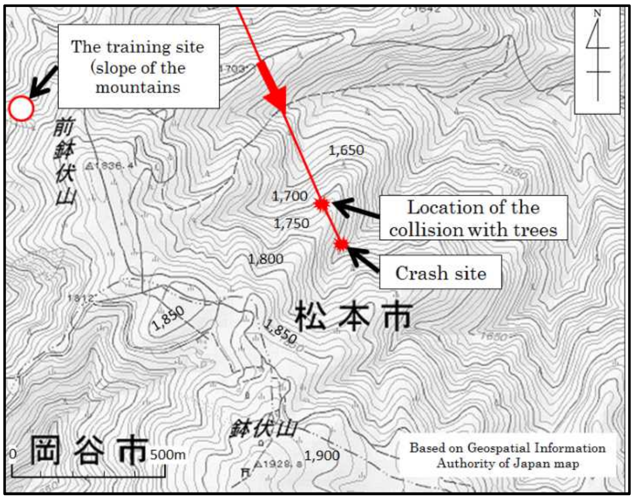

Figure 4: the accident site

(See Figure 4: the accident site, Figure 5: site cross-section, Photo 8: the accident helicopter (accident site), Photo 9: the left pilot seat's CP lever head, Appendix 2: results of measurements taken at the accident site, and Appendix 3: image prepared based on information from drone images.)

Photo 8: the accident helicopter (accident site)

Photo 9: the left pilot seat's CP lever head

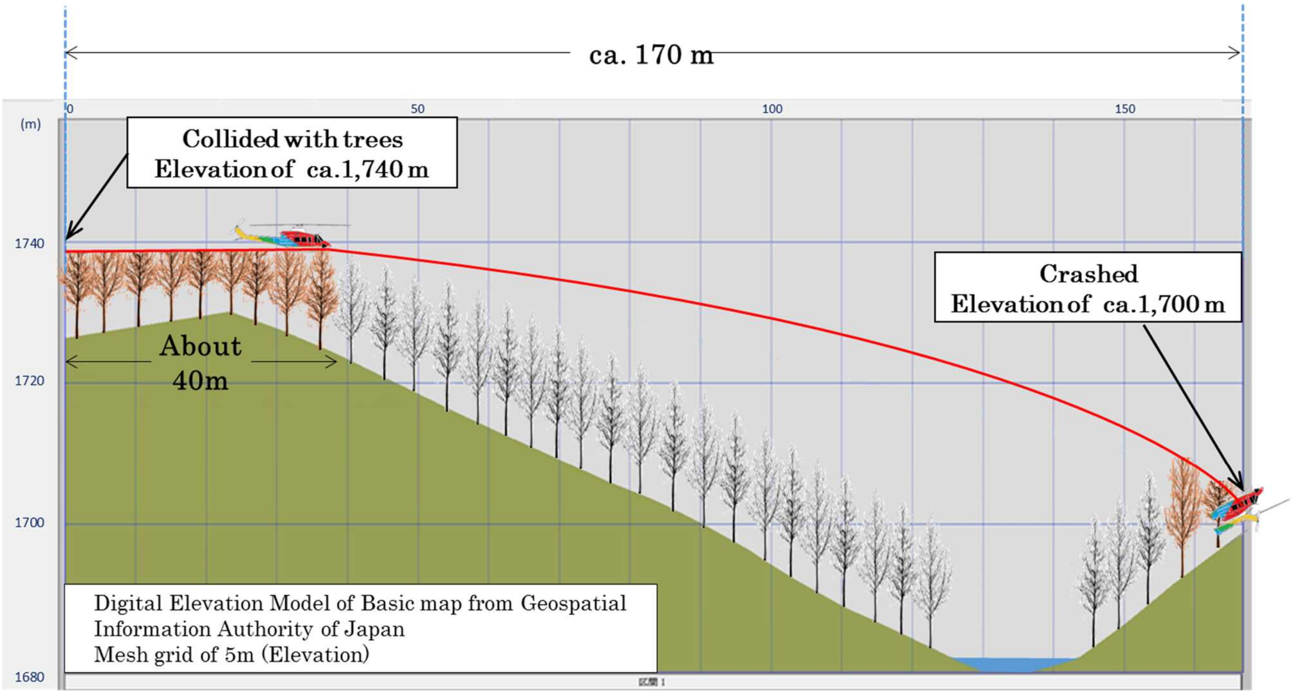

Figure 5: site cross-section

2.8 Damage Details

(1) Fuselage

Much of the cabin was damaged by the force of impact from the front and above. Most of the aft fuselage was severely damaged with the engine attached to the engine deck. All of the windows and doors were severely damaged by the force of impact. The landing gear was relatively undamaged.

(See Photo 10: the accident helicopter (entire helicopter) and Photo 11: cabin)

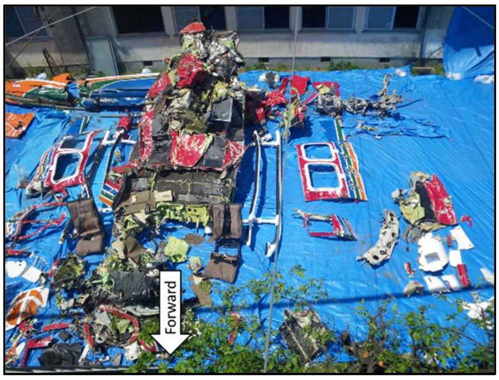

Photo10: the accident helicopter (entire helicopter)

Photo 11: cabin

(2) MR

The four MRBs, which rotate counterclockwise when viewed from above, are identified by the colors of green, blue, orange and red. The yokes of the green MRB and blue MRB were bent downward and were fractured near the spindle. The yokes of the orange and red MRBs were bent upward. The pitch link of the green MRB was fractured at the end of the pitch horn but joined at the rephasing lever. The pitch link of the blue MRB was joined with the pitch horn but fractured at the end of the rephasing lever. The pitch link of the orange MRB was fractured at both ends. The pitch link of the red MRB was fractured at the end of the pitch horn but joined at the rephasing lever.

All of the MRBs were severely damaged overall.

(See Figure 6: MR hub, Photo 12: MR hub, and Photo 13: MRB)

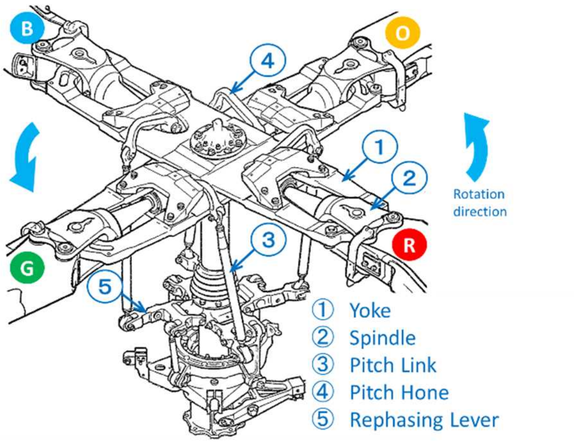

Figure 6: MR hub

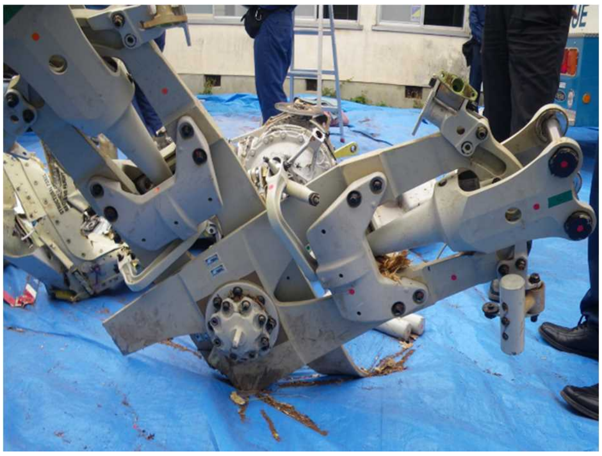
Photo 12: MR hub

Photo 13: MRB

(3) TB

The TB broke off from the aft end of fuselage and was fractured together with the TR's driveshaft at the front of the elevator. The TB was deformed and damaged on the whole. The 42-degree gearbox could not be turned manually because of damage to the TR driveshaft. The 90-degree gearbox rotated manually, but its rotation was limited by the damage to the TR driveshaft.

(See Photo 14: TB)

Photo 14: TB

(4) TR

The two TRBs were bend at the tip sides of their doublers and damaged.

(See Photo 15: TR)

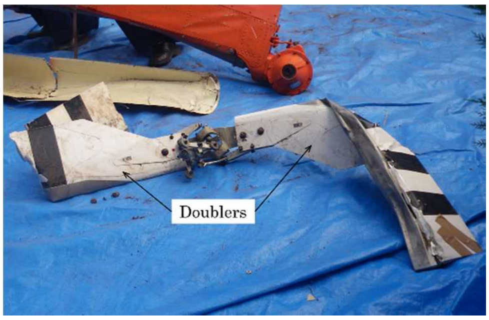

Photo 15: TR

(5) Engines

There were cracks in the gearbox, missing components, deformation of the exhaust pipe, and other damage. The No. 1 engine and No. 2 engine were not connected due to damage of the combine gearbox.

(6) Transmission

The transmission fell off together with its support case and was damaged. It was verified that the drive system was connected by rotating the main input quill and observing movement of the mast through the transmission with movement of the rotor brake disc.

The sump (lubricating oil reservoir) was broken from the support case; however, lubricating oil was present inside the transmission. The sump's chip detector (metal particle detector) was removed and no chips were observed in a visual inspection. The mast and lower chip detectors were removed and no chips were observed in a visual inspection. The oil filter had no chips or foreign material and indicated that it was not being bypassed (normal function).

(See Photo 16: Transmission)

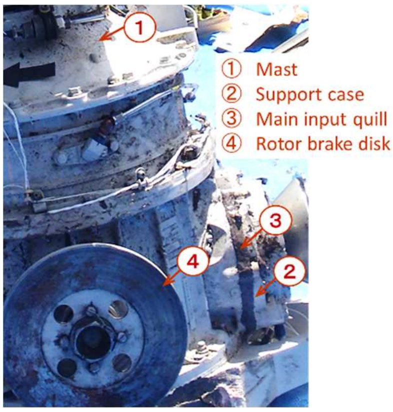

Photo 16: transmission

(7) Control system

The control system was heavily damaged by the force of the impact, and therefore the system's connectivity could not be confirmed.

2.9 Medical Information

2.9.1 Information on Deaths and Injuries

According to the Nagano Prefectural Police, the causes of death of each person on board were as follows:

The captain died from cardiac and aortic injury and the cause of death for mechanic A and seven rescuers were multiple trauma, all of which were caused by extremely strong blunt blows on the whole body.

The blood test for the captain and mechanic A found negative for alcohol and drugs listed as the test items. And there was no findings indicating the incapacitation during the flight such as angina, cardiac infraction and others on the captain and mechanic A.

2.9.2 Information on Past Medical History for the Captain

The past medical history (including operative information) for the captain was as follows:

(a) In January 2011, received a diagnosis of hyperthyroidism, and in April 2011, received radiation treatment for hyperthyroidism.

(b) In November 2013, received a diagnosis of adventitial cystoma of the right popliteal artery, in January 2014, underwent surgery for right popliteal artery graft, and in May 2015, underwent surgery for occluded vessel graft replacement of the right popliteal artery.

The Civil Aeronautics Acts (established on July 15, 1952; Act No. 231) states as follows:

Article 71 (Physical Disabilities) No member of the aircrew of an aircraft shall, when he/she becomes physically unfit to the medical examination standards under Article 31 paragraph (3), engage in air navigation services, even if his/her aviation medical certificate issued under Article 32 is still valid.

In addition, the Ordinance for Enforcement of the Civil Aeronautics Act (established on July 31, 1952: Ministry of Transport Ordinance No. 56) states as follows (excerpts):

Article 61-2 (Medical Standards and Aviation Medical Certificate) The medical standards pursuant to the previsions of Ordinances of the Ministry of Land, Infrastructure, Transport and Tourism pursuant to Article 31 paragraph (3) of the Act and the aviation medical certificate pursuant to paragraph (2) of the Article shall be as the following table.

Qualification	*Medical standards*	*Aviation medical certificate*
Commercial pilot	*Class 1*	*aviation medical certificate (class 1)*

(2) The contents of the medical examination standards listed in the table of the preceding paragraph shall be as listed in Appended Table 4, and the format of aviation medical certificate shall be in accordance with Format 24.

Appended table 4 (Re: Art. 61-2)

Physical examination criteria

Examination item	*Class 1*
1 General	*(5) A person shall not have endocrine disorder or metabolic disorder, or organ damage or dysfunction due to these disorders that may disrupt flight disorders.*
3 Circulatory system and vascular system	*(9) A person shall not have arterial disease, venous disease, or lymphatic disease that may disrupt flight operation.*

The Civil Aviation Bureau's "Manual for Aviation Medical Examinations" (issued on March 2, 2007; Kokukujo No. 531), to which the designated aviation medical examiners shall refer in order to judge the suitability for performance of aviation duties, states as follows (excerpts):

1-5 Endocrine and Metabolic Diseases

2. Disqualifying Conditions

2-1 Thyroid disease requiring treatment

3. Examination Procedures and Precautions

3-1 If the applicant has a history of thyroid disease or is suspected of having the disease, a thyroid function test should be performed.

4. Evaluation Precautions

4-1 If an applicant with thyroid disease (postoperative and post-isotope-treatment) is receiving hormone replacement therapy, he/she is qualified if he/she is asymptomatic with stable FT3 and FT4 [2]*levels over a follow-up period of at least one month after the fixed dose and dosage regimen of the drug has been reached.*

5. Notes

5-3 When the applicant with any of the disqualifying conditions described in paragraph 2 above has a history of surgery for an endocrine or metabolic disease such as pituitary disease, adrenal disease or parathyroid disease, but currently does not need treatment and has normal endocrine function, he/she may apply for the judgment of the Minister of Land, Infrastructure, Transport and Tourism by submitting his/her operative report, postoperative test results on the endocrine system and the clinical course including current status and treatments.

5-4 If the applicants comes under the criteria described in subparagraphs 5-1 to 5-3 above, provided he/she is doing well after a sufficiently long follow-up period, with conditions not expected to progress, he/she may thereafter be granted qualification by a designated examiner by order of the Minister of Land, Infrastructure, Transport and Tourism.

3-9 Vascular Diseases

2. Disqualifying Conditions

2-1 Arterial diseases

(2) Aneurysm or history of its treatment

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*[2] "FT3" and "FT4" are hormones secreted from the thyroid gland, which regulate functions of the metabolism and the sympathetic. Testing those levels in blood indicates the status of the thyroid.

3. Examination Procedures and Precautions

3-1 If aneurysm is suspected, a careful diagnosis should be made by such means as imaging.

5. Notes

5-1 If an applicant who received surgical treatment for an aneurysm (e.g., graft replacement) is doing well after a sufficiently long follow-up period, he/she may apply for the judgment of the Minister of Land, Infrastructure, Transport and Tourism by submitting medical records including the details of the surgery and other treatments and the results of blood tests such as tests of coagulation system.

Given the above, the medical history of the captain should have been declared by himself and confirmed by the designated aviation medical examiners and others respectively about whether to hinder his performance of aviation duties, when those diseases were diagnosed for the first time, or when he applied for Aviation Medical Examinations.

2.9.3 Information on Medicines Prescribed to the Captain

The Medicines proscribed to the captain up until the day of the accident were as follows:

(a) Thyradin-S (Thyroid hormone preparation)

(b) Sarpogrelate hydrochloride (Antiplatelet agent)

(c) Plavix (Antiplatelet agent)

(d) Methycobal (Peripheral nerve disorder treatment agent)

The Civil Aeronautics Acts states as follows:

Article 70 (Intoxicants etc.) No member of the aircrew shall engage in air navigation services while he/she is under the influence of alcohol or drugs or other chemical agents which are likely to impair in anyway his/her ability to perform normal operations of aircraft.

In addition, "Guidelines for the Handling of Medical and Pharmaceutical Products Used by Aircrews" (issued on March 30, 2005; Kokukujo No. 491; herein after referred to as the "Guidelines for the Handling of Medical and Pharmaceutical Products") established by the Flight Standards Division, Aviation Safety and Security Department, Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism states as follows (excerpts):

2. Principle of Using Medical and Pharmaceutical Products

If an aircrew uses any of the medical and pharmaceutical products, he or she shall be required to comply with the provisions of Article 70 and 71 of the Civil Aeronautics Acts and make an appropriate self-judgment. However, regarding the side effects of the medical products in use, if required, it shall be confirmed by the designated aviation medical examiners (designated doctors) or industrial doctors of airlines (aviation industrial physicians) about whether those products conform to the standards for aviation medical examination, including a judgment on the criteria of those medicine use, pursuant to the provisions of "3. Operational Guidelines for Use of Medical and Pharmaceutical Products". In addition, other than the cases mentioned above, it is desirable that aircrews get advice from the designated doctors regarding the cases where it is difficult to make a self-judgment on the influence from their medical products use on their mind and body.

Designated doctors or aviation industrial physicians shall appropriately explain or give advice to aircrews in accordance with the guidelines if asked to confirm or give advice on the use of medical and pharmaceutical products, when they shall need to explain about the following three main items.

- *Possibility that the diseases, for which the medical products are used, would hinder the performance of aviation duties*
- *Possibility that flight conditions (time difference, dehydration, hypoxia and others) would have effects on the response to treatment*
- *Possibility that medical products would develop the adverse effect to impair the safety of aviation*

Even if some crew members stop using medicine, there may be unsuitable for the performance of aviation duties for a certain period of time, because the adverse effect of the medication would not be lost immediately after stopping taking the medicine.

However, medical drugs shall be used for remedies against diseases and aircrews shall have access to effective medical treatment and drugs, which make it possible for them to engage in the aviation duties. It is important to ensure the balance among the appropriate air aviation service standards, medical treatment and their diseases, which is the best for both aircrews taking medicine and the safety of aviation.

In addition, aircrews shall realize that their medical treatment may cause problems, make efforts so that these problems would not hinder the performance of aviation duties, and be mindful of the following matters.

- *When an ethical pharmaceutical is prescribed, aircrews shall receive an adequate explanation for it including its adverse effects, and keep the certificate of medication or its alternative*
- *At the time of purchase of an over-the-counter-drug, aircrews shall understand the contents of the medicine explanatory documents and medicine information attached and keep them, in addition, aircrews shall have the drug stores and the like issue the documents (receipts or others) containing information on the purchase dates, the purchased name of medication, the number of purchased medicines, the purchased stores (these documents would be necessary to issue a sales certificate in the event that there are some adverse effects and it needs to apply for the relief system for sufferers from adverse drug reactions).*
- *Aircrews shall not use the medical and pharmaceutical products whose adverse effects cannot be understood.*
- *Aircrews shall not use the medical and pharmaceutical products that have not passed a year since their being approved and authorized for marketing because their adverse effects have not been fully confirmed.*
- *Aircrews shall also use the medical and pharmaceutical products prescribed and purchased abroad in accordance with laws and regulations of Japan and the guidelines.*

3. Operational Guidelines for Use of Medical and Pharmaceutical Products

It is not possible that the guidelines for use of medical and pharmaceutical products indicate whether to consist with safety flight or not regarding all the medical and pharmaceutical products. Concerning the widely used typical medical and pharmaceutical products and those products used in aviation environment, the guidelines explain about the effect of such products on the performance of aviation duties classifying those products into the following four groups in accordance with the degree of effects on the performance of aviation duties.

A. Medical and pharmaceutical products that are considered safe when used during the performance of aviation duties

B. Medical and pharmaceutical products that require individual confirmation by a designated *doctor or aviation industrial physician well-versed in aviation medicine when used during the performance of aviation duties*

C. Medical and pharmaceutical products that require a judgment on the conformity to the standards for medical examinations by the Minister of Land, Infrastructure, Transport and Tourism

D. Medical and pharmaceutical products that are unsuitable / non-conformity

If it is difficult for the designated doctor to make a judgment on the conformity to the standards for medical examinations about the aircrew using medicine, the aircrew shall be judged as unsuitable / non-conformity by the designated doctor, and he/she shall apply for the judgment of the Minister of Land, Infrastructure, Transport and Tourism by submitting detailed on current status and treatments.

B. Medical and Pharmaceutical Products That Require Individual Evaluations by a Designated Doctor or the Aviation Industrial Physician When Used during the Performance of Aviation Duties

If an aircrew uses any of the medical and pharmaceutical products listed below, he or she must not engage in the performance of aviation duties unless, from the viewpoint of the effects of such products on the normal operation of aircraft and conformity to the standards for medical examinations, a designated doctor or an aviation industrial physician well-versed in aviation medicine confirms the degree of diseases for which they are used, their side effects, and other factors.

○ *Thyroid-hormone replacement therapy*

If an applicant with thyroid disease is receiving hormone replacement therapy, it must be observed and confirmed by a designated doctor or the aviation industry physician that he/she is asymptomatic with stable FT3 and FT4 levels over a follow-up period of at least one month after the fixed dose and dosage regimen of the drug has been reached.

C. Medical and Pharmaceutical Products That Require Judgment by the Minister of Land, Infrastructure, Transport and Tourism regarding the Conformity to the Standards for Medical Examinations

The following medical and pharmaceutical products need to be taken into consideration regarding the fact that they are prescribed for treatment of specific diseases. Therefore, in the aviation medical examination, not only the issues on the use of medical and pharmaceutical products but also the paragraph regarding relevant diseases must be referred to.

If an aircrew uses any of the medical and pharmaceutical products listed in paragraph C, he or she must stop engaging in the performance of aviation duties at the same time when starting to take those listed medical products, and when non-conformity is confirmed, he or she must apply for the judgment of the Minister of Land, Infrastructure, Transport and Tourism before his / her resuming the performance of aviation duties.

The medical and pharmaceutical products listed below are only part of examples and there are many other medical products that fall under the paragraph C. Even if those products are not described in this section, if an aircrew takes or plans to take the medical products whose side effects are not confirmed or concerned, and if it is not sure or could be confirmed to have the effects of such products on the normal operation of aircraft, the designated doctors should not issue an aviation medical certificate to the aircrew, and the aircrew should apply for the judgment of the Minister of Land, Infrastructure, Transport and Tourism.

○ *Antiplatelet agent*

From the above, the medical products prescribed to the captain should have been declared by captain to the designated aviation medical examiners and others, and have been confirmed respectively by the doctors on whether to have effects on his performance of aviation duties or not, when those medical products were prescribed to the captain for the first time, and subsequently when he applied for aviation medical certificate.

However, it could not be determined whether the captain had taken those proscribed medical products on the day of the accident because those products were not included the drug test items described in 2.9.1.

2.9.4 Captain's Application for Aviation Medical Certificate

In the "Item No. 14: Medical History and Others" of the application form the captain submitted to apply for the aviation medical certificate, where applicants should answer about the existence of various diseases and conditions such as diabetes, endocrine disorder or metabolic disorder (hyperlipidemia, hyperuricemia), allergic diseases (asthma, allergic diseases), excessive daytime sleepiness, indication of snoring, mental disorder or disorder of nervous system, attempt of suicide, impaired consciousness including epilepsy, paralysis and fainting, all were marked "No".

In addition, the "Item No. 15: It shall be described (body parts, cause of disease, the time and period) as detailed as possible, if applicable", has some comments fields such as "Hospital stay or surgical operation", "Medical and pharmaceutical products that are regularly used today (including external medicine and sleeping pill)", but there were no comments in all of those fields.

Besides, the aviation medical certificate was issued to the captain since the aviation medical examination, which the captain took without declaring his medical history and others, did not reveal any abnormality regarding the test items checked in the examination.

2.9.5 Thorough Confirmation of the Self-reported Medical Information for the Aviation Medical Examination

In response to the accident of a private owned aircraft (AA2007-6-3 Aircraft Accident Investigation Report by the Japan Transport Safety Board (JTSB)), in December 2007, the Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism made it known to the designated aviation medical examiners that they should have applicants fully realize the importance of self-reported medical information for the aviation medical examination and strive to confirm applicants' self-reported medical information by means of grasp of the medical history and use of medical and pharmaceutical products as much as possible by interviewing the applicants, and so on. Furthermore, upon receiving from the JTSB the factual information on the aviation medical examinations for the captain, which was obtained in the accident investigation of the aircraft operated by the Independent Administrative Institution Civil Aviation College (hereinafter referred to as "the College") (AA2013-9-1 Aircraft Accident Investigation Report by the JTSB), in 2011, the Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism further requested the College, the designated domestic air carriers, the Japan Aircraft Pilot Association, the Scheduled Airlines Association of Japan, the Japan Coast Guard, the National Police Agency, and the Fire and Disaster Management Agency to commit making it known thoroughly that all the relevant aircrews belonging to these organizations and institutions, from the viewpoint of the effects of such products on the normal operation of aircraft and conformity to the standards for medical examinations, must comply with the guidelines for use of medical and pharmaceutical products at the time of using medical products. Moreover, the Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism also requested the designated aviation medical examination facilities and aviation medical examiners to endeavor to make the guidelines known to aircrews at the time of aviation medical examinations and medical consultations from now.

2.10 Information concerning Fire, Firefighting, and Rescue

According to Nagano Prefecture's Crisis Management Department, the captain and two rescuers were placed aboard a NPAU helicopter and transported to a hospital on the day of the accident. The following day, mechanic A and two rescuers were placed aboard a NPAU helicopter, two rescuers were placed aboard a Saitama Fire and Disaster Prevention Aviation Center helicopter, and one rescuer was placed on a Gifu Fire and Disaster Prevention Aviation Center helicopter and all were transported to a hospital. All of the persons on board were confirmed to be deceased at the hospital. The estimated time of death was around 13:40 on March 5, 2017.

2.11 Information on Tests and Research

2.11.1 Internal Examination of the Engine by Borescope

The helicopter was equipped with one PT6T-3D Twin-Pac engine manufactured by Pratt & Whitney Canada. The engine is comprised of two engines coupled to a combining gearbox (CGB). Each engine consists of a three-stage axial compressors and single-stage centrifugal compressor, the combustion chamber, a single-stage compressor turbine and power turbine respectively.

It was confirmed whether manual rotation was possible or not, but found that it was not possible for both engines. When an observation of the engines' interior was conducted using a borescope, scratches were found within the axial compressor's first stage and compressor turbine case of both engines. The power turbine blades of both engines were fractured and scratches were found inside their cases.

(See Photo 17: engine interior)

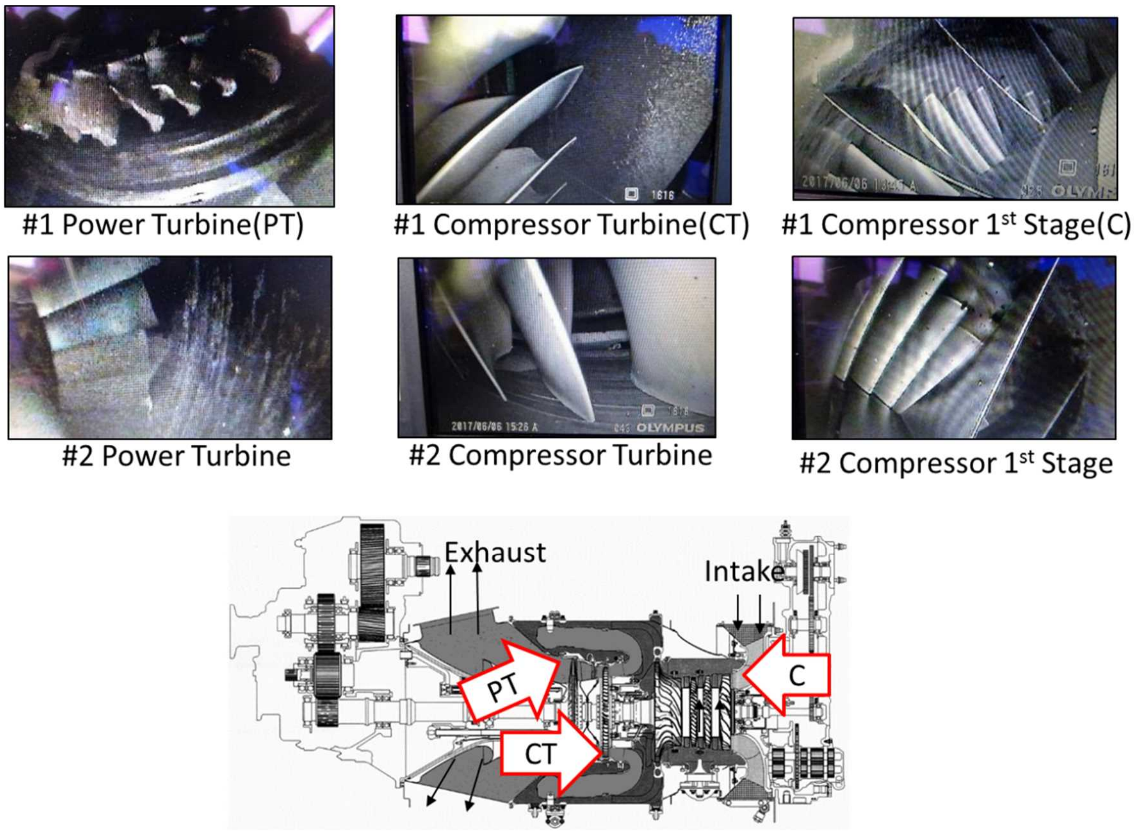


Photo 17: engine interior

2.11.2 Information on the Autopilot

The helicopter had a dual-system autopilot (hereinafter referred to as "the AP"). An examination of the DFCCs (Digital Flight Control Computer), which are the AP's computers, was conducted by their manufacturer (Honeywell), and the records of error codes that had been stored in the computer were extracted. The two DFCCs both indicated that they were working properly at the time of the accident. Nothing was found to be associated with the accident from the records of the error code extracted from the DFCCs.

The AP has the two modes, one is to increase the stability (hereinafter referred to as "the SAS mode"), and the other is to fly while further maintaining the designated value of the attitude (hereinafter referred to as "the ATT mode"). At the time of autopilot, the helicopter selects the ATT mode, however, even at the time of manual operation, it is possible for the helicopter to obtain a stable attitude with the SAS mode.

2.12 Additional Information

2.12.1 Information on the Captain's Helmet

The helmet worn by the captain was found still being worn by the captain near the crash location. The visor was lowered at the time of its discovery. There was an impact mark near the center of the visor, and approximately half of the visor's right side was missing. The visor cover had fallen off the helmet, but there was almost no sign of impact marks or the like. Additionally, almost no damage to the main body of the helmet was found.

(See Photo 18: captain's helmet)

Photo 18 captain's helmet

2.12.2 Information on the In Flight Engine Data Table

(1) Record contents of the In flight engine data table

The contents recorded in log papers reading "In flight engine data table" mentioned in 2.7 is as shown in Table 2. Data concerning the engine were recorded six times from the time the helicopter was at a pressure altitude of 2,500 ft (approximately 760 m: AGL of approximately 100 m) during its climb following takeoff to the time when the helicopter transitioned to approximately level flight at 5,700 ft (approximately 1,740 m). The third and fourth times were data from the check called a "range check" that were conducted while the helicopter climbed at 700 ft/min. In the remarks column is the notation "ITC+2 range is too low!!", however, all of the data were within allowable limits. In the data for the sixth time, when the helicopter transitioned to level flight, mast torque was 60% of that used in normal cruising. In addition, "1310 lb" was recorded as a whole in one remarks column from the third to the fifth times, and also "1310 lb" in the remarks column for the six times

(See Photo 19: the In flight engine data table)

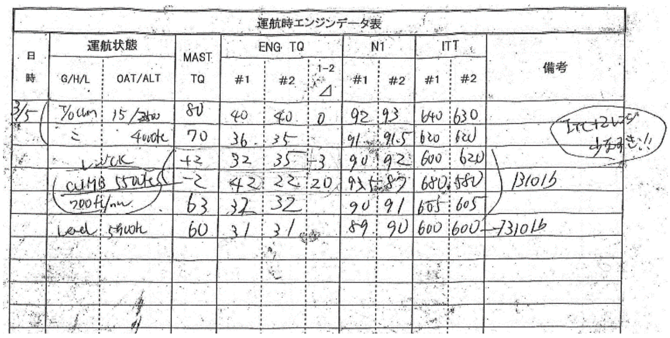


Photo 19 the In flight engine data table

Table 2: the contents recorded in the In flight engine data table

Time/Date	Flight Condition: State	Flight Condition: OAT/ALT	Mast Torque	Engine torque #1	Engine torque #2	Engine torque 1-2	N1 #1	N1 #2	ITT #1	ITT #2	Remarks
3/5	Takeoff Climbing	15/2500	80	40	40	0	92	93	640	630	
	〃	4000	70	36	35		91	91.5	620	620	ITC＋2 range Too low !!
	Range check In Climbing at 5500ft 700ft/min		+2	32	35	-3	90	92	600	620	1310 lb
			-2	42	22	20	93.5	87	680	580	
			63	32	32		90	91	605	605	
	Level flight	5700	60	31	31		89	90	600	600	1310 lb

(2) Information provided by the Center's aviation chief

He thinks that the mechanic A created originally the log papers called "In flight engine data table" and brought them on board to record the engine data and he sometime checked them. If there is no abnormality to be noted, the data is not saved as the documents, therefore, no data in the past are not saved in our center.

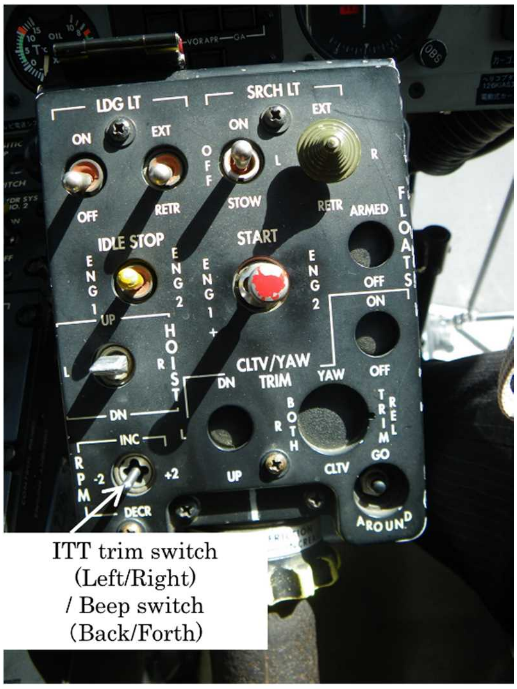


Photo 20: the right pilot seat's CP lever head

The "range check" means the engine data check that is conducted to obtain the data used for N2 (power turbine RPM) control adjustment. During the range check, a pilot flew the helicopter by mainly watching outside, but a mechanic is not able to watch outside because he or she has to concentrate on checking flight instruments while extending the right hand to the right pilot seat and operating the ITT trim switch on the CP lever head in the right pilot seat. When a mechanic conducts a range check after telling a pilot that he would do it, however as data are usually obtained en route on the flight route, it's not necessary to specifically give an instruction on the flight route. Besides, the range check would not be conducted in every flight, let alone on mountain flights.

The helicopter conducted a maintenance work on February 28, 2017 to adjust N2 control, however, as it was not able to adjust it completely, it might conduct the range check to confirm it during the flight of the accident.

When looking at the recorded engine data, the recording has started from when the helicopter commenced to climb just following taking off and the data from the range check is put in the third and fourth lines in the table. The torque differential between the left and right engines is more than 5% that requires the adjustment. The ITC seems to stand for ITT Trim Control. I think the comment of "+2 range, it is too low" means that when adjusting the trim to +2 at mast torque of 70%, he wanted to set the torque in Engine 1 at about 30% and the one in Engine 2 at about 40% respectively, but the torque differential was 3% that was too small. The "1310 lb" in the remarks column seems to indicate the quantity of remaining fuel. It seems that the mechanic A recorded the data from the third to fifth times in a short time and just after that, he recorded the data from the sixth time quickly.

(See Photo 20: the right pilot seat's CP lever head)

2.12.3 Inspection with the Same Type of Helicopter

Video camera image (-4'01")

In the inspection (operating the ITT trim switch with the CP lever moved to the position at the time of climbing)

Photo 21: right arm of mechanic A

(1) Position of mechanic A's right hand

As shown in Photo 21, when the CP Lever was moved up to the same position as at the time of climbing, and the right hand was extended to the ITT trim switch, almost the same composition as in the image of video camera (-4'01") was reproduced.

(See Photo 21: right arm of mechanic A)

(2) View from the cockpit

The inspection was conducted after parking the helicopter with a magnetic heading of 150 degrees, the same heading as at the time of accident. It was conducted at about 13:40 on April 10, 2018, however, the pilot's face was not exposed to direct sunshine. The pilot's view was not blocked and it was possible for him to recognize visually the obstacles lying ahead in keeping the piloting posture, when either only sliding a glance to the instruments without moving his head or facing to the instruments and looking at them. However, when the body was bent forward and the head was lowered a little, the glare shield blocked the forward view (the horizon). Therefore, it seems that when the obstacles lying ahead is approaching, the approaching obstacles may not be recognized visually. In the posture of the mechanic A in (1) mentioned as above, the forward view was blocked because the position of the head lowered.

With two side mirrors installed around the foot part of the outside of the helicopter's window, the view could be limited. When looking at the pilot's face with the visor lowered, the opening state of eyes and his facial expressions were not recognized.

(See Photo 22: eye level in the cockpit.)

Right seat : Facing to the instruments and looking at them

Left seat : the right hand extended to the ITT trim switch

Photo 22: eye level in the cockpit

(3) Different Views with and without Visor

The different views with and without the visor that is attached to the helmet was confirmed. Without the visor, the contrast between outside and inside the helicopter was clear and when looking outside, it seemed that the view was too bright. Immediately looking at the instruments inside the helicopter, it was not to say that anything could not be seen but eyes seemed tired. With the visor lowered, the outside view was clear and not too bright. Immediately looking at the instruments inside the helicopter, it seemed a little dim, but the instrument indicators were readable.

(See Photo 23: views with and without visor)

Photo 23: views with & without visor

(4) Information on the Intercommunication of the Helicopter

It is possible to cut off the intercommunication between passengers and aircrews by turning off the passenger switch on the instrument panel. However, as the headsets for the rescuers are designed to be connected with the intercommunication system, it is pointless to turn off the switch, and I heard it has never been used in an actual rescue operation. As the intercommunication to be recorded on the video camera is picked up through its extension microphone inserted in the speaker of the helmet worn by rescuer B. Therefore, if the microphone comes off the helmet, the intercommunication is not recorded.

2.12.4 Analysis of the Video Camera's Audio

An analysis of the audio recorded by the video camera worn by rescuer B that was mentioned in 2.1.1 (1) found that a spectrum of approximately 22 Hz was recorded at a constant frequency from the beginning of the video until 4.0 seconds before audio recording stopped. Assuming that the sound was generated by the MR, this would be equivalent to approximately 330 rpm. The 100% number of MR revolutions is 324 rpm.

An audio spectrum of approximately 3,300 Hz and an audio spectrum of approximately 3,400 Hz, which were transmitted at a constant frequency respectively. However, immediately after the voice of "minus two", in the former case, the frequency increased by approximately 200 Hz, while in the latter, the frequency decreased by approximately 200 Hz. Those frequencies returned to original frequencies and they were constantly transmitted again, immediately after the voice saying "I return it."

(See Figure 7: audio spectrum inside the helicopter)

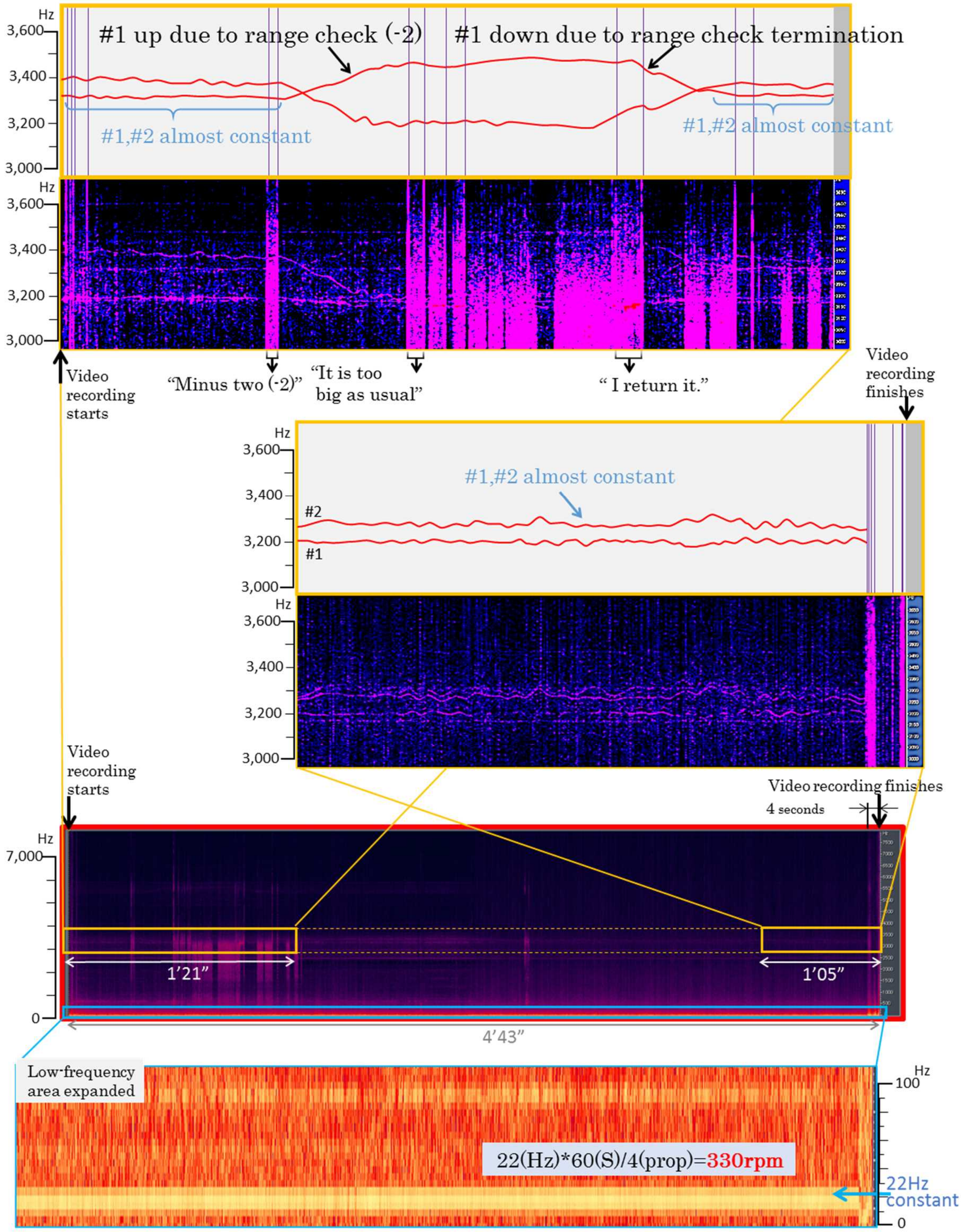


Figure 7: audio spectrum inside the helicopter

2.12.5 Information Concerning Fatigue and Drowsiness

(1) The definition of fatigue

The ICAO: Doc 9966 "Manual for the Oversight of Fatigue Management Approaches, 2nd edition 2016" defines "fatigue" as follows. The Civil Aviation Bureau's "General guidelines for establishment of a safety management structure" (CAB Director-General's notification, enacted on September 26, 2006, Kokukuki No. 530-1, Kokukuki No. 661-1; hereinafter referred to as "the SMS Guidelines") translate this definition as follows.

(ICAO) ***Fatigue.*** *A physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person's alertness and ability to perform safety related operational duties.*

(2) Impact of Workload

The ICAO manual mentioned in (1) above provides the following with regard to the influence of workload (excerpt).

2.4. SCIENTIFIC PRINCIPLE 4: THE INFLUENCE OF WORKLOAD

(excerpt)

Across most types of operations there is fairly wide acceptance of the concept that intermediate levels of workload may contribute least to performance impairment.

Low workload situations may lack stimulation, leading to monotony and boredom which could unmask underlying physiological sleepiness and thus degrade performance.

Instead of leading to boredom, low workload can also result in an individual making a greater effort to remain engaged which in turn increases their workload. At the other end of the spectrum, high workload situations may exceed the capacity of a fatigued individual, again resulting in poorer performance. High workload may also have consequences for sleep, due to the time required to "wind down" after demanding work.

OPERATIONAL IMPLICATION 7. SCHEDULING

To recover from a sleep debt, individuals need a minimum of two full nights of sleep in a row. The frequency of rest periods should be related to the rate of accumulation of sleep debt.

(3) Regarding "microsleep"

The ICAO manual mentioned in (1) above provides the following with regard to microsleep (excerpt).

Micro-sleep. *A short period of time (seconds) when the brain disengages from the environment (it stops processing visual information and sounds) and slips uncontrollably into light non-REMsleep. Micro-sleeps are a sign of extreme physiological sleepiness.*

Non - rapid eye movement sleep (Non - REM sleep). *A type of sleep associated with gradual slowing of electrical activity in the brain (seen as brain waves* (excerpt))*. As the brain waves slowdown in non - REM sleep, they also increase in amplitude, with the activity of large groups of brain cells (neurons) becoming synchronized. Non - REM sleep is usually divided into 4 stages, based on the characteristics of the brain waves. Stages 1 and 2 represent lighter sleep. Stages 3 and 4 represent deeper sleep and are also known as slow - wave sleep.*

Afternoon nap window. *A time of increased sleepiness in the middle of the afternoon. The precise timing varies, but for most people it is usually around 15:00-17:00. This is a good time to try to nap. On the other hand, it is also a time when it is more difficult to stay awake, so unintentional micro-sleeps are more likely, especially if recent sleep has been restricted.*

2.2. SCIENTIFIC PRINCIPLE 2: SLEEP LOSS AND RECOVERY

2.2.1. SLEEP RESTRICTION IN THE LABORATORY

SLEEPINESS CAN BECOME UNCONTROLLABLE

The pressure for sleep increases progressively across successive days of sleep restriction.

Eventually, it becomes overwhelming and people begin falling asleep uncontrollably for brief periods, known as micro-sleeps. During a micro-sleep, the brain disengages from the environment (it stops processing visual information and sounds). In the laboratory, this can result in missing a stimulus in a performance test. Driving a motor vehicle, it can result in failing to take a corner. Similar events have been recorded on the flight deck during descent into major airports and in air traffic controllers at the end of a night shift.

(4) Regarding the impact of time differences (jet lag)

The ICAO manual mentioned in (1) above provides the following with regard to the impact of jet lag (excerpt).

2.3.5. JET LAG

Flying across time zones exposes the circadian body clock to sudden shifts in the day/night cycle. Because of its sensitivity to light and (to a lesser extent) social time cues, the circadian body clock will eventually adapt to a new time zone.

Studies with participants flown as passengers have identified the following factors that affect the rate of adaptation to a new time zone:

(excerpt)

After eastward flights across 6 or more time zones, the circadian body clock may adapt by shifting in the opposite direction, for example shifting 18 time zones west rather than 6 time zones east. When this happens some rhythms shift eastward and others westward (known as resynchronization by partition) and adaptation can be particularly slow.

Additionally, "Rinsho Koku Igaku" (clinical aviation medicine), published by the Japan Aeromedical Research Center (published on April 30, 1995), states the following (excerpt).

Chapter 5: Medical Problems Associated with International Travel

Synopsis

The division or shortening from night time sleeping, or early-morning awakening due to time differences brings increases drowsiness during the day and decreases concentration. Drowsiness during the day influences on aviation safety by lower the wakefulness of aviation crew members and generating a feeling of fatigue. The amplitude of the core body temperature (rectal temperature) rhythm planarizes as a result of time differences; however, the rhythm begins to align comparatively rapidly in about two days and subsequently gradually gets into alignment. A tendency has been observed whereby the secretion rhythms for cortisol and melatonin (types of hormone) planarize and become irregular a result of time differences and then slowly adapt after about seven days. Disturbances in biorhythm are more marked with easterly travel, which moves the biological rhythm phase forward and makes it necessary to bring the phase back into alignment.

2. Time differences and changes in biological rhythm

1. Drowsiness and wakefulness rhythm

(3) Daytime drowsiness caused by time differences

Even though a person's daytime physiological drowsiness suddenly becomes stronger, he may not sense this subjectively. In other words, there is a state in which, although the body is becoming sleepy, the person does not feel sleepy.

4. Regarding realignment of biorhythm in the place where time difference is experienced

In one case involving the study of easterly flights, when travel covered a time difference *of eight hours, gaining alignment with the local time took about seven days for the drowsiness-wakefulness rhythm and about ten days for the simultaneously measured heartbeat rhythm. Realignment of the cortisol rhythm took between one week and ten days when an easterly flight had an eight-hour time difference. It was previously thought that the body temperature rhythm had difficulty becoming realigned; however, it is now thought that its phase moves rapidly toward realignment during one or two days immediately following the day of travel and then subsequently gradually gets into realignment. Moreover, the course of alignment is not consistent, but rather occurs in a zig-zag manner depending on the rhythm, and therefore caution is required when studying the speed of realignment with body temperature only.*

3. Responding to time difference-related symptoms

2. Attempt to accelerate adaptation by changing the biorhythm cycle.

(1) Sleep medication

It is probable that taking short-acting sleep medication ensures to sleep well and lead to enhancing daytime activities and enjoying a good sleep at night, and therefore it helps reduce the adverse effects of jet lag. (excerpts)

However, sensitive handling is required, as it is reported that a patient who used triazolam together with alcohol developed a temporary amnesia. (excerpts)

According to a recent study of aviation crew members, drowsiness-wakefulness rhythm disorders were 3.5 times more common among crew members in their 50s and 60s than for those in their 20s and 30s. This suggests that, even when people have experience handling time differences, they cannot overcome physiological aging.

2.12.6 Information on the Morning Rescue Activity

The circumstances of the rescue activity that was executed in the morning of the day of the accident were as follows.

10:25	Takeoff from the Airport
10:40	Arrival at Kengamine, Mount Norikura, where an injured person was awaiting rescue
10:43	Lowering of one rescuer
10:48	Onboard recovery of one injured person and one rescuer
11:01	Arrival at a hospital (in Matsumoto City)
11:03	Takeoff from the hospital
11:09	Arrival at the Airport

2.12.7 Information on the Captain

(1) Duty circumstances of the captain

The captain had daytime duty with days off on Wednesdays and Thursdays of each week. His duty circumstances immediately prior to the accident are as shown in Table 3. He took a vacation for 13 days between February 15 and February 27, during which he made an overseas trip of ten days (Republic of Finland; return trip in an easterly direction with a time difference of seven hours). His flight times between the end of his vacation until the accident were 49 minutes for rescue training on February 28, 1 hour and 8 minutes for new rescuer training on March 3, 1 hour and 20 minutes as a pilot training instructor on March

4, and 44 minutes for an emergency operation on the day of the accident.

Of the Center's three pilots, two were in training, and therefore all emergency operations for rescue activity, etc., were carried out by the captain alone. He went to work on his days off when requests for work came in. Throughout 2016, the number of days he handled emergency operations was 91, of which 17 were days in which he came in on his day off. The captain had worked continuously at the Center since its establishment for about 20 years.

Table 3: Captain's Attendance State Immediately before the Accident

Month	Day	On/Off (duty)	Morning	Afternoon
2	15	Off	(13 consecutive holidays started)	
	16			
	17			
	18~27		Overseas travel to Republic of Finland	
	28	On	Rescue training (49 minutes)	Ground duty
3	1	Off		
	2	Off		
	3	On	Ground duty	New rescuer training (1 hour 08 minutes)
	4	On	Flight training (1 hour 20 minutes)	Ground duty
	5	On	Emergency flight (44 minutes)	The accident occurred

- There was no overtime work.

(2) Information on the captain's camera

The captain' camera described in 2.7 recorded the images of the rescuers on board in the search and rescue operation conducted in the morning of the day of the accident and the ground scenery taken during the flight at a low altitude. Some of those photos, where the captain's left upper arm and the instrument panel reflected in a glass were seen, indicated that the captain was shooting a camera sitting in the right pilot seat in the cockpit.

According to the minutes of meeting regarding safe flight on November 13, 2006 with the participation of the former Center head, Center's aviation chief, the captain, Mechanic B and a mechanic who had already left a job, as for the Captain's behavior of shooting camera with his hand during the right turn in flight, the former Center Head warned the captain saying "It is an unsafe issue. The safe operation should be followed through."

(See Photo 24: photos recorded on the captain's camera)

Rescuers in the helicopter in flight in the morning on March 5, 2017

Outside scenery of the helicopter on January 28, 2017

Photo 24: photos recorded on the captain's camera

(3) Statement of pilot A of the Center

The captain hardly drank alcohol, always took care of keeping in good shape and commuted by walking for about 30 minutes every morning. On the day of the accident, his face had a healthy color as ever and pilot A did not noticing anything unusual about him. Although there was a rescue activity in the morning, the captain executed his subsequent duties as per usual and did not appear to be fatigued or in poor condition.

(4) Statement of Pilot B of the Center

Pilot B was hired by the Center as a pilot on January 1, 2015 and qualified to operate the helicopter in June 2015. However, he was only allowed to handle ferrying. The captain did not permit two-pilot operations added one pilot in the left in addition to a pilot in the right seat on grounds of the internal regulation and that the skill of pilot B was not able to be confirmed.

(5) Statement of Mechanic B

The winds in Nagano Prefecture are not calm even at high altitudes, and under the ATT mode of helicopter's AP, the helicopter immediately began pitching and rolling and became hazardous in strong wind. For this reason, the captain only used the ATT mode of the AP in straight flight during air transport in airspaces with little turbulence at high altitude.

Mechanic B observed the captain's piloting close-up for 20 years. The captain had flown near the helicopter's crash site many times. Because the Training site was on the opposite slope of the mountain, if the captain were checking the Training site, he would have flown at a higher altitude, and so it was unthinkable that he would descend near the ground around the helicopter's crash site. Mechanic B had never seen the captain appear drowsy while flying and had never had a near miss. The captain conducted rescue activity with calm judgment after understanding the local mountain topography and carefully checking the movement of the clouds. Because the captain was the only pilot who could actually go to rescue sites, Mechanic B thought he was probably under unmeasurable stress from the hard work, but the captain had never showed that.

2.12.8 Information on mechanic A

(1) Information from the Center's Aviation Chief

Mechanic A was hired by the Center on August 1, 2011. Prior to that, he had conducted aircraft maintenance at a helicopter aviation company and government office beginning from 1994, and had been qualified for maintaining the helicopter.

The duties of the mechanic sitting in the left pilot seat of the helicopter during flight include monitoring the instruments, operating the radio (except communications with the air traffic authority), operating the hoist's power supply, operating the ITT trim or beep switch, adjusting Nr (the number of MR revolutions), and recording the time. Mechanic A extends his hand to the right pilot seat side when operating the ITT trim or beep switch.

(2) Statement of Mechanic B

One of the jobs of the mechanic in the left pilot seat is to observe outside—in other words, to supplement the pilot's vision. Mechanic B thought that mechanic A would have not hesitated to say so even to the captain if he had seen a danger.

2.12.9 Provision Concerning the Pilot's Obligation for Keeping Watch

The Civil Aeronautics Act stipulates as follows;

Article 71-2 (Pilot's Obligation for Keeping Watch) Any person who is piloting an aircraft *(omission) shall, while in flight, keep watch so as not to collide with other aircraft or other objects (omission), except under such weather conditions that will not permit him/her to recognize any objects outside his/her own aircraft.*

2.12.10 Provision Concerning Minimum Safety Altitude

The Civil Aeronautics Act stipulates as follows;

Article 81 (Minimum Safety Altitude) No aircraft shall be flown, except during taking off or landing, at an altitude lower than that specified by Ordinances of the Ministry of Land, Infrastructure, Transport and Tourism, taking into consideration the safety of persons or objects on land or water as well as the safety of aircraft; provided, however, that the same shall not apply when permitted by the Minister of Land, Infrastructure, Transport and Tourism.

Article 81-2 (Special Exceptions for Search or Rescue) The provisions of the preceding three articles (Places for Landing and Takeoff, No-Fly Zone, Minimum Safety Altitude shall not apply to flights conducted by aircraft specified by Ordinances of the Ministry of Land, Infrastructure, Transport and Tourism for search and rescue operations in case of aircraft accidents, maritime disasters, and other accidents.

Besides, regarding the aircraft subscribed under Ordinances of the Ministry of Land, Infrastructure, Transport and Tourism mentioned as above, the Ordinance for Enforcement of the Civil Aeronautics Act stipulates as follows;

Aircraft used by (omission) fire preventive organizations of local governments and engaged in search or rescue activities.

2.12.11 Information concerning CRM

The "Crew Resource Management: An Introductory Handbook" (herein after referred to as "CRM Handbook") issued by the United States' Federal Aviation Administration (FAA) defines CRM in flight as follows;

CRM is defined as the effective utilization of all available resources-- equipment and people -- to achieve safe, efficient flight operations. (omission) Therefore, the concept of effective CRM combines individual technical proficiency with the broader goal of crew coordination, thus integrating all available resources to achieve safe flight.

In the CRM Handbook, it is stated that skills in executing CRM (hereinafter referred to as "CSR Skills") are classified as "Communication processes and Decision Making", "*Team Building and Maintenance*" and "*Workload Management and Situational Awareness*". Within them, it states, as grounds for the necessity of "the Assertiveness", which is an element of "*Communication processes and Decision Making*", that accident reports reveal a number of instances in which crew members failed to speak up even when they had critical flight information to enable to have averted a disaster, and that these types of incidents lead to the conclusion that crewmembers are often unwilling to state an opinion or to take a course of action, even when the operation of the aircraft is clearly outside acceptable parameters. Additionally, it states that the elements of following CRM skills are included in the Assertiveness. (Excerpted below)

- *Inquiry: inquiring about actions taken by others and asking for clarification when required.*
- *Advocacy : the willingness to state what is believed to be a correct position and to advocate a course of action consistently and forcefully.*
- *Assertion: stating and maintaining a course of action until convinced otherwise by*

further information.

Furthermore, the CRM Handbook states with regard to *"leadership,"* which is an element of "team building and maintenance," that leadership would more properly be called leadership/followership. Leadership is not a one-way process, but requires both leader actions and effective crewmember responses. The leadership role must be to ask for opinions and suggestions, clarify conversation, provide feedback (to responses from followers), and maintain a positive climate to encourage good crew member relations and to invite full participation in crew activities.

2.12.12 Information concerning the Organization

(1) The Center's organization

The Center is established as a local agency of the Firefighting Section of the Crisis Management Department in the Nagano Prefectural Office. It operates its flight operations independently, rather than accepting pilots and other personnel from private-sector aviation companies on an outsourcing basis. According to the Alps operations manual (hereinafter referred to as "the Manual"), which established essential points concerning the operations and activities of the helicopter, a fire and disaster prevention helicopter, the director of Nagano Prefecture's Crisis Management Department is the overall supervisor and the Center Head is the operations supervisor.

(See Figure 8: organization of the Center)

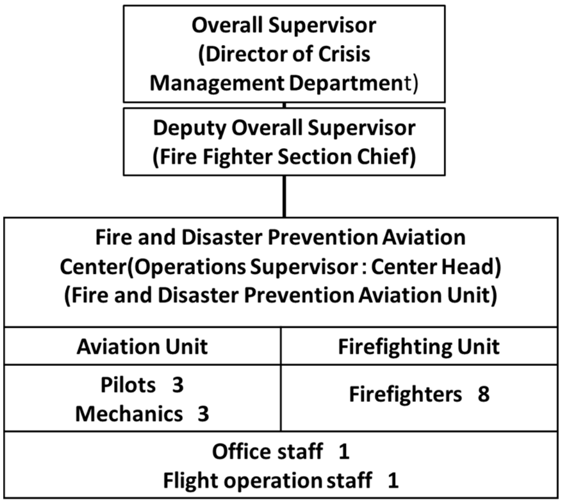


Figure 8: organization of the Center

(2) Statement of the Center Head

The head, who is also the Center's operations supervisor and safety management supervisor, was assigned to the Center in April 2016. He had no prior experience in aviation, crisis management, and disaster prevention.

Regarding the operation with one pilot, this is based on the Manual, and there were no instances in which two pilots were on board, except when an instructor was seated in the left pilot seat during training. When the need to revise the Manual arises, the Center prepares a proposal and the Firefighting Section makes a decision regarding it. Labor management concerning employees' days off and other matters is handled by the Center.

Each day, employees on duty attend a morning meeting together and check each other's physical condition. Because the captain was the only pilot who could handle emergency operations, the captain was pressed for time. Even though we tried to raise other pilots, we had the problem of finding training time easily, as emergency operations would come in, there was rescue team training to perform, and there were times when flying was prohibited by the weather.

2.12.13 Regulations concerning the Helicopter's Operation

Concerning the helicopter's operation, the followings are provided in the Manual (excerpt).

(4) Personnel assignment

Category	*Activity*	*Aviation unit*		*Firefighting unit*
		Pilot	*Mechanic*	
Basic onboard personnel	*Emergency*	*1*	*1*	*3*
	Rescue	*1*	*1*	*3*
	Firefighting	*1*	*1*	*3*
	Disaster response	*1*	*1*	*2*
Night time		*—*	*—*	*1*

- It may change depending on the situation of the disaster etc.

It should be noted that the Manual contains no specific description concerning the duties of rescuers aboard the helicopter, division of duties, etc.

2.12.14 Safety Measures for Fire and Disaster Prevention Helicopters by the Fire and Disaster Management Agency

The Fire and Disaster Management Agency (FDMA) of the Ministry of Internal Affairs and Communications gives advice, recommendations, and guidance to municipalities that conduct firefighting operations and to local prefectural governments that support those municipalities by using aircraft based on Article 37 of the Fire Organization Act (Law No. 226 of 1947).

(1) Study group on mountain rescue by fire and disaster prevention helicopters

Following crashes involving fire and disaster prevention helicopters engaged in rescue activities in mountainous areas of the Gifu Air Rescue Team in 2009 (Japan Transport Safety Board Aircraft Accident Investigation Report AA2011-7-1) and Saitama Disaster Prevention Air Squadron in 2010 (Report AA2012-2-2), the FDMA organized a study group, compiled a report (report of the study group on mountain rescue by fire and disaster prevention helicopters) in March 2012, and made the report's content known to local prefectural governments and other organizations throughout Japan that operate fire and disaster prevention helicopters. The report contains the following items (excerpt).

Chapter 5: Flight Operations

5.1 Maintenance of Operation system

4) Two-pilot system

It can be said that operation with a two-pilot system is the most fundamental and effective method for achieving the safe operation of helicopters. Specific effects are thought to include reduction of pilots' blind spots, lessening of the physical and mental burden on pilots, prevention of human error by cross-monitoring, and the availability of another pilot to take over when a pilot has a physical problem.

Chapter 8: Summary

8.2 Study Results and Countermeasures

Organizational factors

Training

- *"Training of commanders and improvement of command abilities," "acquirement of fundamental knowledge and skills by air unit members" (omission) are matters that must be addressed as an organization.*

Operation System

- *Establish items required for safe operations in regulations, guidelines, manuals, and other items pertaining to helicopter operations (omission) and work to a workplace culture that emphasizes safety. Additionally, operation by two-pilot system is desired for safe operations.*
- *Endeavor to keep watch with certainty by executing regulations in voice procedures concerning keeping watch in blind spots.*

2.12.15 Information concerning Emergency Locator Transmitter

The helicopter was equipped with an emergency locator transmitter (ELT) with switches (G switches) designed to automatically activate with impact from six directions; namely, front, back, left, right, up, and down (2.3 G from the front, 12 G from the other directions). When an examination was conducted by agent of the manufacturer following the accident, it was found that the ELT had not activated in this accident. The examination after the accident revealed that the G switches that should activate with impact from the front, left, above, and rear were stuck because the bulb-shaped parts inside the ELT were firmly fixed.

The helicopter's ELT had passed an inspection, which included a functional inspection of the G switches, which was conducted by the ELT manufacturer's agent on May 22, 2006. On June 21 of the same year, the ELT system, which included the main ELT unit as well as a buzzer, remote switch, and antenna, was installed into the helicopter at a certified workplace, and was checked for maintenance and modifications based on the stipulations of Article 19-2 of the Civil Aeronautics Act. Following the ELT system's installation into the helicopter, regular inspections of the ELT system (after one year or 600 hours, whichever occurs first) were conducted at the same certified workplace, which is also an inspection business that is registered under Article 24-2 of the Radio Act (Law No. 131 of May 2, 1950). The most recent regular inspection was conducted on June 30, 2016. According to the person who conducted that inspection, the person conducted the functional inspection of the G switches by shaking the main unit in accordance with the manufacturer's maintenance manual (hereinafter referred to as "the CMM") and found no abnormalities; however, the inspection form did not have a space for notations concerning the G switches, and therefore he did not make any notations concerning it.

Functional inspection of the G switches was not specified in the certified workplace's maintenance procedure manual for the ELT system. However, "G-Switch Functional Check" was included in the CMM's regular inspection checklist, and a detailed inspection procedure was provided.

2.12.16 Information on the Flight Recorder

The helicopter was not equipped with a device that records the circumstances of aircraft operation (i.e., flight recorder). As is shown in Table 4, based on Article 149 of the Civil Aeronautics Act Enforcement Regulations (Devices for Recording Aircraft Operations), the helicopter was not used for the purpose of air transport services and had a maximum takeoff weight of no more than 7,000 kg, and was thus not required to be equipped with a flight recorder.

On the other hand, new technologies for simple flight recorders for small aircraft are being developed and have been installed on some aircraft for training and safety purposes. Moreover, the Civil Aviation Bureau has been investigating and studying future safety measures concerning small aircraft that include installation of simple flight recorders based on the opinions from experts, related organizations and others at "The Safety Promotion Committee Concerning Small Aircraft", which was established in FY2016.

Table 4 devices for recording the circumstances of aircraft operation

Aircraft category		*Device*
Rotorcraft	*Rotorcraft used for the purpose of air transport services with maximum take-off weight exceeding 3,180 kilograms but not more than 7,000 kilograms, and with an initial airworthiness certificate issued on or after October 11, 1991.*	*Cockpit Voice Recorder capable of retaining the voice and main rotor speed information (except in the cases where the main rotor speed information is recorded in Flight Data Recorder) recorded during at least the last 30 minutes.*
	Rotorcraft with maximum takeoff weight exceeding 7,000 kilograms, and with an initial airworthiness certificate issued on or after 1 October 11, 1991	*1 Flight Data Recorder capable of recording the following matters* (30 matters are omitted) *2 Cockpit Voice Recorder capable of continuous recording of the latest 30 minutes or more of voice records*

2.12.17 Permission under the Civil Aeronautics Act

Permission under the provisos of Article 79 of the Civil Aeronautics Act (places for landing and takeoff) and of Article 81 (minimum safety altitude), which concerns landing at the Helipad and flying below minimum safety altitude at the Training site, had been obtained, however, the permission concerning flying below minimum safety altitude around the vicinity of the crash site of the helicopter was not obtained.

2.13 Beneficial and Effective Examination Technologies

2.13.1 Use of Drone

In order to ascertain the topography and tree situation at the accident site, aerial images were taken using a drone (type of unmanned aircraft: Zion QC730) and the images were processed to planar images and preparation of three-dimensional images.

(See Photo 25: drone in flight and Appendix 3: image prepared based on information from drone images)

Photo 25: drone in flight

3. ANALYSIS

3.1 Qualifications of Personnel and Others

The captain had both valid airman competence certificates and valid aviation medical certificates.

3.2 Airworthiness Certificate

The helicopter had a valid airworthiness certificate, and had been maintained and inspected as prescribed.

3.3 Relationship with Meteorological Conditions

As mentioned in 2.6, it is highly probable that the metrological conditions near the accident site at the time of the accident did not have an impact on the flight of helicopter.

3.4 Circumstances of the Flight

As described in 2.1and 2.1.1 (1), it is highly probable that the helicopter took off from the Airport with the captain, mechanic A, and seven rescuers on the floor, from which the rear seats had been removed, aboard and headed toward the Helipad for the purpose of conducting the final test in hoist operator training for rescuer B. It is highly probable that the helicopter planned to land at the Helipad, drop off one rescuer, and then conduct training using the hoist at the Training site.

As described in 2.1.2, it is certain that the helicopter took off from the Airport, headed northeast while climbing above the city, entered the airspace above the mountains, and turned right. It is highly probable that the helicopter took a flight route that would take it past the Training site viewing on right side of the helicopter, and flew toward Mt. Hachibuse while maintaining roughly level flight at a speed of approximately 100 kt. It is certain that as the higher the mountains' elevation got, the lower the helicopter's altitude above the ground level (AGL) became, despite the tree-covered mountainside that was looming ahead, the helicopter collided with trees while maintaining attitude and speed.

As described in 2.1.2, the helicopter leveled off at about 1,740 m. It is somewhat likely that this was because the helicopter was trying to ensure the safety altitude of 150 m or higher from the destination, the Helipad, with an elevation of about 1,580 m. Regarding the helicopter's selection of the route not to go directly to the destination, it is probable that this circuitous route was taken in order to make time to conduct engine data checks en route, however, it could not be specified. Regarding the selection of a flight route whereby the helicopter passed the Training site viewing on right side of the helicopter, it is somewhat likely that this was because the captain wanted to check the condition of the Training site by himself, however, as was mentioned in 2.12.7 (5), it is probable that the helicopter should have flown at a higher altitude for the captain to check it by himself.

It is probable that the helicopter should have gone directly to the Helipad after turning right by taking the avoidance route (at a constant altitude) as shown in Figure 10 in order to continue flying with the maximum safe altitude from the ground (150 m) without changing flight altitude.

It is highly probable that, in order to pass on the beam of the Training site maintaining the maximum safe altitude of 150 m above Mt. Hachibuse, which was the highest mountain in the vicinity, it was necessary for the helicopter to climb about 340 m after turning right by taking the avoidance route (by climbing) as shown in Figure 11.

However, it is somewhat likely that while maintaining the maximum safe altitude, the helicopter took neither the avoidance route at a constant altitude by directly heading for the Helipad nor the avoidance route by climbing, instead, it continued to fly toward Mt. Hachibuse at a constant altitude after turning right, its AGL became lower as flying into over the mountains region, and the helicopter approached the ground.

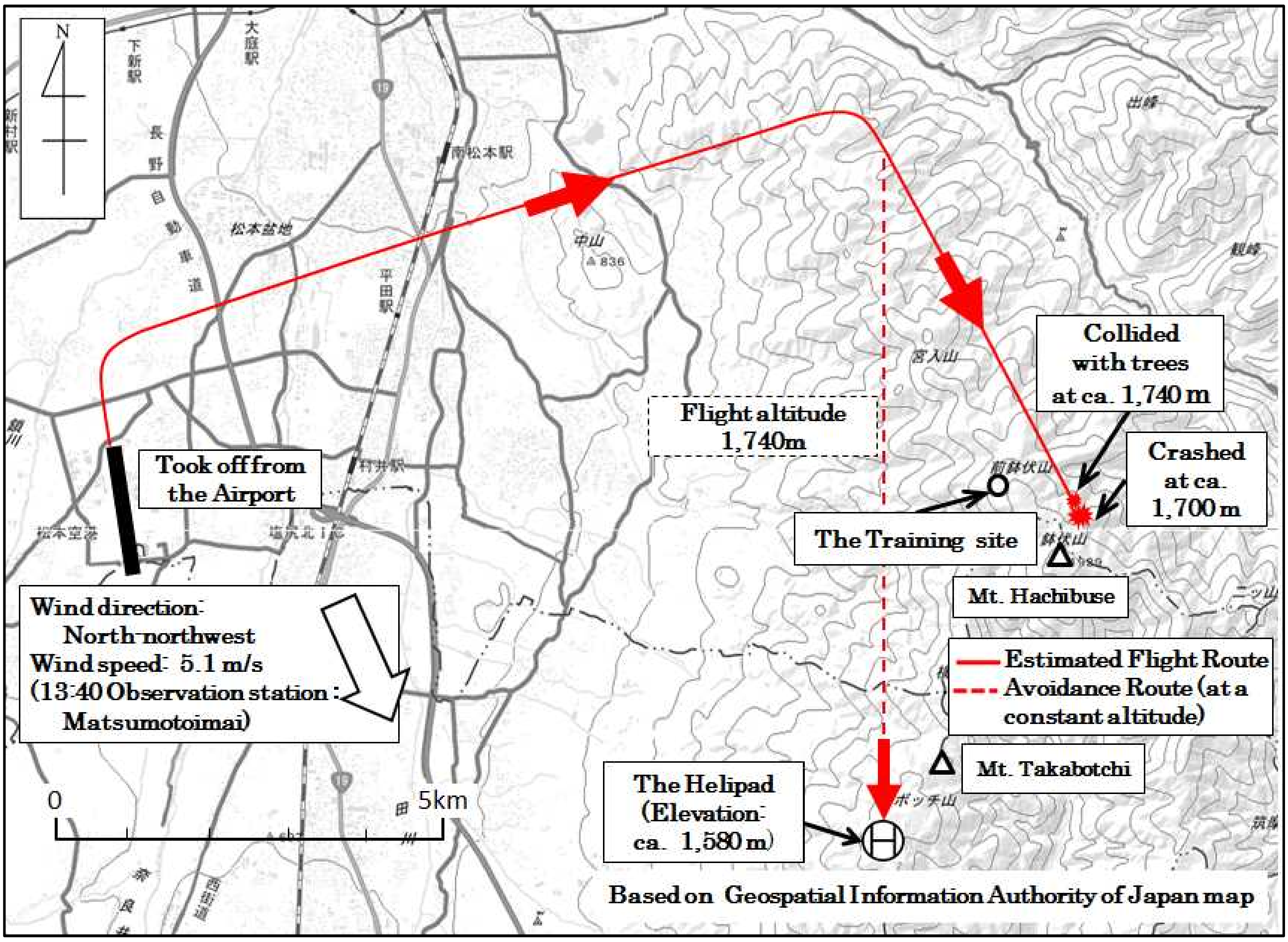


Figure 10: avoidance route (at a constant altitude)

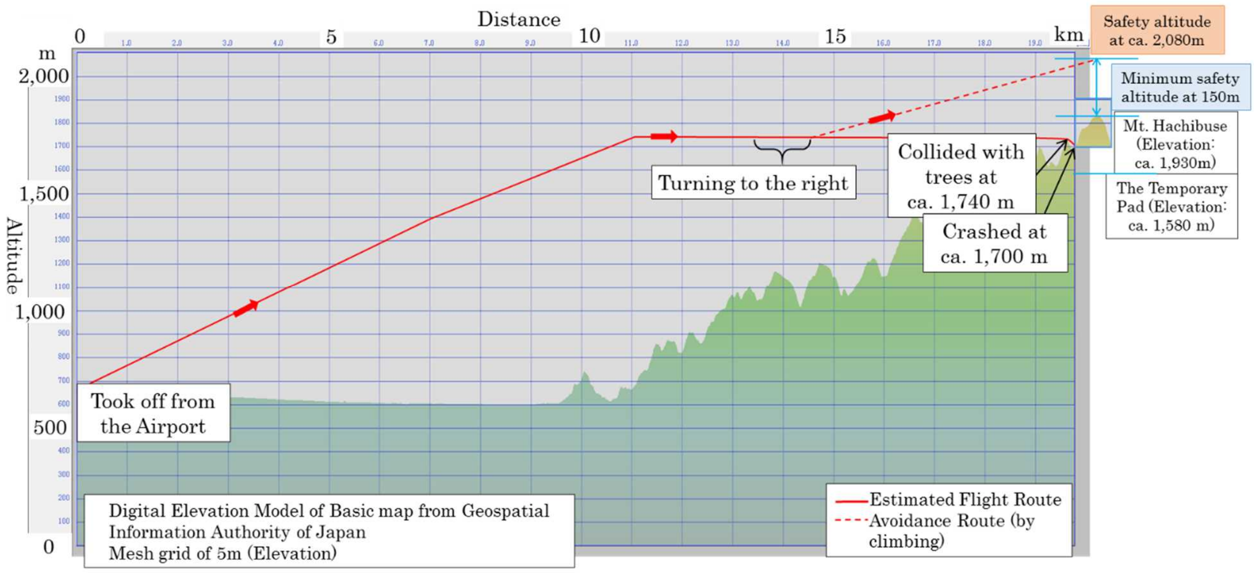


Figure 11: avoidance route (by climbing)

3.5 Circumstances at the Time of the Collision with the Tree and Crash

As described in 2.7, from the fractured circumstances of the trees and nearby scattered circumstances of the left cockpit door, the lower fuselage parts, the CP lever head, and the part of the damaged MRB, it is highly probable that the helicopter crashed its fuselage and MRB into trees over a distance of approximately 40 m as shown in Figure 5. It is highly probable that the helicopter received massive damage to its fuselage's nose and the MRB at that point, and it is also highly probable that, as the helicopter subsequently passed through the air above the valley, it had temporarily separated from the tree but had already fallen into an uncontrollable condition.

From the circumstances of the crash site mentioned in 2.7 and the circumstances of damage to the cabin mentioned 2.8 (1), it is highly probable that the helicopter turned upside-down and collided with an approximately 40-degree slope from its nose. It is highly probable that each of the MRBs, TB, TR, transmission, and other parts were damaged by the impact. From the images taken by the video camera mentioned in 2.1.2, it is highly probable that it was four seconds later after the helicopter collided with trees when the video recording stopped by the impact of the helicopter crashing into the ground.

3.6 Circumstances of the Engines at the Time of the Accident

According to the operating engine data table for the helicopter that was mentioned in 2.12.2 (1), it is highly probable that there were no abnormalities in the helicopter's engines from the time of takeoff until transition to level flight at 5,700 ft (approximately 1,740 m).

From the circumstances of internal damage to both engines which were described in 2.11.1, it is highly probable that the compressors and each turbine were rotating and the engine was operating when the helicopter crashed and external pressure was applied to the engines. Additionally, from the fact that a spectrum of approximately 22 Hz was recorded at a constant frequency on the sound on the video camera described in 2.12.4 from the beginning of recording until four seconds before the recording stopped, it is highly probable that the MR had been rotating at constant rpm until the helicopter collided with trees.

3.7 Regarding Engine Data Checks during Flight

As described in 2.12.2 (1), engine data was recorded in Table 2: The Contents Recorded in the In Flight Engine Data Table six times from takeoff to level flight. It is highly probable that the helicopter was conducting engine data checks en route from takeoff. As described in Table 1 in 2.1.2, it is probable that the sound of mechanic A's voices saying "−2 (minus two)", which was recorded 4'17" before the collision with trees, was a signal for obtaining the engine data for the range check "−2" in the fourth check of Table 2. It is probable that the situation described in Table 1 as "mechanic A, holding a data sheet, extends a hand to the right pilot seat", which was recorded 4'01" before the collision with trees, indicated that mechanic A was operating the ITT trim switch to conduct range checks as described in 2.12.3 (1). It is probable that mechanic A's voice saying "I return it" described in Table 1, which was recorded 3'41" before the collision with trees, indicated a sign for his returning the torque difference to the original value to obtain data for the fifth check in Table 2. As described in 2.12.4, the following two cases were confirmed, in one case where the frequency of an audio spectrum of approximately 3,300 Hz increased by approximately 200 Hz, while in the other case where the frequency of an audio spectrum of approximately 3,400 Hz decreased by approximately 200 Hz, immediately after the voice saying "-2 (minus two)". It is highly probable that based on the contents recorded in "In flight engine data table", the former case showed the audio spectrum of No.1

engine and the latter, No.2 engine. It is also highly probable that mechanic A operated the ITT trim switch immediately after saying "−2 (minus two)" and "I return it".

Based on the fact that the values in the remarks column in Table 2, which seems to indicate the quantity of remaining fuel, are all the same from the third to the fifth and the sixth, it is probable that the sixth check was conducted immediately after the range checks. As it was 2'00" before the collision when the helicopter commenced turning right above the mountains, it is probable that engine checks had been completed until then.

As described in 2.12.2 (2), it is highly probable that mechanic A was conducting engine checks, concentrating on the flight instruments, and hardly watched outside. It is highly probable that his entry of "+2 range is too low!!" in the remarks column was made after he made the third and fourth engine data entries, and it is somewhat likely that his attention was focused on addressing the engine data check records even after the engine checks completed, but this could not be specified.

3.8 Regarding the Captain's Helmet Visor

As described in 2.12.1, from the fact that the captain's helmet visor had an impact mark near the center and approximately half of its right side was missing, although the visor cover was not broken, it is probable that the visor received an impact from the right side while in a lowered state. As was described in 2.1.1 (1), from the fact that the captain's visor was raised at the time of takeoff, it is probable that the captain lowered his visor while in flight. The captain right upper arm moved 1'30" before the collision with trees, as described in Table 1 in 2.1.2, it is somewhat likely that it was because turning right at that time would have the helicopter face to the direction close to the southern sun, and the captain lowered his helmet visor to ward off the glare of the sun; however, this could not be specified.

As described in 2.12.3 (3), with the visor lowered, the outside view was clear and not too bright, and the instrument indicators were readable. Therefore, it is probable that the use of visor had no effect on flying the helicopter. However, with the visor lowered, the opening state of eyes and the facial expressions were not recognized from outside.

3.9 Circumstances Inside the Helicopter at the Time of the Accident

From the fact that no warning sounds indicating problems with the helicopter or abnormal sounds were recorded in the recorded sounds of the video camera described in 2.1.2, it is somewhat likely that there were no abnormalities in the helicopter until it collided with trees. As described in Table 1 in 2.1.2, from the fact that after the helicopter turned right above the mountains, captain's right upper arm moved 1'30" before the collision with trees, it is somewhat likely that there was nothing wrong with the captain's physical condition.

Any voices were not recorded after rescuer B said, "Right rear clear" 2'00" before the collision until when the helicopter collided with trees. From this fact, it is somewhat likely that all members on board had not responded to the approaching danger, however, as described in 2.12.3 (4), as there is a possibility that the extension microphone of the video camera might have come off the helmet and the intercommunication might not be recorded, this could not be specified.

3.10 Regarding Past Medical History and Medicines Prescribed to the Captain

As described in 2.9.2 and 2.9.3, it is certain that the captain was under treatment for the hyperthyroidism, underwent surgery for cystic adventitial degeneration of the right popliteal artery two times, and taking the prescribed medicines, which were categorized into class B and C respectively in the list of the Guidelines for Handling of Medical and Pharmaceutical Products. However, it could not be clarified whether the captain was subject to influence of those previous diseases, which would hinder the performance of aviation duties, or not and whether the captain took those prescribed medicines during the flight and he was affected by those medicines or not.

3.11 Factors of the Helicopter's Not Taking Avoidance Maneuver Even Getting Close to the Ground

As described in 2.1.2, according to the information obtained from the images on the video camera, it is certain that the higher the mountains' elevation got, the lower the helicopter's altitude above the ground level (AGL) became, despite the tree-covered mountainside that was looming ahead, the helicopter collided with trees while maintaining attitude and speed. It is highly probable that from the fact mentioned as above, no action had been taken to avoid the collision until the helicopter collided with trees. The factors are as follows;

3.11.1 Failures in the Helicopter and Others

As described in 2.1.2, warning sounds indicating problems with the helicopter and abnormal warning sounds were not recorded until the helicopter collided with trees. As described in 2.8, the investigation on the accident helicopter did not reveal any results indicating problems with the helicopter and abnormality in its engine. As described in 2.11, the internal examination of the engine and the analysis of the DFCC error codes of the AP did not reveal any results indicating abnormality in its engine and the AP. Based on the facts mentioned as above, it is probable that it is unlikely to have been unable to take any actions in order to avoid the collision due to failures in the helicopter and others. Based on the facts mentioned as above, it is probable that it is unlikely that avoidance maneuver was not performed intentionally.

3.11.2 Maneuver Taken Intentionally by the Captain

According to the information obtained from the images on the video camera as described in 2.1.1 and the statement as described in 2.12.7(3), anything unusual about the captain was not confirmed on the day of the accident. In addition, it is probable that there are not rational grounds for the captain to intentionally engage in such a high-risk behavior as not taking avoidance maneuver. Based on the facts mentioned as above, it is probable that it is unlikely that avoidance maneuver was not performed intentionally.

3.11.3 Captain's Incapacitation

As described in 2.12.7 (3), the captain was habitually careful about his health, and anything unusual about the captain was not confirmed on the day of the accident. As described in 2.1.2, the information obtained from the images on the video camera did not reveal any images and voices indicating the incapacitation of the captain. As described in 2.9.1, the causes of death of the captain revealed no findings indicating the incapacitation during the flight. Based on these facts as above, it is unlikely that the captain fell into the incapacitation during the flight.

It is highly probable that as described in 2.9.2, the captain had surgical history of cystic adventitial degeneration of the right popliteal artery or its past medical history, and hyperthyroidism or its past medical history, and as described in 2.9.3, he was under treatment with medication categorized into class B and C in the list of the Guidelines for Handling of Medical and Pharmaceutical Products. It is probable that the captain engaged in aviation duties without applying for the judgment on whether to conform to the medical examination standards because he had obtained valid aviation medical certificates without declaring his medical information mentioned as above. However, as described in 3.10, it could not be clarified about those effects on captain's performance of aviation duties.

3.11.4 Recognition on Circumstances that the Helicopter Approaching the Ground

(1) Lack of keeping sufficient outside watch

(a) Concentrating on the flight instruments

As described in 3.7, it is probable that the helicopter was conducting engine data checks en route from takeoff until starting a right turn above the mountains. On the other hand, as the engine checks had already finished before the helicopter started a right turn, the captain was not required to concentrate on the flight instruments. Therefore, it is very unlikely that the captain did not recognize on the circumstances that the helicopter was approaching the ground due to concentrating on the flight instruments.

(b) Operations for camera and others

As described in 2.12.7 (2), it is highly probable that with a camera, the captain sitting in the pilot seat had ever shot the scenes of inside and outside of a helicopter during flight. However, any images of flying at around the time of the occurrence of the accident were not stored in his camera which was found in the accident site. Besides, there was no image of the captain operating his camera in the records on the video camera. Based on those facts as above, it is unlikely that the captain was operating his camera at the time of the occurrence of the accident.

(2) Sleep

(a) Lack of fitness for fatigue and jet lag

As was described in 2.12.7 (1), after taking a long vacation, the captain flew 49 minutes for rescue training, had two days off, flew 1 hour and 8 minutes for new rescuer training, and then the next day flew 1 hour and 20 minutes as a pilot training instructor. From this most recent flight history, it is probable that these hours were not a particularly heavy workload for a pilot who flew more than 300 hours a year.

Given that the rescue activity that took place during the morning of the day of the accident that was described in 2.12.6 lasted 44 minutes from takeoff to landing, it is probable that, even if it was stressful, it was not a particularly heavy workload for the captain. As was described in 2.12.7 (3), from the fact that, even after the rescue activity, the captain executed his duties as per usual and did not appear to those around him to be fatigued or in poor condition, it is probable that he was not experiencing any particular physical problem.

On the other hand, given that it is somewhat likely that subsequent flight on which the accident occurred included a lower workload compared to the rescue activity that took place in the morning, it is somewhat likely that latent physiological drowsiness occurred as was described in 2.12.5 (2). Additionally, from the fact that the time of the accident was in the afternoon, it is probable that the time was near the time when the microsleep mentioned in 2.12.5 (3) tends to occur. Moreover, as was described in 2.12.7 (1), six days prior to the accident, the captain ended a ten-day overseas trip and traveled in an easterly direction with a time difference of seven hours, it is somewhat likely that the disruption in his circadian rhythm caused by his overseas travel might remain and have effects on his performance of aviation duties. There were several factors for the captain in this condition to fall into a microsleep, however, this could not be clarified whether he actually fell into such a state, as all of the persons aboard the helicopter died.

(b) Effects of medical and pharmaceutical products

As described in 2.9.1, the blood test for the captain found negative for alcohol and drugs listed as the test items. But as described in 2.9.3, the medical products prescribed to the captain should have been confirmed respectively by the designated doctors and others, and have been applied for the judgment on conformity to the medical examinations standards by the Minister of Land, Infrastructure, Transport and Tourism. However, it could not be clarified about whether the dose of those medical products had sleep inducing effects or not.

3.11.5 Use of AP

As was described in 2.12.7 (4), from the fact that the captain only used the ATT mode of the AP in straight flight during air transport in airspaces with little turbulence at high altitude, it is somewhat unlikely that the captain was using the ATT mode of the AP when the accident occurred. Because, even if he had been using the ATT mode, he could have quickly switched to manual, it is probable that the captain's use of the ATT mode could not have been a factor behind his not taking avoidance maneuver.

Incidentally, as described in 2.11.2, even at the time of manual operation, it is possible for the helicopter to obtain a stable attitude with the SAS mode, therefore, it is somewhat likely that the helicopter would have stably flown in the SAS mode even if any flight operation had not been conducted by the captain (no input in the flight control system).

From the analyses from 3.11.1 to 3.11.5, regarding not taking the avoidance maneuver, even though the helicopter was getting close to the ground, it is somewhat likely that the captain could not recognize the dangerous situation and did not take any avoidance maneuver because he was in a state where the arousal level was lowered with microsleep, and so on, due to the effects of fatigue and time difference. However, it was not possible to clarify whether he actually fell into such a state.

3.12 Regarding CRM During the Flight

As described in 2.12.9, the captain, who was operating the helicopter, had to keep watch so as not to collide with other objects. If, for some reason, he could not keep watch, it was highly probable that the captain should have instructed mechanic A, who was an airman in the pilot seat, to temporarily keep watch for him.

As described in 2.12.8 (1) and (2), mechanic A was highly experienced as a mechanic and was thought to be a person who would speak frankly, even to the captain, if danger existed. Therefore, if mechanic A did not question the captain before the accident occurred, as was described in 3.7, it is somewhat likely that his attention would be focused on the engine data recorded in the engine data checks and that he was looking only at the instruments and the log papers, not keeping sufficient outside watch; however, this could not be specified, as mechanic A died.

It is somewhat likely that the rescuers sitting on the mountain side in the cabin looked outside and noticed that the helicopter's route was abnormally too close to the ground. According to the information from the video camera, they did not ask questions to the captain or warn him. If some rescuers, who noticed the approaching danger, did not ask the captain about the route or altitude in this case, it is somewhat likely that it was because they thought that the highly experienced captain and mechanic A, who should have been grasping the outside situation and keeping watch forward; that they got used to low-altitude flight so much that their sensitivity to the danger became lower due to rescue mission and training; however, this could not be specified, as all of the rescuers aboard the helicopter died.

As described in 2.12.11, it is important for conducting safe aircraft operations that all crew members CRM is fully functioning under the appropriate leadership of the captain. The Center conducts flight operations with the mechanic seated in the left pilot seat, it is probable that the mechanics can be actively used as cooperative resources in order to realize safe aircraft operations. Therefore, it is desired that the Center will endeavor to establish the CRM appropriately based on the Center's flight operations.

3.13 Regarding Two-Pilot Operations

The helicopter, which was an aircraft piloted by one person, was capable of being operated by the captain alone even if another pilot was present. Thus, as was described in 2.12.13, personnel assignment for the helicopter was established with one pilot for all activities. In general, the operations of fire and disaster prevention helicopters have high urgency and require flight in mountainous regions and other tough environments, and therefore they have high difficulty compared to ordinary flight operations. Given this, the assignment of pilots and other personnel demands sufficient consideration from the standpoint of maintaining operational safety.

Additionally, as described in 2.12.14, study groups of the FDMA recommend using two-pilot system. Moreover, as described in 2.12.14 (1), it is said that using two-pilot system are thought to be effective in terms of reducing pilots' blind spots, lessening of the physical and mental burden on pilots, prevention of human error by cross-monitoring, and the availability of another pilot to take over when a pilot has a physical problem, etc. Despite the presence at the Center of two pilots other than the captain who were in training, operations by one pilot (the captain) in accordance with the regulations mentioned in 2.12.13 were adhered to thoroughly in operational activities. Based on the items mentioned in the reports of the above-mentioned study groups, it is desired that the Center study using a two-pilot crew when possible.

3.14 Conformity to the Standards for Medical Examinations

It is highly probable that as described in 2.9.2, the captain had hyperthyroidism and cystic adventitial degeneration of the right popliteal artery or their past medical history, and as described in 2.9.3, he was under treatment with medication categorized into class B and C in the list of the Guidelines for Handling of Medical and Pharmaceutical Products. However, it is certain that the captain obtained the medical aviation certification and engaged in his performance of aviation duties without making a self-report on his medical information for the aviation medical examination. It is probable that when the captain was diagnosed as hyperthyroidism around in January 2011, he should have declared the medical information such as his treatment status and therapeutic medicine to the designated aviation medical examiners, and according to the doctors' instructions, he should have taken required additional examinations, and if required, he should have applied for the judgment of the Minister of Land, Infrastructure, Transport and Tourism And after this, as described in 2.9.2, it is highly probable that the captain should not have engaged in the performance of aviation duties until the conformity to the standards for medical examinations was confirmed.

In the Aviation Medical Examination, it is difficult to make an appropriate judgment on whether to conform to the standards of Aviation Medical Examination unless applicants declare their medical history and information accurately. As described in 2.9.5, since 2007, the Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism has made it known to the designated aviation medical examiners that they should strive to confirm the contents of self-reported medical information which are submitted by applicants for the aviation medical examinations. And since 2011, the Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism has further requested the aircrew related organizations to commit making it known thoroughly that all the relevant aircrews belonging to these organizations must comply with the guidelines for use of medical and pharmaceutical products, and also requested the designated aviation medical examination facilities and aviation medical examiners to endeavor to make the guidelines known to aircrews at the time of aviation medical examinations and medical consultations from now. Moreover, the Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism needs to provide complete instruction that aircrews must accurately self-report their medical information to apply for the aviation medical certification and if non-conformity is suspected, they must not engage in the performance of aviation duties, and must receive instructions from the designated aviation medical examiners and others, even if his/her aviation medical certificate is still valid.

3.15 Photographing by the Captain during Low-Altitude Flight

As described in 2.12.10, the provisions of the Minimum Safety Altitude shall not apply to the helicopter when it conducts flights for search and rescue operations in case of aircraft accidents, maritime disasters, and other accidents. However, if the helicopter flies at a low altitude for search and rescue operations, careful flight maneuvers are required with fully recognizing that it is flying at such an altitude that the safety of persons or objects on land or water is not taken into consideration. However, as described in 2.12.7 (2), the captain of the helicopter in operation by one pilot was shooting camera during the flight at such a low altitude that shall not be allowable from the aspect of safety, and it is probable that there might have some cases where keeping outside watch was not conducted appropriately.

As described in 2.12.7 (2), on November 13, 2006, the captain was warned against his behavior of shooting camera with his right hand during the right turn in flight by then Center Head saying, “It is an unsafe issue. The safe operation should be followed through.” It is highly probable that the captain had not have followed the instruction at least recently.

3.16 Regarding the ELT

As was described in 2.12.15, it is probable that the ELT installed on the helicopter did not activate because the G switches, which are designed to activate with impact from the front, left, above and rear, were stuck and because the impact was not sufficiently strong to active the another G switches that are designed to activate with impact from the other directions.

Regarding the time when the G switches became stuck, it was said that a G switch inspection (conducted during the regular inspection on June 30, 2016) was conducted as instructed according to the CMM; however, this could not be clarified, as no inspection record exists.

Because the ELT is an important piece of equipment whose activation or non-activation when an accident occurs can affect human survival, inspection of items established by the manufacturer must be carried out with certainty within the time period set by the manufacturer. Therefore, the contents contained in the manufacturer’s maintenance manual, including that pertaining to functional inspection of G switches, must be clearly stated in the ELT system maintenance manual of the certified workplace, and the person who conducts an inspection or maintenance must leave records of that inspection or maintenance.

Especially, even when a G switch satisfies technical requirements at the time of its production, it may deviate from those requirements by becoming stuck or degraded with the passage of time. Therefore, it is important to make periodic inspections of ELT G switches mandatory.

3.17 Regarding Flight Recorders

As was described in 2.12.16, the helicopter was not required to be equipped with a flight recorder and was not equipped with one. In this accident, although all of the rescuers aboard the helicopter died, it was possible to make use of video camera images taken by a rescuer as objective data to verify factual information and analyze the causes. However, it is probable that had the images not been available, scientific analysis of the accident would have been extremely limited in scope.

For aircraft that are required to fly within small safety margins, such as in severe weather conditions or at low altitude for firefighting, disaster management, or other activities involving life-saving and the like, the installation and utilization of a flight recorder, including the simple type mentioned in 2.12.16, can prove useful in better understanding of the characteristics and flight operations of an aircraft for special flight services by regularly analyzing and evaluating the flight conditions in ordinary flight operations, and if an incident or an accident occurs, it will contribute significantly to precisely identifying its causes and developing effective recurrence prevention measures. Accordingly, equipping such aircraft with flight recorders is considered as high priority and it is desired to study for its realization and promotion with the cooperation of relevant parties.

3.18 Regarding Fire, Firefighting, and Rescue

Regarding rescue-related activities pertaining to this accident, as was described in 2.10, it is highly probable that an appropriate response within a mountainous region in winter was made.

4. CONCLUSIONS

4.1 Summary of the Analysis

(1) It is highly probable that the helicopter took off from the Airport with the captain, mechanic A, and seven rescuers and planned to conduct training using the hoist at the Helipad. (3.4)

(2) It is certain that the helicopter took off from the Airport, headed northeast while climbing above the city, entered the airspace above the mountains, and turned right. It is highly probable that it headed toward Mt. Hachibuse in continuing roughly level flight at a speed of about 100 kt. It is certain that although the helicopter's altitude above the ground level (AGL) became lower gradually, and the tree-covered mountainside was looming ahead, the helicopter collided with trees while maintaining attitude and speed. (3.4)

(3) The helicopter leveled off at about 1,740 m. It is somewhat likely that this was because the helicopter was trying to ensure the safety altitude of 150 m or higher from the destination, the Helipad, with an elevation of about 1,580 m. (3.4)

(4) It is highly probable that while maintaining the maximum safety altitude, the helicopter took neither the avoidance route at a constant altitude by directly heading for the Helipad nor the avoidance route by climbing, instead, it continued to fly toward Mt. Hachibuse at a constant altitude after turning right, its AGL became lower as flying into over the mountains region, and the helicopter approached the ground. 3.4)

(5) It is highly probable that the helicopter fell into an uncontrollable condition as it crashed its fuselage and MRB into trees over a distance of approximately 40 m. (3.5)

(6) It is highly probable that the helicopter turned upside-down and collided with an approximately 40-degree slope from its nose. It is also highly probable that it was four seconds later after the helicopter collided with trees when the video recording stopped by the impact of the helicopter crashing into the ground. 3.5)

(7) It is highly probable that there were no abnormalities in the helicopter's engines from the time of takeoff until transition to level flight. As the engine had been operating when the helicopter crashed, it is highly probable that the MR had been rotating at constant rpm until the helicopter collided with trees. (3.6)

(8) It is highly probable that the helicopter was conducting engine data checks en route from takeoff. When the helicopter commenced turning right above the mountains, it is probable that engine checks had been completed before starting the right turn over the mountains. It is highly probable that mechanic A was conducting engine checks, concentrating on the flight instruments, and hardly watched outside. And it is somewhat likely that his attention was focused on addressing the engine data check records even after the engine checks completed, but this could not be specified. (3.7)

(9) It is probable that the captain lowered his visor while in flight. It is also probable that the use of visor had no effect on flying the helicopter. (3.8)

(10) It is somewhat likely that there were no abnormalities in the helicopter until it collided with trees. It is somewhat likely that during the time from when he helicopter turned right above the mountains until when captain's right upper arm moved, at least there was nothing wrong with the captain's condition like loss of consciousness. (3.9)

(11) Any voices were not recorded after rescuer B said, "Right rear clear" until the helicopter collided with trees. From this fact, it is somewhat likely that all members on board had not responded to the

approaching danger, however, as there is a possibility that the extension microphone of the video camera might have come off the helmet, this could not be specified. (3.9)

(12) It is certain that the captain was under treatment for the hyperthyroidism, underwent surgery for cystic adventitial degeneration of the right popliteal artery two times, and he was taking the prescribed medicines, which were categorized into class B and C respectively in the list of the Guidelines for Handling of Medical and Pharmaceutical Products. However, it could not be clarified whether the captain was subject to influence of those previous diseases, which would hinder the performance of aviation duties, or not, and whether the captain took those prescribed medicines during the flight and he was affected by those medicines or not. (3.10)

(13) Regarding the helicopter's not taking avoidance maneuver, it is somewhat likely that the captain could not recognize the dangerous situation and did not take any avoidance maneuver because he was in a state where the arousal level was lowered with microsleep, and so on, due to the effects of fatigue and time difference. However, it was not possible to clarify whether he actually fell into such a state. (3.11)

(14) The captain should keep watch so as not to collide with other objects. If, for some reason, he could not keep watch, it is highly probable that the captain should have instructed that it was highly probable that the captain should have instructed mechanic A to temporarily keep watch for him. (3.12)

(15) If mechanic A did not question the captain about the flight route and the altitude, it is somewhat likely that his attention was focused on the instruments and the log papers, and therefore he did not keep sufficient outside watch; however, this could not be specified, as mechanic A died. (3.12)

(16) If the rescuers in the cabin did not question the captain about the flight route and the altitude, it is somewhat likely that they thought that the highly experienced captain and mechanic A, who should have been grasping the outside situation and keeping watch forward; that they got used to low-altitude flight so much that their sensitivity to the danger became lower due to rescue mission and training; however, this could not be specified, as all of the rescuers aboard the helicopter died. (3.12)

(17) It is important for conducting safe aircraft operations that all crew members CRM is fully functioning under the appropriate leadership of the captain. It is probable that the mechanics can be actively used as cooperative resources in order to realize safe aircraft operations in the flight operations at the Center. Therefore, it is desired that the Center will endeavor to establish the CRM appropriately based on the Center's flight operations. (3.12)

(18) The Center conducts flight operations by one pilot (the captain) in accordance with the regulations. However, it is desired that the Center consider introducing the operation by two-pilot system when possible. (3.13)

(19) It is highly probable that the captain had hyperthyroidism and cystic adventitial degeneration of the right popliteal artery or their past medical history, and he was under treatment with medication. However, it is certain that the captain obtained the medical aviation certification and engaged in aviation duties without making a self-report on his medical information for the aviation medical examination. (3.14)

(20) It is probable that when the captain was diagnosed as hyperthyroidism, he should have declared the medical information such as his treatment status and therapeutic medicine to the designated aviation medical examiner, and according to the doctors' instructions, he should have taken required additional examinations, and if required, he should have applied for the judgment of the Minister of

Land, Infrastructure, Transport and Tourism. And after this, it is highly probable that the captain should not have engaged in aviation duties until the conformity to the standards for medical examinations was confirmed. (3.14)

(21) In the Aviation Medical Examination, it is difficult to make an appropriate judgment on whether to conform to the standards of Aviation Medical Examination unless applicants declare their medical history and information accurately. The Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism needs to provide complete instruction that aircrews must accurately make a self-report on their medical information to apply for the aviation medical certification, and if non-conformity is suspected, they must not engage in aviation duties, and must receive instructions from the designated aviation medical examiners and others, even if his/her aviation medical certificate is still valid. (3.14)

(22) The captain of the helicopter in operation by one pilot was shooting camera during the flight at such a low altitude that shall not be allowable from the aspect of safety, and it is probable that there might have some cases where keeping outside watch was not conducted appropriately. (3.15)

(23) The contents contained in the manufacturer's maintenance manual, including that pertaining to functional inspection of G switches, must be clearly stated in the ELT system maintenance manual of the certified workplace, and the person who conducts an inspection or maintenance must leave records of that inspection or maintenance. (3.16)

(24) For aircraft that is required to fly within small safety margins in activities involving life-saving and the like, the installation and utilization of a flight recorder can prove useful in better understanding of the characteristics and flight operations of an aircraft for special flight services by regularly analyzing and evaluating the flight conditions in ordinary flight operations, and if an incident or an accident occurs, it will contribute significantly to precisely identifying its causes and developing recurrence prevention measures. Accordingly, equipping such aircraft with flight recorders is considered as high priority and it is desired to study for its realization and promotion with the cooperation of relevant parties. (3.17)

4.2 Probable Causes

It is highly probable that this accident occurred because while flying over the mountains, any avoidance maneuver was not taken even though the helicopter was getting close to the ground, resulting in the collision with trees and the crash.

It is somewhat likely that any avoidance maneuver was not taken even though the helicopter was getting closer to the ground because the captain's arousal level was reduced and could not recognize the dangerous situation, however it was not possible to clarify whether he actually fell into such a state.

4.3 Other Identified Matters concerning Safety

(1) Regarding the self-reporting of past medical history and others for Aviation Medical Examinations

In the accident, it is highly probable that the captain had a past medical history and a surgical history and he was under treatment with medication. However, it is certain that he had obtained the aviation medical certificate without making a self-report on those medical information.

In the examination for the Aviation Medical Certificate, it is difficult to make an appropriate judgment on whether to conform to the standards of Aviation Medical Examination unless applicants declare their medical history and information accurately. Applicants for the aviation medical examinations must accurately make a self-report on their medical information to apply for the aviation medical certification.

(2) Regarding the shooting camera by aircrews during the performance of aviation duties

In the accident, the captain of the helicopter in operation by one pilot was shooting camera during the flight at such a low altitude that shall not be allowable from the aspect of safety, and it is probable that there might have some cases where keeping outside watch was not conducted appropriately.

(3) Regarding the inspection and maintenance of the emergency locator transmitter (ELT)

In the accident, the ELT that was installed on the helicopter did not activate~~d~~. It is probable that this was because the G switches were stuck due to the impact to the ELT of the helicopter.

Regarding the time that the G switches became stuck, this could not be clarified, as no inspection record exists.

Because the ELT is an important piece of equipment whose activation or non-activation when an accident occurs can affect human survival, inspection of items established by the manufacturer must be carried out in accordance with the provisions of Article 151 of the Civil Aeronautics Act Enforcement Regulation and certainly within the time period set by the manufacturer. Therefore, the contents contained in the manufacturer's maintenance manual, including that pertaining to functional inspection of G switches, must be clearly stated in the ELT system maintenance manual of the certified workplace, and the person who conducts an inspection or maintenance must leave records of that inspection or maintenance. Especially, even when a G switch satisfies technical requirements at the time of its manufacture, it may deviate from those requirements by becoming stuck or degraded with the passage of time. Therefore, it is important to make periodic inspections of ELT G switches.

5. SAFETY ACTIONS

5.1 Safety Actions Taken by Nagano Prefecture

Following the accident, Nagano Prefecture is engaged in the following safety measures by organizing a "study group on the fire and disaster prevention flight operations system"

(1) Creation of a safety management system.

Assignment of a safe flight operations manager, holding of safe flight operations meetings and evaluations of safe flight operations by third parties

(2) Measures for safe flight operations

Introduction of operation by two-pilot system, creation of a checking system involving at least two people, clarification of fly/no-fly decision-making and the scrub procedure, clarification of sharing of duties between the captain and co-pilot and clarification of monitoring, keeping outside watch and report by all members on board

(3) Rescuer training, health promotion, equipment maintenance

Systematic rescuer training, CRM training, training by flight simulator to deal with the emergency situation, development of the healthcare standards and regular operation of a helicopter auto-tracking system

(4) Development of pertinent regulations

Amendment of "operations management guidelines of Nagano Prefecture fire and disaster prevention helicopters" and development of "safety operations guidelines of Nagano Prefecture fire and disaster prevention helicopters" in order to specify the items necessary for safe flight operations

5.2 Safety Actions Taken by the Fire and Disaster Management Agency, Ministry of Internal Affairs and Communications

The FDMA implemented the following actions targeting local prefectural governments and other organizations that operate fire and disaster prevention helicopters based on the accident.

(1) Notification concerning thorough reinforcement of safety (March 2017)

(2) Fact-finding survey on thorough reinforcement of safety (April 2017)

(3) Implementation of interviews with individual organizations (May and June 2017)

In addition, the FDMA organized a "study group on improvement and enhancement of fire and disaster prevention helicopter safety," and studied the measures for improving safety, measures for enhancing the fire and disaster prevention flight operations system, and measures for training and securing fire and disaster prevention helicopter pilots. In the group study, following items were discussed; CRM training, introduction of operation by a two-pilot system, installation of flight recorder and voice recorder, development and enhancing commitment of regulations and guidelines pertinent to helicopter flight safety, development and enhancing commitment of manuals pertinent to helicopter activities (keeping outside watch, voice procedures and others), and management of pilots skill.

6. OPINIONS

6.1 Opinions to the Ministry of Land, Infrastructure, Transport and Tourism

6.1.1 Regarding the Self-reporting of Past Medical History and Other for Aviation Medical Examinations

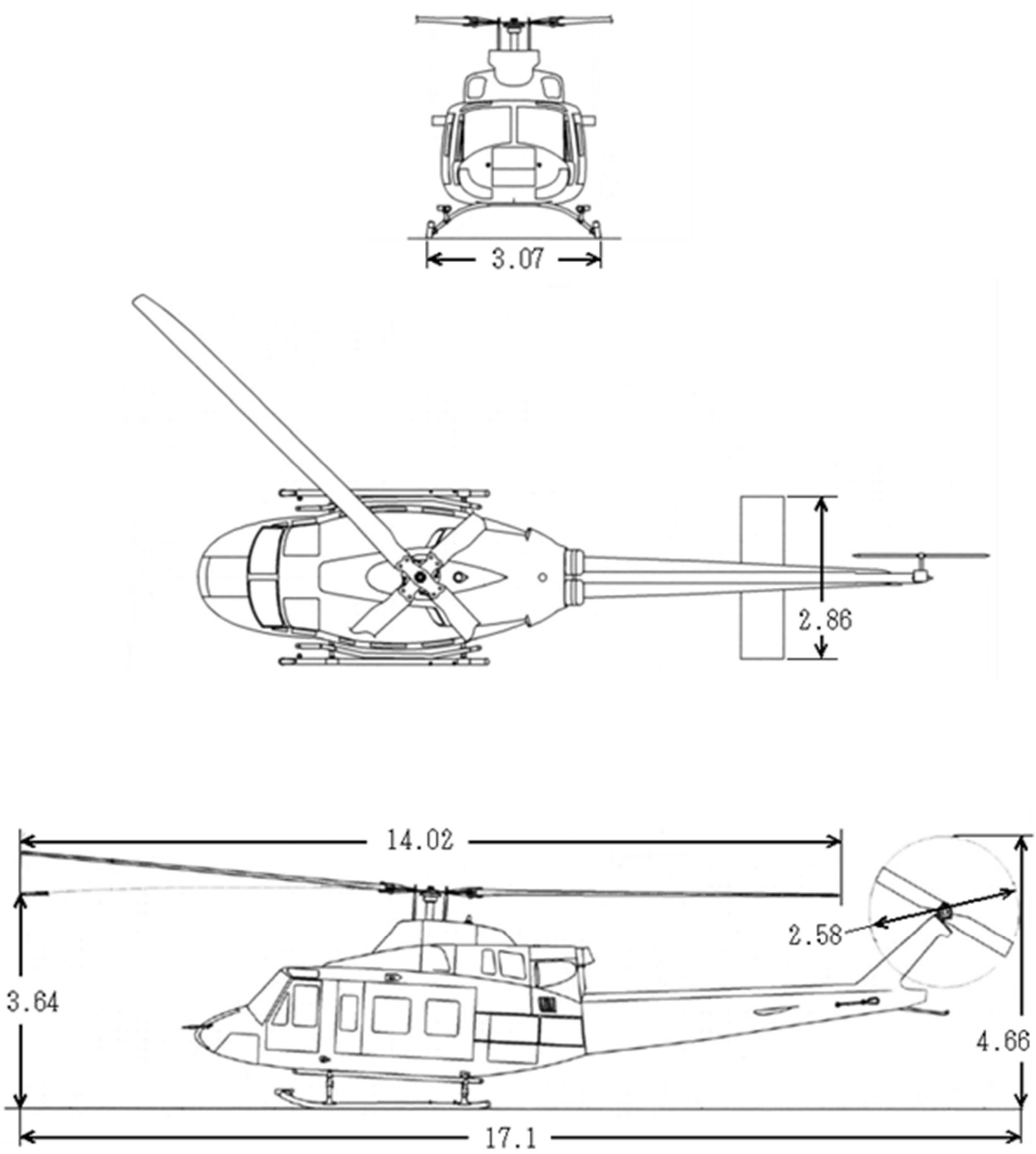
In the accident, it is highly probable that the captain had a past medical history and a surgical history and he was under treatment with medication. However, it is certain that he had obtained the aviation medical certificate without making a self-report on those medical information. In the examination for the Aviation Medical Certificate, it is difficult to make an appropriate judgment on whether to conform to the standards of Aviation Medical Examination unless applicants declare their medical history and information accurately.

Therefore, in view of the identified matters of the accident investigation, in order to ensure the safety of aviation, the Japan Transport Safety Board states an opinion pursuant to the provision of Article 28 of the Act for Establishment of the Japan Transport Safety Board to the Ministry of Land, Infrastructure, Transport and Tourism as follows:

It is necessary that the Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism thoroughly instruct aircrews to accurately make a self-report on their medical information to apply for the aviation medical certification, and if non-conformity is suspected, they must not engage in the performance of aviation duties, and must receive instructions from the designated aviation medical examiners and others, even if his/her aviation medical certificate is still within validity period.

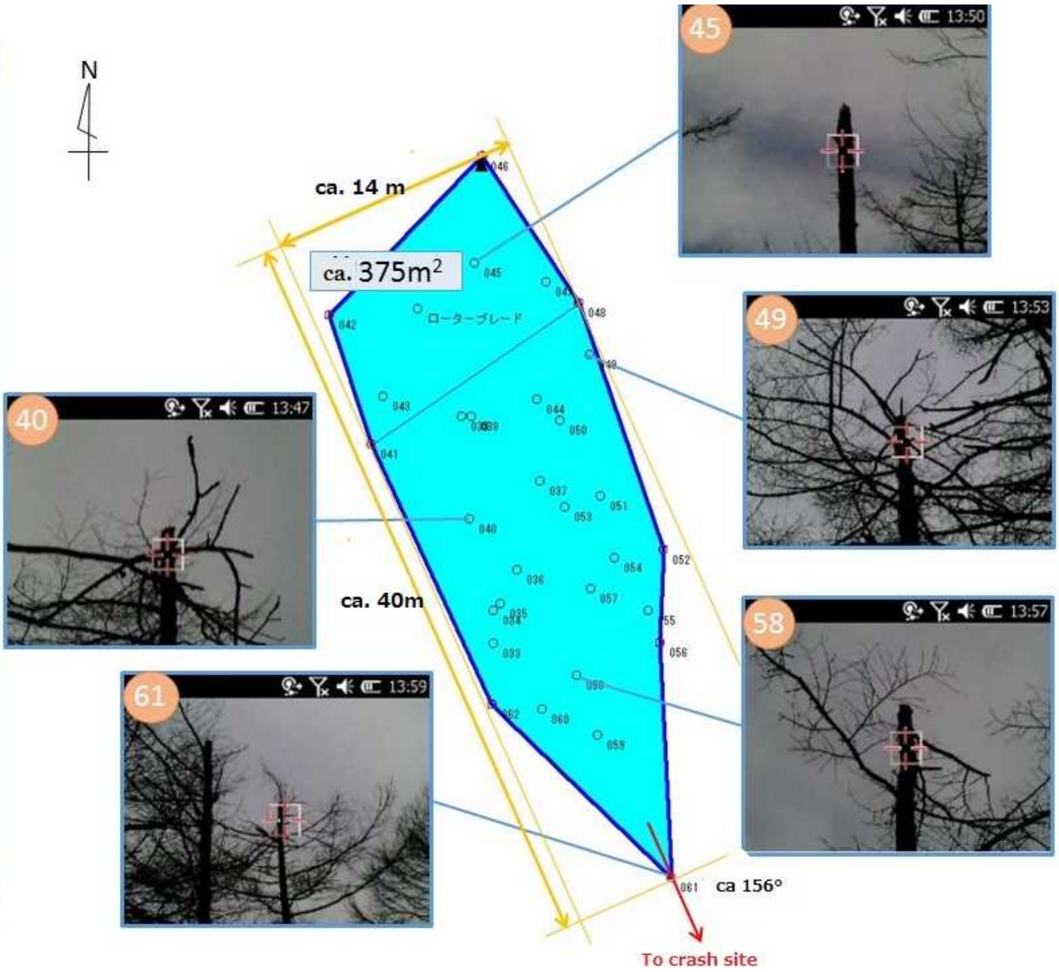
Appendix 1: three angle view of a Bell 412EP

Unit: m

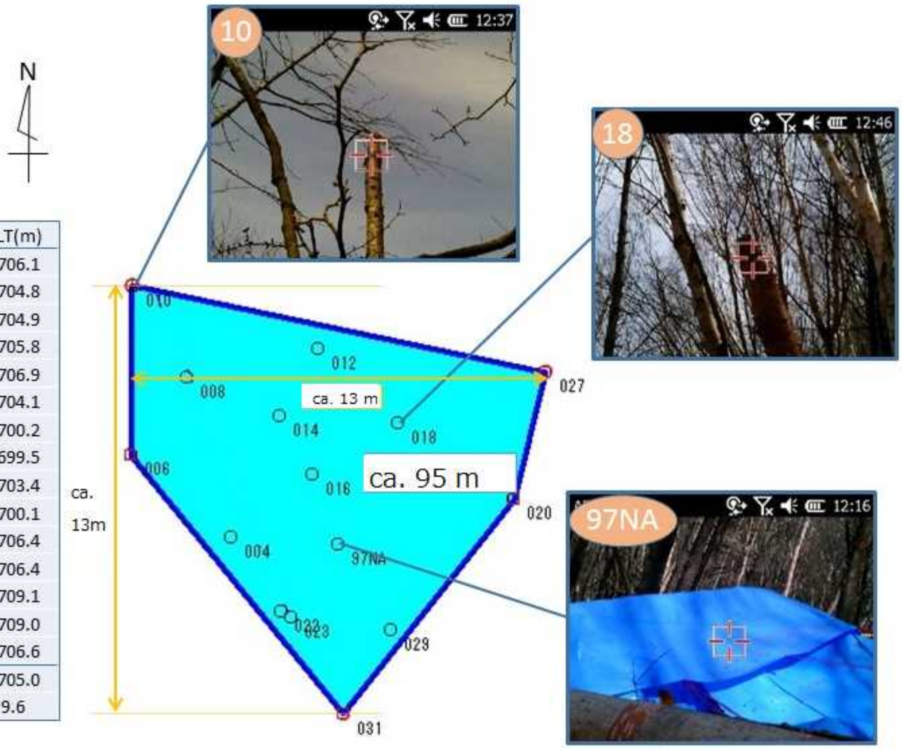


Appendix 2: results of measurements taken at the accident site

No.	ALT(m)
33	1738.3
34	1738.5
35	1738.6
36	1738.5
37	1738.5
38	1737.7
39	1737.7
40	1737.7
41	1736.8
42	1736.8
43	1739.1
44	1737.1
45	1737.2
46	1737.2
47	1737.2
48	1737.1
49	1737.1
50	1737.4
51	1737.2
52	1737.2
53	1737.4
54	1737.3
55	1737.2
56	1737.2
57	1737.3
58	1738.5
59	1738.6
60	1738.6
61	1739.1
62	1739.9
ave	1737.8
Δ	3.1



No.	ALT(m)
97NA	1706.1
4	1704.8
6	1704.9
8	1705.8
10	1706.9
12	1704.1
14	1700.2
16	1699.5
18	1703.4
20	1700.1
22	1706.4
23	1706.4
27	1709.1
29	1709.0
31	1706.6
ave	1705.0
Δ	9.6



Appendix 3: image prepared based on information from drone images