~ Case Studies and Accident Analysis ~

JTSB Digests

JTSB (Japan Transport Safety Board)

(Issued in April, 2014)

Digest of Aircraft Accident Analyses

For Prevention of Helicopter Accidents

1. Preface

In June, 2013, the Board made an investigation report public about an accident involving a helicopter which made a forced landing in Higashikagawa City, Kagawa Prefecture during its power transmission lines inspection flight in September 2011, and recommended the aircraft operator to give careful considerations and take necessary measures to establish a system to prevent unforeseen events due to movement of embarkation on board, and to enable pilots to perform emergency procedures of aircraft without failure. The Board also made a safety recommendation to the European Aviation Safety Agency (EASA) which controls the airworthiness of the aircraft to make it mandatory to modify electrical equipment and its wiring in the rear hold of the helicopter. The Board also made a recommendation to the EASA on the emergency operations.

In regards to an accident involving a helicopter crashed into a mountain slope in September, 2010 when it was flying for transporting cargo by sling load, the Board made an investigation report public in January, 2013, and made recommendations to the aircraft operator to review its flight operations whether there were non-compliance activities against laws and regulations, to remind all its employees engaged in safety-related works including pilots and mechanics of the importance of observing fundamental safety standards such as minimum safe altitudes, and to review internal contingency communication procedure.

Furthermore, the Board made another investigation report public in September, 2013 about the serious incident of the helicopter of which inside the engine was damaged during transporting an emergency patient in March, 2009, and made safety recommendations to the EASA on the method and amount of application, and precautions for use of the biocides as it was a contributing factor to cause a developing into a heat concentration in the Upper Structure of combustion chamber.

Recent cases under investigation by the Board include an accident in September, 2013 in Gojo City, Nara Prefecture, involving a rescue who has got injured his left index finger while being lifted with a helicopter hoist during the rescue mission, and a serious incident in October, 2013 involving a privately-owned helicopter which took off from Kumamoto Airport, resulted in an air proximity incidents with a nearby hovering Disaster Prevention helicopter near the airport.

In view of these ongoing situation, we present some case studies of accidents involving helicopters investigated by the Board and various statistical data for the prevention of similar accidents.

We ask those concerned to aim for further enhancement in safety assurance, and hope that this digest will be used as teaching materials on various occasions such as safety seminars, and will be able to contribute to the prevention of helicopter accidents.

The definition in this digest of "Helicopter accidents and serious incidents"

Among the aircraft accidents and serious incidents for which the former Aircraft and Railway Accidents Investigation Commission and the Board conducted investigations from October, 2001 until October, 2013, accidents and serious incidents (and accidents) involving helicopters.

Some of the accidents and serious incidents referred to in this digest are under investigation, and the figures may change.

2. Statistics

The number of accidents and serious incidents involving helicopters was 77 (63 accidents and 14 serious incidents), and among these cases, we have made investigation reports public for 70 cases (60 accidents and 10 serious incidents).

The below is the statistics on the situations of these accidents and serious incidents involving helicopters for which the Board conducted investigation.

* Figures 1 to 3, 6 and 7 show data for a total of 77 cases including accidents and serious incidents under investigation, and Figures 4, 5 and 8 through 13 show data for 70 cases whose investigation reports of accidents and serious incidents have been made public.

Statistics on the accidents and serious incidents

By the number of helicopter accidents and serious incidents, there were 16 (15 accidents and 1 serious incident) in 2002, which was the highest number while the number drops to 3 (1 accident and 2 serious incidents) in the following year. The number of accidents and serious incidents varies from year to year. (See Figure 1)

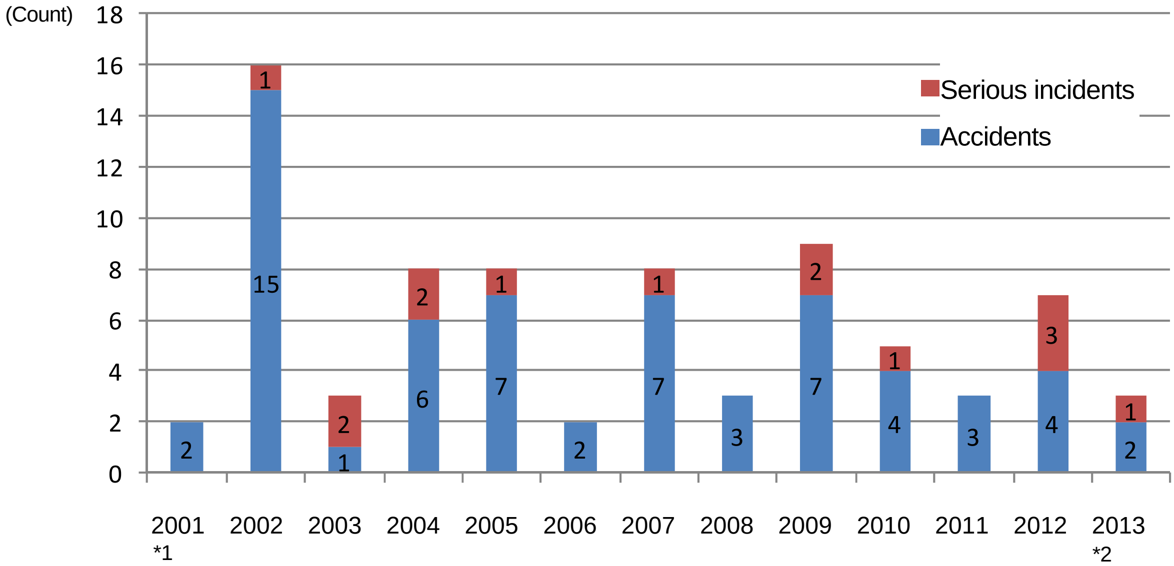


Figure 1: Changes in the number of helicopter accidents and serious incidents

*1: The 2001 figure includes the accidents and serious incidents added to the investigation since October 2001 by the Aircraft and Railway Accidents Investigation Commission.

*2: The 2013 figure includes the accidents and serious incidents added to the investigation by October, 2013.

Breakdown by type of accidents

By the accident type, the number of crashes was 27 (42.9%) which accounts for nearly half of the total accidents , followed by 6 (9.5%) each in other fatalities and injuries (ground crew etc), damage to aircraft at forced landing, damage to aircraft at landing, and other reasons.
(See Figure 2)

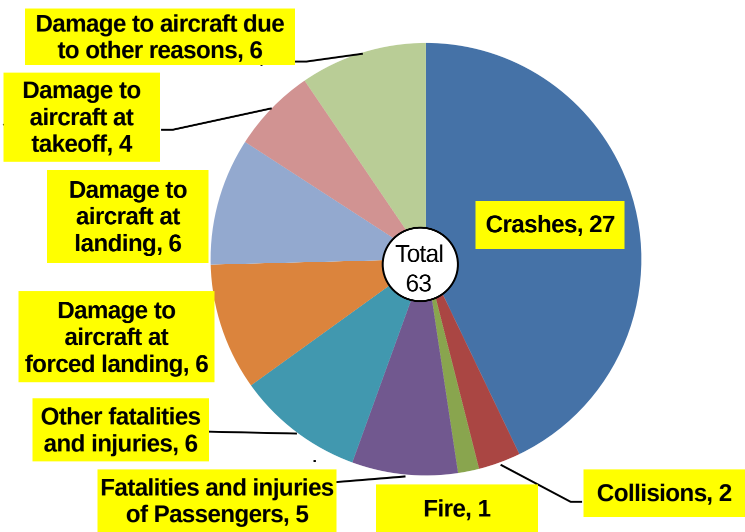


Figure 2: The number of cases by the type of accidents

Breakdown by type of serious incidents

By the type of serious incidents, the number of near misses with another aircraft was 6 (42.9%), engine stoped 3 (21.4%), and damage to engine and runway inclusions 2 (14.3%) each. (See Figure 3)

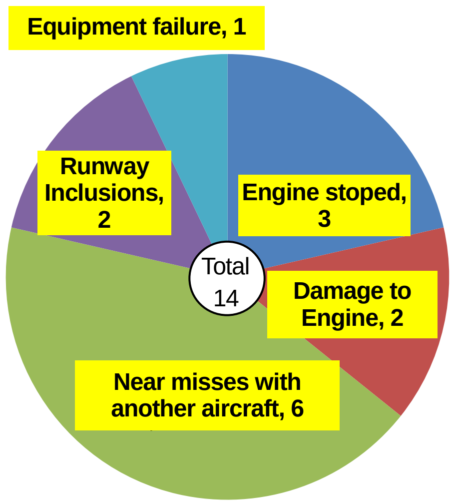


Figure 3: The number of cases by the type of serious incidents

Breakdown of the fatalities and injuries

By the number of fatalities and injuries, there were 15 accidents occurred in 2002, among which there were total 20 fatalities and injuries including 5 fatalities, 8 seriously injured and 7 slightly injured, and it was the highest number of fatalities and injuries. The second highest number was in 2007 with 7 accidents and total 18 fatalities and injured including 6 fatalities, 10 seriously injured and 2 slightly injured.

By the type of fatalities and injuries, 14 members on board died from the 4 accidents in 2010 as they were all crash accidents. (See Figure 4)

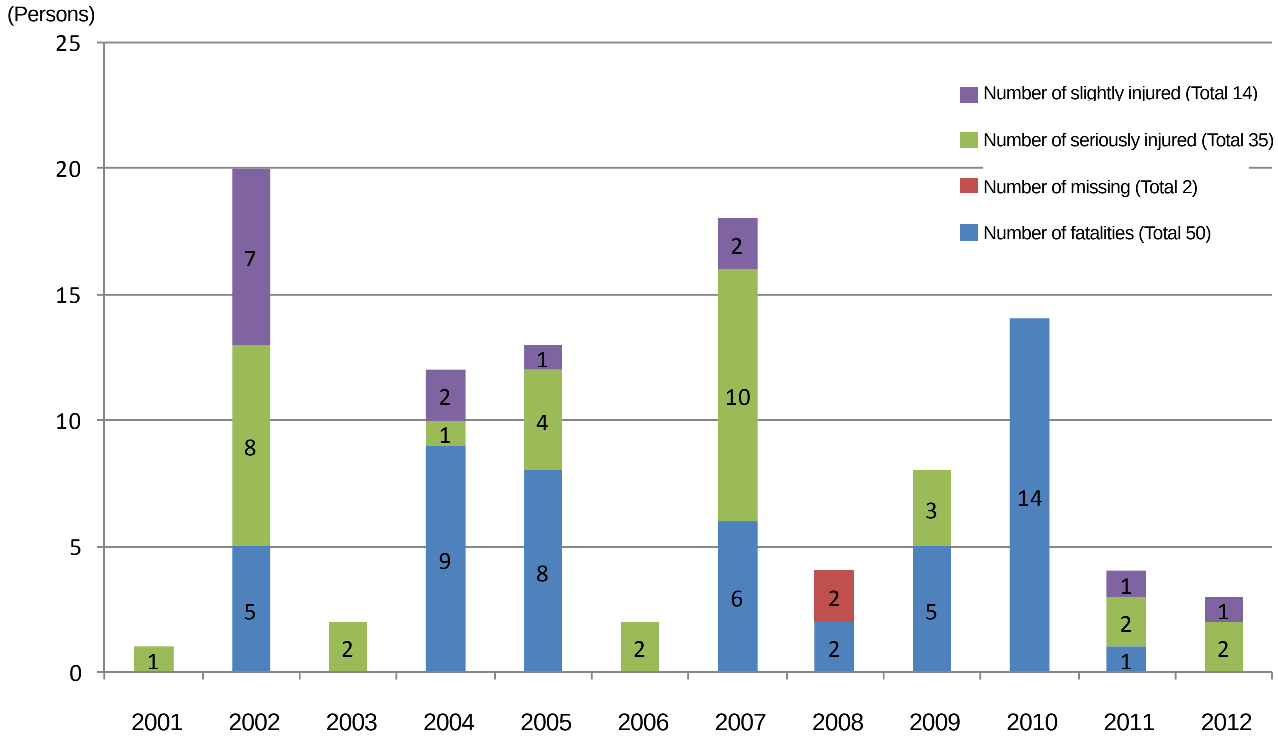


Figure 4: Changes in the number of fatalities and injuries（By the type of fatalities and injuries）

By the occupational category, there were 6 fatalities and injuries of members on board in an accident in Suishodake, Toyama City, Toyama Prefecture in 2007 involving a helicopter crashed into a slope immediately after taking off from Suishodake temporary helipad for passenger transport.

Other fatalities and injuries include non-persons on board such as ground crew and escorts. (See Figure 5)

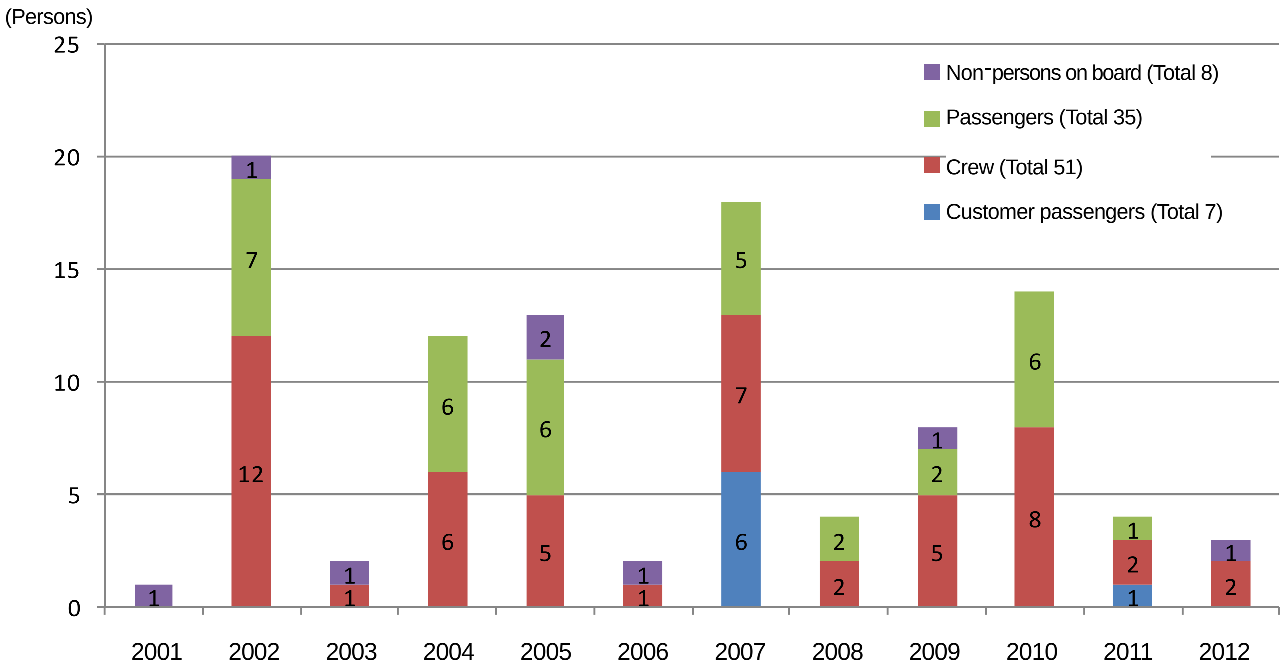


Figure 5: Changes in the number of fatalities and injured (By occupational category)

Breakdown of accidents and serious incidents by month

As for the number of accidents and serious incidents by month, there were 12 (15.6%) in July and in October, which were the highest in the year, followed by 10 (13.0%) in September. Accidents and serious incidents increase during the summer and towards the autumn except in August. (See Figure 6)

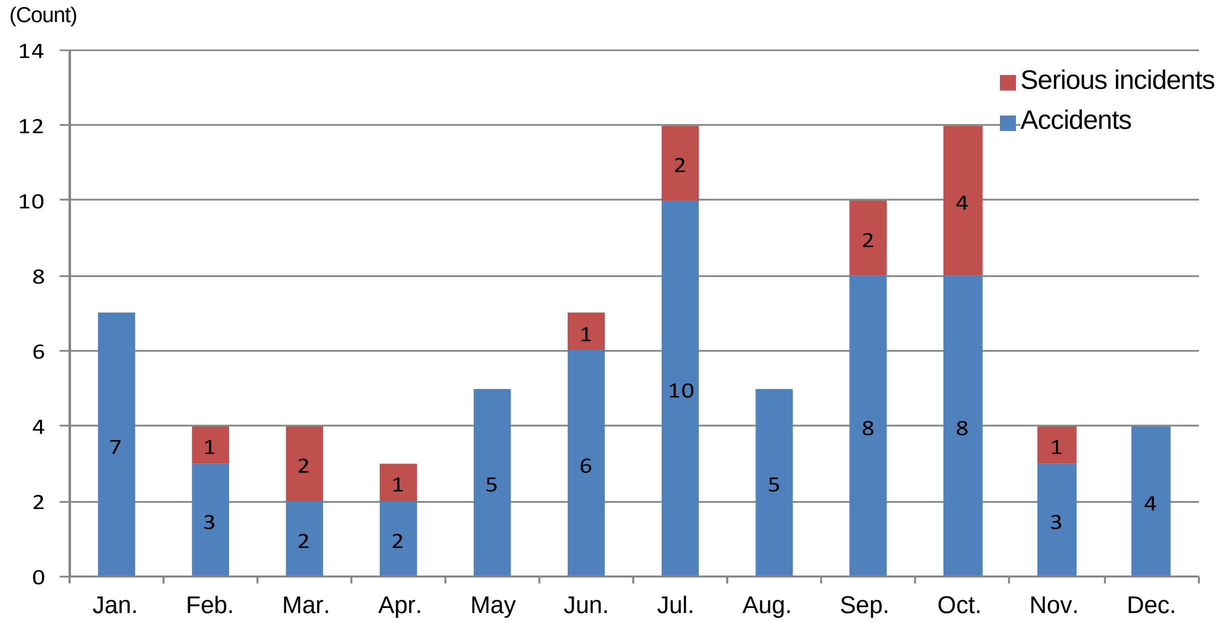


Figure 6: Number of accidents and serious incidents by month

Breakdown of accidents and serious incidents by the time of day

As for the number of accidents and serious incidents by the time of day, the highest number of accidents and serious incidents was 12 (15.6%) between 11:00 to 12:00, followed by 9 (11.7%) between 9:00 and 10:00, 13:00 and 14:00, and 15:00 and 16:00 respectively. In overall, accidents and serious incidents were concentrated between 9:00 and 17:00. (See Figure 7)

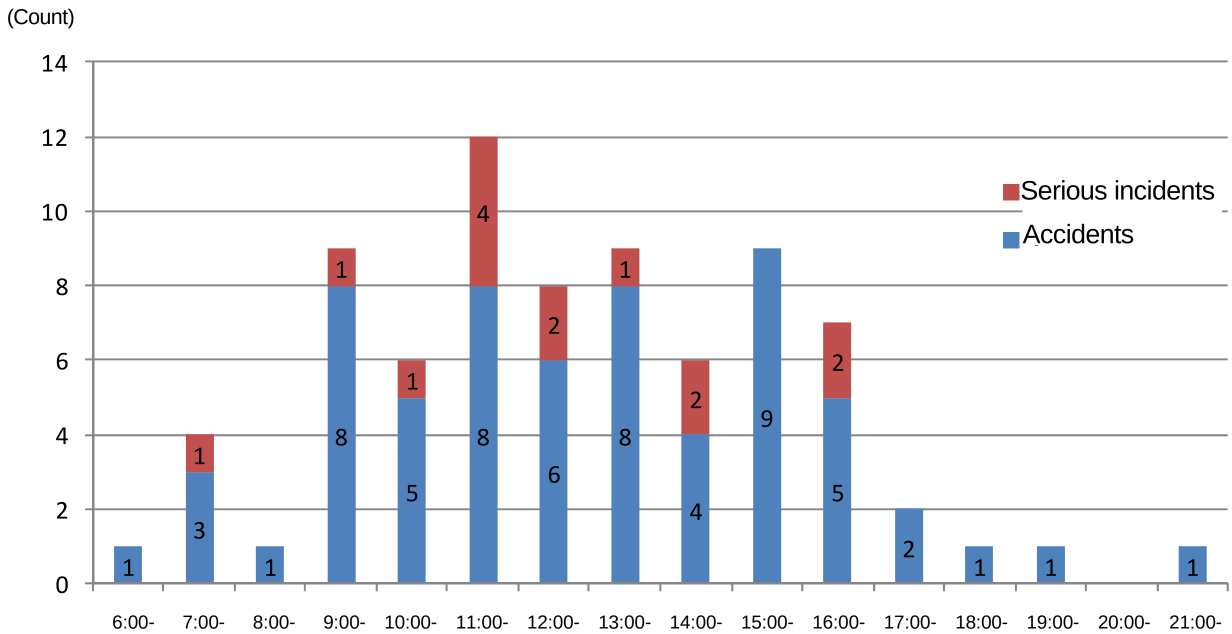


Figure 7: Number of accidents and serious incidents by the time of day

Breakdown of aircraft damage categories

By the aircraft damage category, the number of destroyed aircrafts was 39 (55.7%), while substantially damaged aircrafts was 10 (14.3%), slightly damaged aircraft was 1 (1.4%), and aircrafts with no damage was 19 (27.1 %). (See Figure 8)

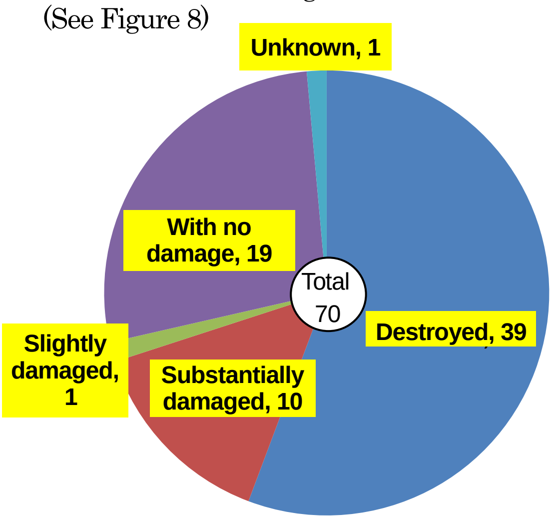


Figure 8; Breakdown of aircraft damage categories

Breakdown of accidents and serious incidents sites

By the accidents and serious incidents sites, the number of accidents and serious incidents that occurred at aerodromes/temporary aerodromes was 22 (29.7%), while 17 (31.4%) in mountains, 10 (14.3%) each in agricultural fields/mountain forests and on the sea. (See Figure 9)

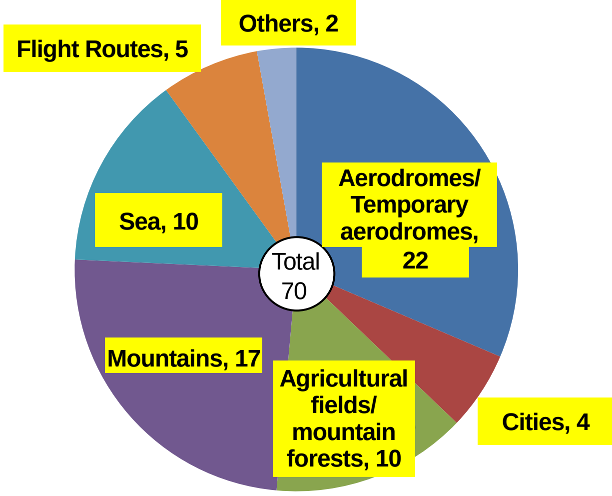


Figure 9: Breakdown of accidents and serious incidents sites

* Definition of “Aircraft Damage Categories”
Destroyed: It is extremely difficult to recover the aircraft’s airworthiness due to the damage.
Substantially damaged: The aircraft needs a major repair to recover its airworthiness due to the damage.
Slightly damaged: The aircraft needs a minor repair or simple component replacement to recover its airworthiness due to the damage or failure.

Breakdown of operation phase

By the operation phase at the time of the accidents and serious incidents, the number of accidents and serious incidents during cruising phase was 47 (67.1%), at landing phase was 14 (20.0%) and at take-off phase was 7 (10.0%). Accidents and serious incidents in cruising phase account for nearly 70%. (See Figure 10)

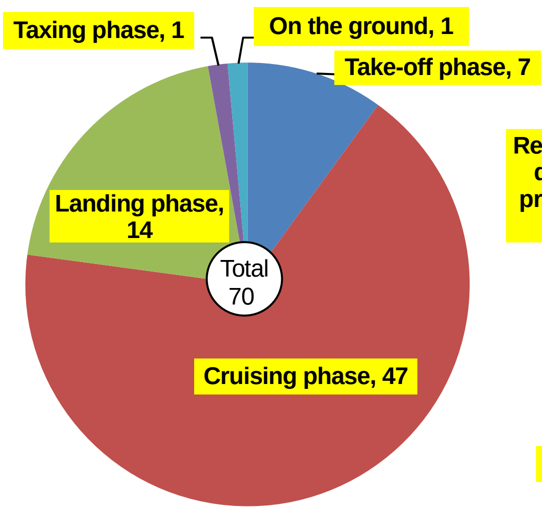


Figure 10: Breakdown of operation phase

Breakdown of flight purposes

By the flight purpose, the number of cargo transportation flights was 13 (18.6%) which accounts for the highest number among the total flight purposes, followed by 6 (8.6%) each in patrols, familiarity and ferry flights. (See Figure 11)

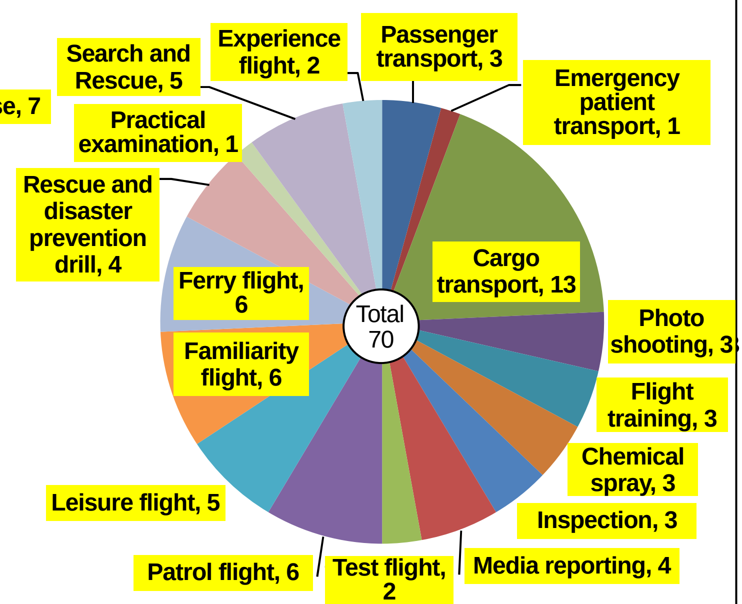


Figure 11: Breakdown of flight purposes

Categories of Causes

Approx. 80% of accidents and incidents are caused by human factors

When the causes of accidents and serious incidents in the investigation reports are categorized into four categories; human, mechanical, environmental and organization factors, the number of accidents and serious incidents caused by human factors and by human/environmental factors is 16 (22.9%) each, and human/organizational factors is 8 (11.4%). Approximately 80% accounts for "human factors or combination of multiple factors involving human factors". (See Figure 12)

Among various classifications of human factors, following is the further breakdown of human factors based on "unsafe action", (*3), "Inappropriate action", "failure in detection" and others. In this classification, there are 19 (33.3%) of "Inappropriate actions" cases, which include carelessness, omission of confirmation and sloppy operational practices and this type of human factors accounts for the highest number in all human factors. The second highest is 15 (26.3%) "compound human factors" which involve multiple human factors". Other human factors include 7 (12.3%) "Judgment errors" instances including assumption and presumptions, 5 (8.8%) "unsafe actions" such as neglecting a caution light and precautionary requirements, 4 (7.0%) "failed in detection" instances such as unable to identify what should be identified (e.g. power lines), and 3 (5.3%) "forgot" instances due to distractions. (See Figure 13)

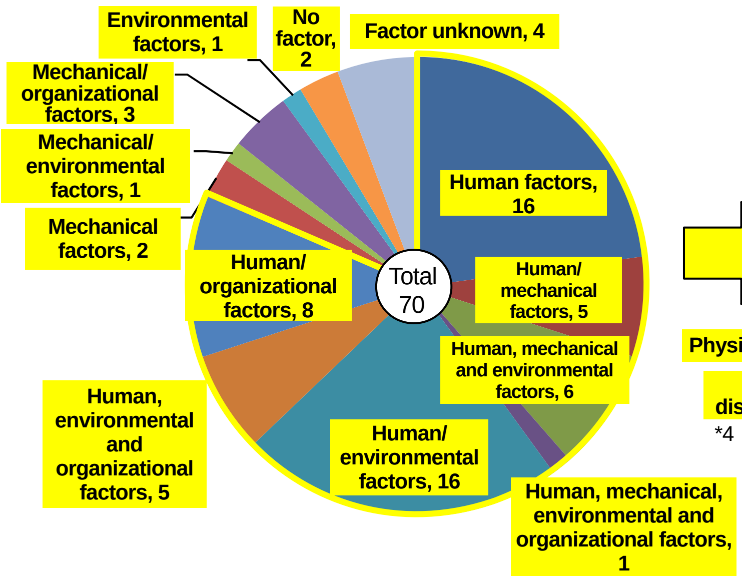


Figure 12: Breakdown of cause categories

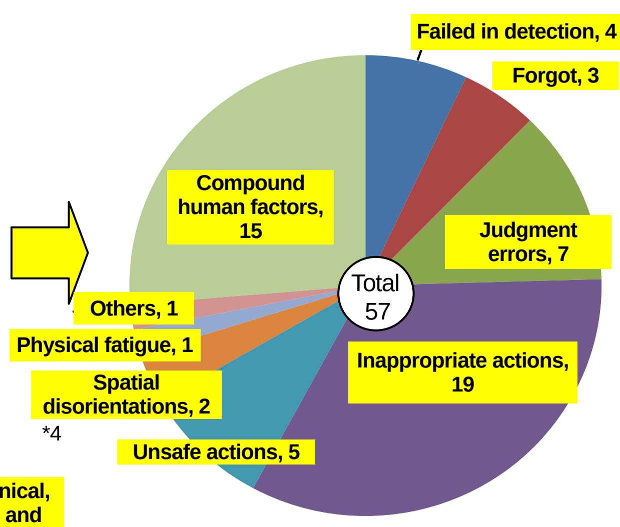


Figure 13: Breakdown of human factors

*3: Any deliberate action which might impede the safety of oneself or others without its intention. (This is the original definition of this digest.)

*4: Loss of proper perception of one's position and direction (spatial orientation) in space caused by gravity (G), one's vision and psychological effects. The spatial disorientation in flight often occurs in night flight or instrument flight. Special disorientation includes the cognitive defects in one's tilt perception, meaning one's tilt perception differs from actual tilting of the aircraft, or the directional disorientation, meaning one's direction perception differs from actual direction of the aircraft. Special disorientation is a critical symptom which could lead to a fatal accident.

Examples of human factors

Failed in detection

- ○ Indistinct contrast of a steel tower and power lines against ground background made their detection difficult.

Judgment error

- ○ Safety was not the first priority in in-flight decision making such as returning to the original point or destination change.

Inappropriate actions

- ○ Insufficient rudder pedal input.
- ○ A lack of awareness in near-by aircraft due to concentration on to flying direction.
- ○ No advance checking performed on the ground or from sky for any obstacles in the accident site.

Examples of mechanical factors

- ○ Not considered repetitive compression and shear strain generated lead to fatigue of the composite material.
- ○ Red rust created with the corrosion of the contact surface of the inner ring and the outer ring caused volume expansion in the space between the two rings and this restricted the movement of the two rings.

Examples of environmental factors

- ○ Visibility degradation from rain at night.
- ○ Sudden strong tailwind.
- ○ Fog restricted visibility.

Examples of organizational factors

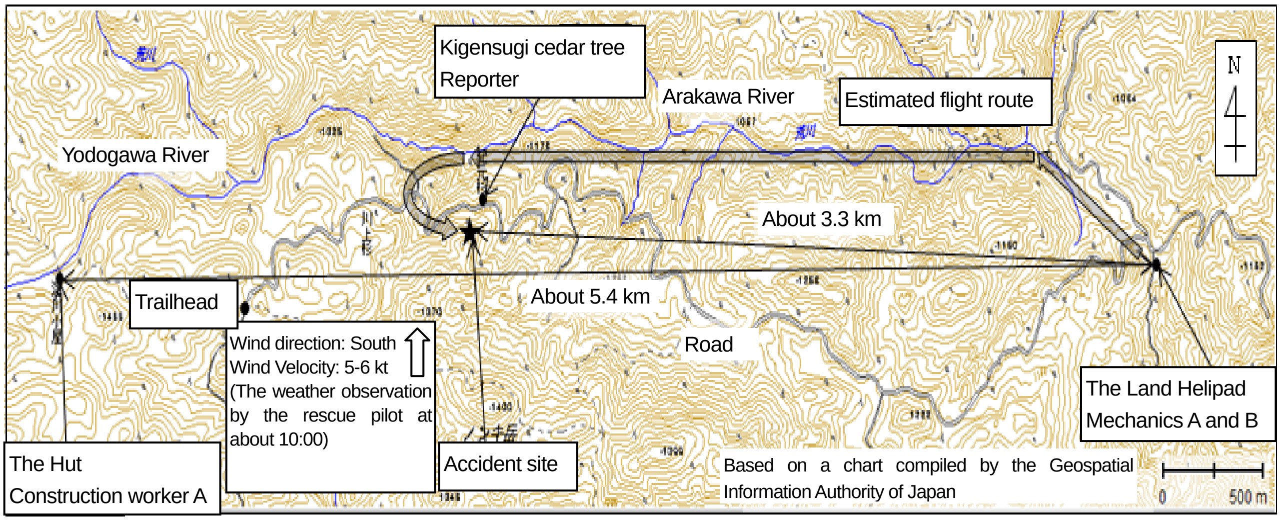
- ○ No established communication system in place for cargo transport.
- ○ Regarding the burden sharing for mountain rescue activities no clear recognition.

Case 1

Crash during cargo transport with underslung external cargo caught in trees or rocks into the mountain slope

Summary: On Sunday September 26, 2010, an Aerospatiale AS332L operated by Company A, took off for sling load cargo transport from Yakusugi Land temporary helipad (hereinafter referred to Land Helipad) located in Yakushima-Town, Kumage-Gun, Kagoshima Prefecture, and crashed into the mountain slope near Kigensugi cedar tree in Yakushima-Town at about 07:50 local time (UTC+9 hours).
Onboard the helicopter were a pilot and a loadmaster, and both of them suffered fatal injuries.
The helicopter was destroyed and consumed by fire.

Estimated Flight Route



Events leading to the Accident

The helicopter took off from Land Helipad for cargo transport, and was flying in the mountain near Kigensugi cedar tree in Yakushima-Town for stone transport.

The helicopter picked up 6th cargo and took off from Land Helipad in the usual manner, but it did not return.

A reporter near Kigensugi cedar tree came to Land Helipad and reported to one of construction workers that the helicopter had crashed.

Type Helicopter

Meteorological Conditions

Mechanics A and B at the Land Helipad received a call from the pilot during the 5th cargo transport saying "The helicopter might land (at Land Helipad) and stand by because of worsening weather condition".

Construction worker A at the cargo unloading site in the vicinity of the Hut heard faint sound of the helicopter coming toward him during the 6th cargo transport and the sound became faint as if the helicopter were turning away on the way.

The elevation of the accident site is about 1,290 m (4,230 ft), and the pilot of the disaster prevention helicopter, the Disaster Prevention Aviation Center, stated "It was overcast with the cloud base 4,500-4,600 ft (1,370-1,400 m) hanging over the ridge in the vicinity of the accident site and the horizontal visibility was good at about 10:00.

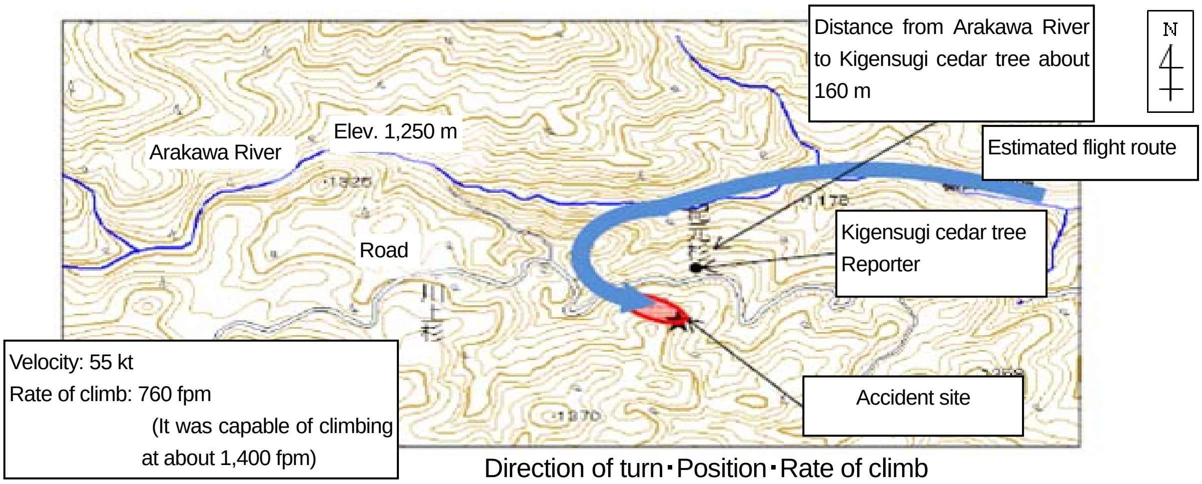
It is probable that the squeezed opening between the lowered cloud base and the surface made it difficult for the helicopter to continue the flight near the cargo unloading sites in the vicinity of the Hut at the time of the accident.

It is probable that the weather conditions over the accident site were such that the cloud base was 100 m above the site-small opening between the ground and the cloud base.

Flight Route at the Time of the Accident

It is probable that the flight route was along the valley of Arakawa and Yodogawa River due to the following reasons:

- The Reporter stated that he had heard the helicopter flying back and forth when he was near Kigensugi cedar tree, and had seen it flying in the valley to the north of the Kigensugi cedar tree in the direction of the Hut.
- It is probable that due to the following advantages the pilot chose to fly in the valley rather than over the mountain ridge for the route of helicopter short distance shuttle flights for cargo transport, as he was aware of the absence of linear obstacles (such as wires and cables) and was fully familiar with the geographical features.
  - A flight at low altitude will shorten the length of the route and provides the helicopter with better margin of usable power (cargo sling capability), which lead to less time and fuel consumption.
  - Flying over a river provides bigger AGL altitude.



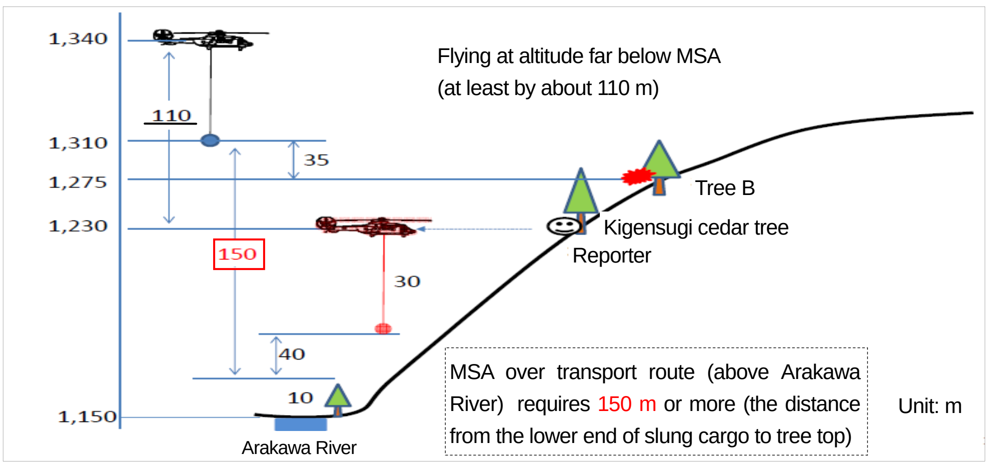
Direction of turn･Position･Rate of climb

Reasons for Unavoidable Collision with the Trees

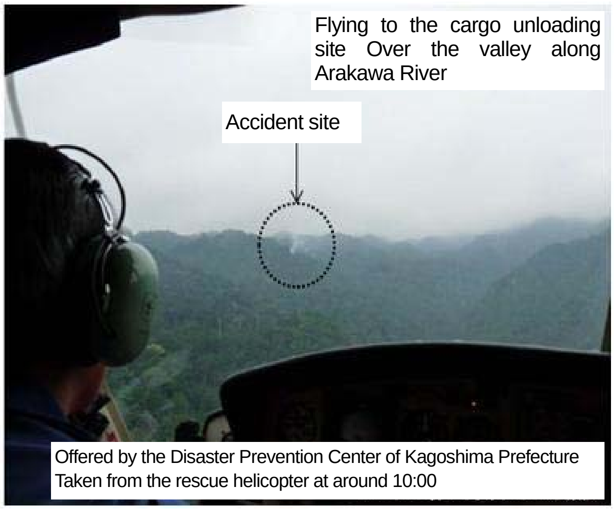
It is probable that the pilot selected the easier maneuver of the left turn than OGE hovering (*1) above the Arakawa River, although the latter was possible if he accepted a large control input. His selection resulted in the proximity to the slope in the valley causing the underslung cargo being caught in the branches of Tree B or Rock A. Reason for his selection are as follows:

- It is highly probable that the helicopter was flying over the route for the cargo transport far below the Minimum Safety Altitude (MSA).
- The pilot possibly reduced the climb rate to avoid in-cloud situation during the turn, as the opening between the flying altitude and the cloud base was small, although it had enough climbing power to avoid the collision with trees.
- The pilot possibly failed to judge the cargo clearance from the tree top because it was the left turn—his right seat position hampered his look-out, with the cargo slung with 30 m long slings.

*1: "OGE" hovering stands for out of Ground Effect hovering (hovering at an altitude larger than half the length of a MR diameter where the ground reaction force created by the downwash is unavailable). OGE hovering requires a larger amount of engine power than IGE (In Ground Effect) hovering which is normally carried out below OGE hovering altitude.



Flight altitude



Accident Site Taken From Afar During Rescue Operation

Aerial Photo of Accident Site

Probable Cause: In this accident, it is probable that the helicopter, while flying in the mountain valley with underslung external cargo, made a left turn to return back, crashed after nearing the slope with its underslung cargo caught in ground objects such as trees or rocks during maneuver. The post-crash fire consumed the helicopter and the pilot and the loadmaster suffered fatal injuries.
The followings are possible reasons why the helicopter came close to the slope during the left turn, and the underslung cargo came to be caught in ground objects such as trees or rocks: capable OGE hovering for turn-back was not carried out; en route altitude was well below MSA; the climbing was restrained during the left turn as the opening under the cloud base was small; and the failure of judging underslung cargo clearance from the trees.

In order to Prevent Recurrence

In view of the result of this accident investigation, the JTSB, pursuant to the provision of paragraph (1) of the Article 27 of the Act for Establishment of the JTSB made the following recommendation to Company A.

Company A needs to review flight operations whether there were non-compliance activities against laws and regulations, to remind all employees engaged in safety-related works including pilots and mechanics of the importance of observing fundamental safety standards such as minimum safe altitude and to review internal contingency communication procedures.

Safety Actions Taken Response to the Recommendations by the Company A

○ From the views of compliance against laws and regulations, Company A reviewed safety related events such as non-compliance against laws and regulations on all the works of every unit of Operation/Maintenance of Air Operation Department and as a result of this review took improving measures as necessary.

○ To remind the meaning and importance of complying with safety standards such as MSA, Company A decided to hold the safety meeting for all the employees of Air Operation Department, and thoroughly and continually enforce its implementation through Aviation Safety Event, safety education, or CRM.

○ Company A checked and reviewed the current contingency communication procedures and took the following countermeasures.

(1) As a result of this review, it was confirmed that there existed a few working sites where no on-demand communication was available between heliport and cargo loading/unloading site.

(2) As a result of reviewing the communication procedures and evaluating the supplemental communication means, Company A decided to establish the on-demand communication procedures with asking for the cooperation of ordering agent.
When ordering agents are not able to provide necessary communication equipment, Company A loans satellite mobile phones to them.
Company A purchased 6 set of satellite mobile phones and placed a set at each of their branch offices.

(3) As a result of reviewing the clarification of communication procedures between heliport and cargo loading/unloading site, Company A decided to take the following measures and notified the concerned personnel of them.

・ Make a separate chart of site communication procedures at the site where no contingency communication procedures is mentioned in a construction plan on work order.
・ Add a check item for emergency communication procedures on meeting sheet of before-work, and confirm it before work by work-crews.
・ Add a description on emergency communication procedures in “Study Guide of Cargo Transport” of Company A.

The investigation report of this case is published on the Board’s website (issued on January 25, 2013).
http://www.mlit.go.jp/jtsb/eng-air_report/JA9635.pdf

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

Case2

Crash during hoisting down rescuers in the ravine downstream of waterfall plunge pool for rescue operation

Summary: On Sunday July 25, 2010, a Eurocopter AS365N, owned by Saitama Prefectural Government took off from a temporary helipad in Otaki, Chichibu City, Saitama Prefecture at 10:48 local time (UTC+9 hours) for a rescue operation and crashed, while hoisting down two rescuers (Air Rescuer A and Firefighter A) to a ravine upstream of Takigawa, around 11:03.
Of seven persons on board, two hoisted-down rescuers survived, however, five persons (a pilot in command, a pilot, two rescuers from Saitama Disaster Prevention Aviation Unit and a firefighter from Fire Brigade Headquarters) sustained fatal injuries.
The aircraft was destroyed, however, no fire broke out.

Events leading to the Accident

Around 09:18

The Disaster Prevention Aviation Center received an official rescue request from Fire Brigade Headquarters, in which one of the female member of the gorge climbing party (nine members) slipped into a waterfall plunge pool and was receiving resuscitation on site.

Around 09:42

The aircraft took off from the Center, with five persons on board—the PIC, the LST pilot with a license of land-use single turbine engine helicopter, and three Air Rescuers.

Around 10:20

The aircraft headed for Deai-no-oka temporary helipad (Deai-no-oka Helipad) to join firefighters.

Around 10:48

The aircraft took off from Deai-no-oka Helipad with two additional Firefighters.
After reaching the would-be rescue area and a recon flight, it located the party and chose the hovering point for the hoist descent.

Around 11:00

The aircraft made a right circling flight to the accident area and occupied the hovering position downstream of the plunge pool for the preparation of the hoist descent.

Around 11:02

The two rescuers (the Air Rescuer A and the Firefighter A) began the hoist descent.
The aircraft, during its hoist operation, lowered its AGL altitude above stream from about 60 m to about 51 m, and this means increased proximity to the obstacles considering the geographical features near the accident site and reducing the safe distance.

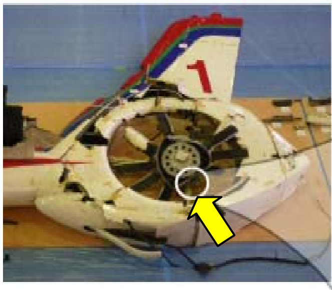
Tree branches were sucked into the Fenestron, and the aircraft lost its yaw control due to the damaged tail rotor, started to spin to the left, and its main rotors contacted with trees located left aft side of the aircraft.

Around 11:03

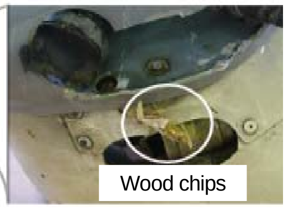
The aircraft lost horizontal stability due to spinning and moved to north-westward slashing tree branches and crashed into the left bank cliff from the nose.

Causal Factors of the Accident

Just After the Occurrence of the Accident
(This picture was taken by a member of the gorge climbing party)



Fenestron



Tree fragments viewed in the direction of the arrow

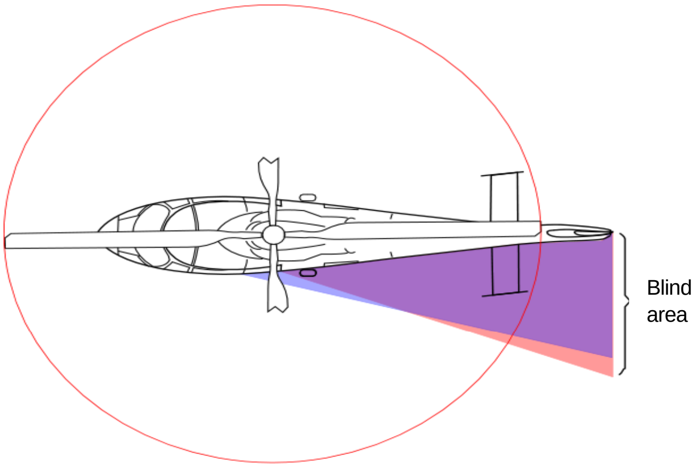
As the aircraft hovered to the left without changing its heading until it occupied the hoist descent position, it is probable that the PIC did not have the sufficient confirmation of the obstacles to the left and the LST pilot did the left-side watch.

For details, refer to "Looking Out During a Hovering Operation" (next page)

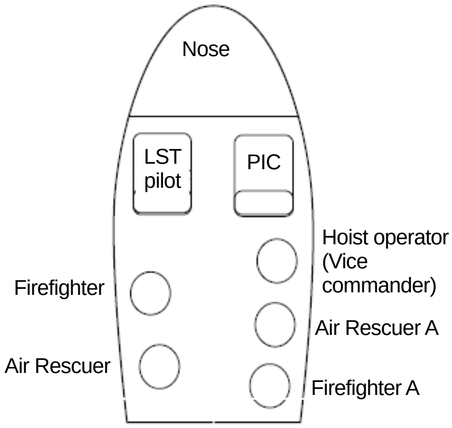
It is probable that PIC lowered the AGL hovering altitude to avoid the difficulties associated with long hoist cable operation at higher hovering altitude than the usual training altitude.

It is very likely that the aircraft crashed when it hovered to the left to adjust the position without appropriate looking out, the Fenestron's tree contact developed into a loss of yaw control followed by main rotor tree strike.

Looking Out During a Hovering Operation



Blind Area in Aft Left Section of Aircraft



Cabin layout of on-board members

Legend
- Blind area from the left pilot station seen through the cabin window
- Blind area from the cabin rear seat

On-board member's assignment
- PIC: Aircraft control (steady hovering on target)
- Co-pilot: Looking out to the left, engine instrument monitoring and communication
- Hoist operator: Hoist operation, aircraft guidance and looking out to the right aft
- Standby rescuers: Preparation for their part of descent, confirmation of the target

The Aviation Unit maintains that they did looking out per duty assignment as described in the above figure when a helicopter hovers in a small confined area. However, usually the left cabin slide door is closed during hoist operation therefore blind area exists near the Fenestron as depicted in the above figure, unable to see from the aircraft interior.

It is not certain whether the PIC confirmed the left side of the aircraft or gave instructions to watch that section before moving to the left for the position adjustment, it is very likely that the looking out to the left aft was inappropriate.

Although the voice procedures (call-out procedures for rescue mission) did not include looking out, the JTSB considers it desirable to include the looking out in the voice procedure so that aircraft occupants do looking out properly per duty assignment.

In order to Prevent Recurrence

When a helicopter hovers in a small confined area it is imperative to keep close watch against obstacles for keeping safe distance for main rotor and Fenestron.
It is most likely that inappropriate looking out to the left aft lead to the aircraft's tree contact and consequently developed into accident. The JTSB believes that the necessary training should be repeated to train aircraft occupants to do proper looking out responding to the rescue site circumstances.
On the other hand, the hoist camera's AGL altitude just after the occupation of the hovering point for a hoist descent was about 60 m, the altitude gradually diminished as the time passed. It is very likely that the allowable length of hoist cable was about 90 m and the aircraft was able to hoist down rescuers without lowering its altitude; however, the aircraft chose to lower its altitude leading to the proximity with obstacles.

In general, a rescue hoist operation is carried out under difficult circumstances so that there are cases where hoist and other equipment capability has to be used to its maximum extent while all the aircraft occupants keep looking out in order to accomplish its mission safely. Whereas the difficulties of high AGL altitude hovering for the rescue mission by unwinding the cable long are understandable; however are commonly shared by pilots in general; however there may be situations where no other alternatives exist. Assuming tough situation where high AGL hovering is required, it is important to keep prepared by periodical rescue training under the high AGL hovering circumstance.

The investigation report of this case is published on the Board's website (issued on February 24, 2012).
http://www.mlit.go.jp/jtsb/eng-air_report/JA31TM.pdf

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

Case 3

Uncontrolled Crash into the Ground with Damaged Tail Rotor by Sling Cable during Cargo Transport Flight

Summary: On Monday October 3, 2011, a Eurocopter AS350B3, operated by Company A, took off from the Karasawa temporary helipad in Kiyokawa Village, Aiko-gun, Kanagawa Prefecture to transport cargos and sustained damage to its airframe during flight. The helicopter crashed into the Choja-yashiki Campground.
Two people in total were onboard the helicopter, a pilot and an onboard mechanic. The pilot was killed and the onboard mechanic was seriously injured. The helicopter was destroyed and a fire broke out.

Events leading to the Accident

Around 09:30

The helicopter took off from Karasawa temporary helipad to transport cargos to the location of unloading sites No.1 to No.6.

After flying to and from the sites a number of times, the onboard mechanic observed the sling cable flying in the wind in the direction of the posterior end of the fuselage (around the tail guard) in the rearview mirror and reported the observation to the PIC.

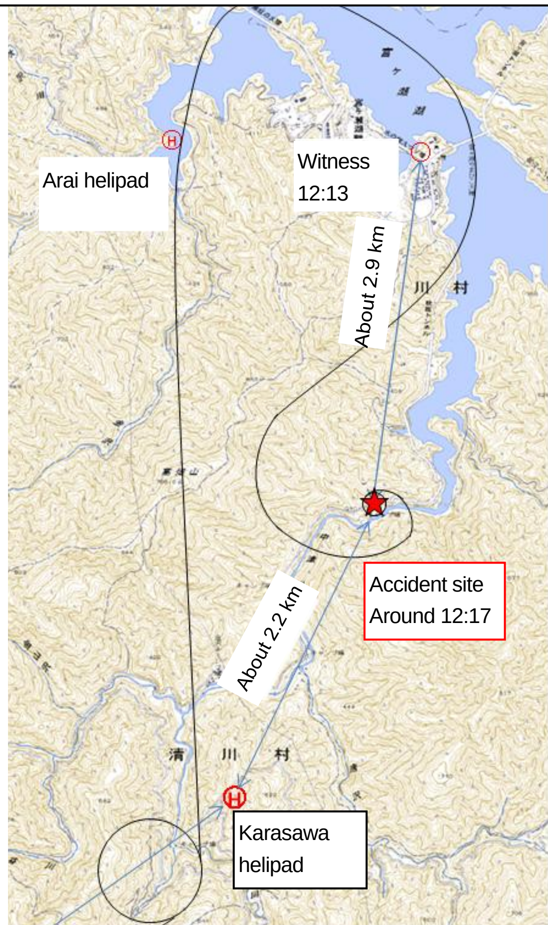
Around 12:05

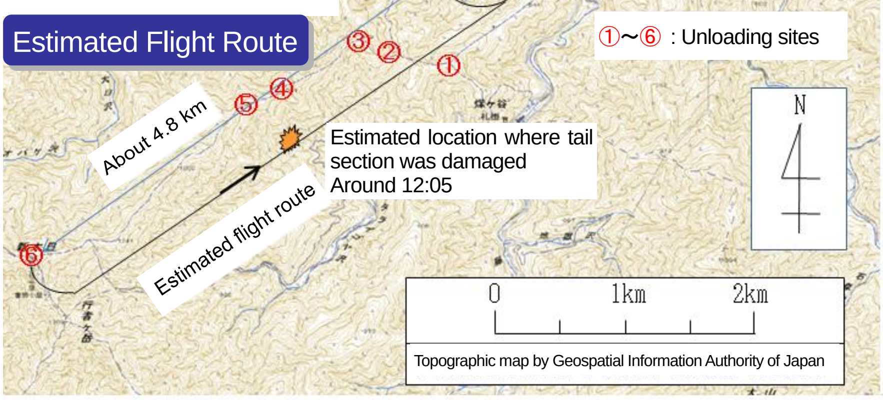
After unloading the cargos at No.6 site, around midpoint of the return route to the Karasawa helipad, the onboard mechanic heard a loud "Bang" sound.
When the onboard mechanic observed behind the helicopter, he found the tail rotor stopped rotating and the blade was broken.

The pilot continued the flight to search for the landing site while contacting with the onboard mechanic and a ground operator.

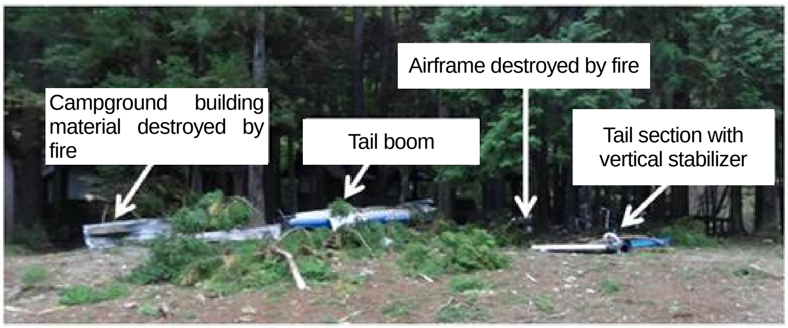
After initial yawing, the helicopter gradually lowered its nose.

Around 12:17 The helicopter crashed into Choja-yashiki Campground





Accident Helicopter



Accident Site

Damage to the Tail Rotor

The sling cable was not stable

Information on sling work was provided by the helicopter's design and manufacturing company in its Service Letter, but was not shared with the Flight Operation Department of Company A.

At the time of the accident, a sling cable of 7 m long was attached with no load.

→ It is highly probable that the sling cable was not stable due to insufficient ballast (*1) weight and it is probable that the sling cable was prone to cause the upward movement.

*1: Weight for adjusting the center of gravity

Service Letter from Helicopter's Design and Manufacturing Company (excerpt)

◇Unloaded sling cables, especially short sling cable (5 to 10 m), should be ballasted with at least 15 kg at cargo hook.
◇With unloaded sling cable, avoid descending at airspeed above Vy (*2), and avoid load factors (*3) less than 0.5 G.
(Omitted)

*2: Vy is the best rate of climb speed and is used to attain the maximum height in a short period of time.
*3: Value of load acting on aircraft during flight (forces acting on aircraft such as air force, inertia force) divided by aircraft gross mass.

Recognition of cargo sling condition

During the flight before accident, the onboard mechanic observed the sling cable coming close to the tail of the fuselage and reported the observation to the pilot.

→ It is probable that the PIC did not recognize the situation until the warning was given by the onboard mechanic and therefore had not appropriately monitored the sling cable with the mirror.

Increased airspeed

Fog occasionally flowed into No.6 unloading site, causing occasional brief difficulties in unloading cargo.

→ It is possible that the PIC increased the airspeed to accelerate the pace of work considering the remaining work to be done when returning from No.6.

Upward movement of sling cable

When the pilot adjusted the flight route downward, the helicopter entered into the downward accelerated flight.

→ The distance between the end of the sling cable and the tail section decreased, because the sling cable moved relatively upward due to the effect of inertia and aerodynamic force.

It is probable that the sling cable contacted the tail rotor, damaging with and damaged the tail rotor and resulting in a loss of the tail rotor thrust.

Decision on an Emergency Landing

◇ According to the Company A's Manual, pilots are required to select emergency landing sites prior to starting the work of cargo transport, and it is probable the PIC was not prepared for such an occurrence and was not well-prepared so as to be able to decide where to make an emergency landing.
◇ It is probable that the pilot continued flying the helicopter, without anticipating the possibility that the damage to the helicopter could worsen and make the helicopter uncontrollable.

Training of the Pilot

Training for Preparation for Tail Rotor Failure

- Training for this preparation was provided two times at 4 years and 9 months or more ago before this accident, but they were based on the assumption of the tail rotor control failure in the different type of helicopter to approach and land on a runway.

Training for Autorotation (*4)

- Training for autorotation based on the assumption of an engine failure was provided.

*4: A flight condition where the main rotor blades are driven by the force of the relative wind passing through the blades while descending, rather than by the engine.

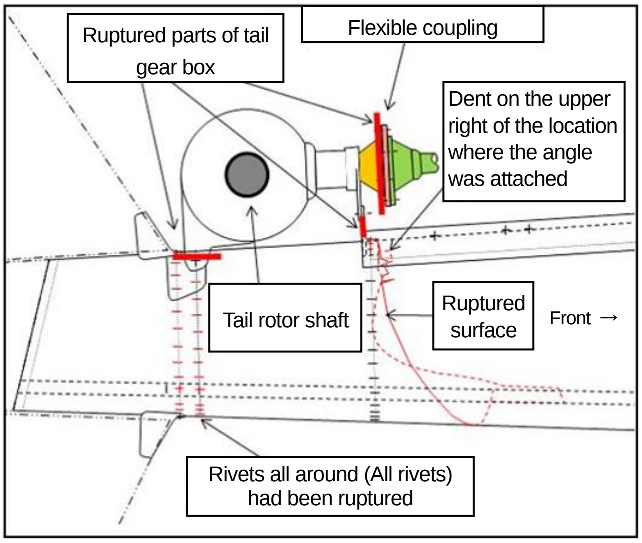
It is possible that the pilot had difficulty deciding on whether to make an emergency landing by autorotation upon loss of tail rotor thrust.

Uncontrollable Helicopter and the Crash

The mount of the tail gear box was broken by the impact of the contact of sling cable with the tail rotor causing the tail rotor shaft to tilt backward.

The flexible coupling with no support swung wildly, with the protruding portion colliding with and damaging the surrounding structure, and the damage to the tail section was exacerbated while searching for an emergency landing site.

It is probable that the helicopter became uncontrollable and crashed as a result of the rupture of the tail section including the vertical stabilizer.



Ruptured Tail Boom

In order to Prevent Recurrence

(1) The following measures should be taken to prevent the sling cable from contacting the airframe.
- If towing a sling cable without any attached load, an appropriate amount of ballast should be attached to the hook to maintain the balance of the sling cable.
- During a flight, sudden sharp movements should be avoided, such as a reduction in load factor and sudden lowering of the tail section.
- While being towed, the sling cable should be monitored appropriately with a rearview mirror or other device, and an airspeed at which an appropriate distance to the airframe can be ensured should be maintained.

(2) To be prepared for accident such as in this case where tail rotor lost thrust, it is generally necessary to take the following measures.
- Pilots should select appropriate emergency landing sites before flight and should always keep these selected sites in mind and be prepared for an emergency, including expectation which site to choose in different situations.
- If damage to the airframe may be anticipated to expand, which can result in increased difficulty in operating the helicopter, pilots should make an emergency landing as soon as possible.
- Training on emergency procedures should periodically be provided so that pilots can maintain necessary skills.

○ Safety Actions Taken by Company A

(1) Amendment to Flight Procedures: Flying with a light-weighted hook alone slung beneath the helicopter is prohibited and the descending airspeed of a helicopter with a sling cable shorter than 10 m must be Vy or lower.
(2) Special training on emergency procedures for tail rotor failure and procedures for selecting emergency landing site was provided to all pilots. Periodic assessment of the flying skill of pilots engaged in cargo transportation carrying a load slung beneath the helicopter will be made.
(3) Safety Management Department was established to confirm that no problem related to laws and regulations exist, as well as to confirm safety prior to issuing work instructions.
(4) The technical information communication system was amended to widely disseminate to all departments involved the technical information from manufacturing companies or other relevant sources.

○ Measures taken by the Design and Manufacturing Company

The design and manufacturing company changed the Caution section of External Load Transport in the Flight Manual attached to the Type Certificate to include the description of "ballast" as follows.

Before change : "Flying with a cable with no load attached or an empty net slung beneath a helicopter is prohibited"
After change : "Flying with an un-ballasted sling or an empty net slung beneath a helicopter is prohibited"

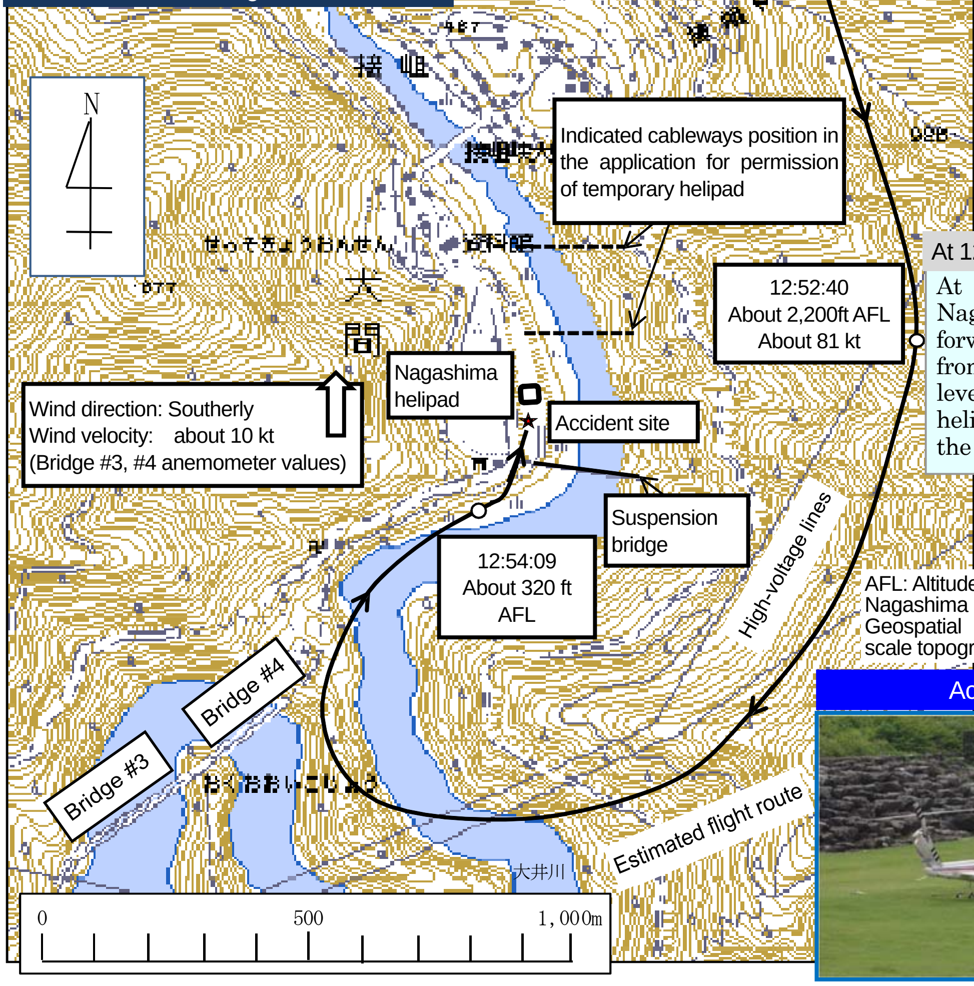
The investigation report of this case is published on the Board's website (issued on April 26, 2013).
http://www.mlit.go.jp/jtsb/eng-air_report/JA508A.pdf
(This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.)

Case 4

Persons on board were injured as a result of hard landing during a high descent rate

Summary: On Friday June 29, 2012 at 12:54 local time (UTC+9 hours), a Bell 412EP, owned by Chubu Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism (operated by contracted Company A) experienced a hard landing when attempting to land at upstream of Nagashima Dam temporary helipad, Kawanehon-cho, Haibara-Gun, Shizuoka Prefecture. The pilot suffered serious injuries, and one of the passengers suffered minor injuries.
There were eight persons on board, consisting of the pilot, two crews and five passengers.
The helicopter was slightly damaged, but there were no outbreak of fire.

Estimated Flight Route



At 12:52:40

At about 800 m east of Nagashima Helipad, with a forward airspeed of 81 kt and from about 2,200 ft above field level (AFL) of the helipad, the helicopter was descending in the south-southwest direction.

AFL: Altitude above field level of the Nagashima Helipad.
Geospatial Information Authority 1/25000 scale topographic map was used.

Accident Helicopter

Events leading to the Accident

About 10:00

The helicopter made the first landing at Nagashima Helipad. The PIC determined that the wind was calm from the conditions of the surrounding trees and other things. The PIC avoided a southward approach that would pass over hardly visible cableways at the north of Nagashima Helipad, deciding to use a northward approach instead. This was the PIC's first time to land at Nagashima Helipad.

At 11:55

The helicopter took off from Shizuoka Heliport with a pilot and seven persons onboard, and after completing a flight to confirm the situation of damage from natural disaster in the area of Oi River basin, the helicopter began an approach to land at Nagashima Helipad.

The helicopter continued to maintain a high descent rate of about 1,300 ft/min while approaching at a high angle, which corresponds to about 55% of induced velocity.

To next page

Causal Factors of the Accident

Prior to the helicopter's takeoff or landing, it was not prepared to clearly indicate the extents of the heliport, etc. and set up wind direction indicators.

For details, refer to "Management of The Temporary Helipad" (next page)

For the approach at the time of the accident, the pilot determined that the wind was calm just as during the first landing, and he passed through a relatively low area between a suspension bridge and a road from the south, making the approach on a northward route with as shallow a pass as possible.

The pilot probably believed from the condition of the nearby trees, etc. that the wind was not strong, and without having an accurate grasp of the wind conditions, made a northward approach with a tailwind of about 10 kt, passing over an easily-visible suspension bridge.

Making an approach from a comparatively high altitude with a target in front of the unmarked helipad, it is probable that the resulting approach was made at a high angle.

From previous page

12:54:12

The onboard mechanic reported the pilot, "The left side is clear".
While descending from an altitude of about 280 ft AFL with a magnetic course of about 010°, the CP position started to gradually be pulled from about 31%, No.1 engine torque (*1) (TQ1) began increasing from about 12% and TQ2 began increasing from about 5%.

12:54:23

While descending from an altitude of about 40 ft AFL with a magnetic course of about 005°, the CP position was being pulled from about 64%, and both TQ1 and TQ2 were increasing from about 47%.
At this point, the pilot exclaimed "Ah…".

12:54:27

The helicopter bounced once before coming to stop.

The pilot continued to descend at low power output from the base leg (*2) to the final approach, and began to pull the CP position from 15 seconds before touchdown, with the helicopter on a nearly straight- line route.

At 5 seconds before touchdown, although the pilot pulled the CP position to about 56%, a position at which transitioning to a hovering state is normally considered possible, this result could not be achieved, therefore it is highly probable that the pilot continued to pull the CP further, until touchdown occurred with the CP ultimately near its operation limit of about 71%.

It is probable that the cause of the hard landing was not a lateness in the pulling of the CP, on the contrary, there existed a condition in which the power output was increased but there was no increase in main rotor (MR) lift, suggesting the occurrence of VRS (*3).

*1: "Engine torque" refers to the rotational moment generated by engine to drive a rotor, etc. For the helicopter, the engine torque value is noted in %, and if both No.1 Engine and No.2 Engine reach about 60% when both engines are in operation, the mast torque of the main rotor will be near its operating limit of 100%.
*2: A traffic pattern before entering final course (final) established for aircraft taking off from or landing to an aerodrome.
*3 Phenomenon which occurs at certain power output when a helicopter transitions from hovering to vertical descent. When the increased downward airflow velocity induced by main rotors becomes equal to helicopter's descent rate, downwash by main rotors flows upward along circumference of main rotors, resulting in generation of vortex like the donuts, and lead to rapid loss of lift.

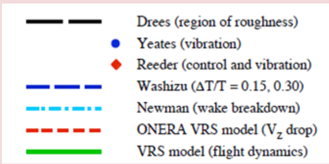
Causes of Entry into VRS Boundaries

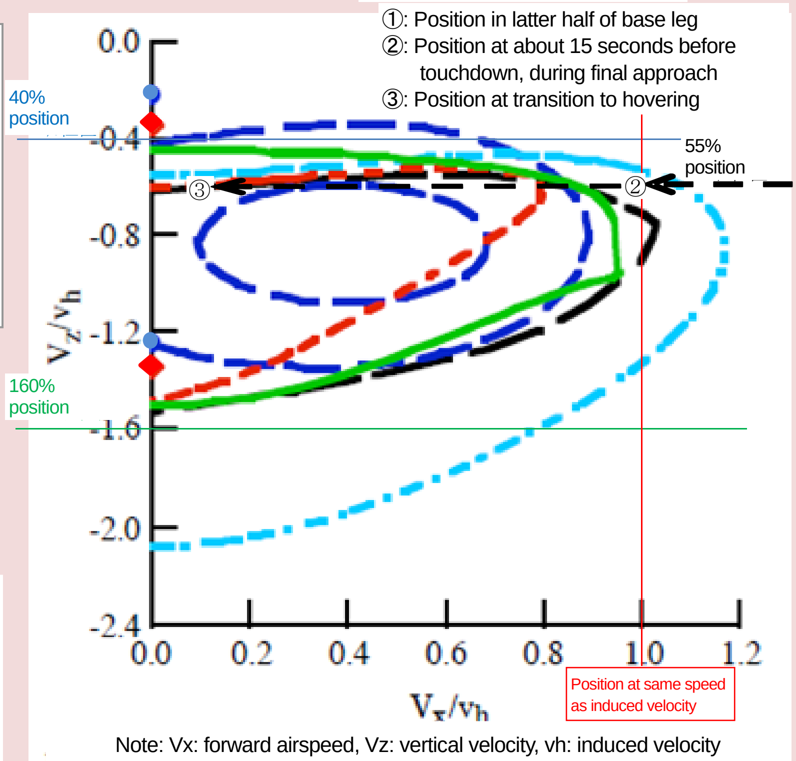
Operating in VRS during a landing approach is extremely dangerous because in general cases, a helicopter will not have sufficient altitude to escape it. Therefore, it is critically important to assure that a helicopter does not enter VRS boundaries during a landing approach.
Because it becomes easier to enter VRS boundaries roughly when the descent rate is a large value between about 40% and about 160% of the induced velocity and the forward airspeed becomes smaller than the induced velocity (refer to the figure below), flight within this range of conditions must be avoided. Consequently, it is necessary to select a traffic pattern that does not involve approach at a high angle with a tailwind.

At 37 seconds before touchdown during the latter half of the helicopter's base leg, its forward airspeed was about 30 kt and its descent rate was about 1,300 ft/min. Therefore, the ratio of the helicopter's descent rate to its induced velocity (about 2,360 ft/min: about 23kt) becomes -0.55, and the ratio of the forward airspeed to the induced velocity becomes 1.3, which are **outside of the VRS boundaries** as indicated by ① in the figure.

At about 15 seconds before touchdown the descent rate was about 1,300 ft/min and the forward airspeed was about 22 kt, their ratio to the induced velocities become about -0.55 and about 0.96 respectively, which are **near the entry point of the VRS boundaries** as indicated by ② in the figure.

It is probable that the helicopter's forward airspeed continued to decrease during its high descent rate because it was attempting to land on steep approach path under tailwind conditions.





Note: Vx: forward airspeed, Vz: vertical velocity, vh: induced velocity

Figure: Relationships with VRS Boundaries

From US NASA "STI (Scientific Technical Information) Report Series"

Management of the Temporary Helipad

Prior to the helicopter's takeoff or landing, it was not prepared to clearly indicate the extents of the heliport, etc. and set up wind direction indicators.

It is highly probable that these preparations were not carried out because there was no coordination involving the contracted operator Company A.

The operation supervisor was to coordinate with Chube Bureau's personnel in charge of operation when preparing operation plan, but he failed to request indication of the boundaries of the helipad as well as the setup of windsocks.

The coordination involving these request was somewhat inactive, because the management of the temporary helipad is the responsibility of the Chubu Bureau, and it is possible that this is related to the fact that it is the contractor who would need to make a request to the contractee regarding items for preparation.

The absence of indication for the boundaries of the helipad and the failure to set up windsocks are considered one of factors in this accident.

Because these are fundamental items required for safe operation, there is a necessity to reaffirm their importance and to create a system by which it is sufficiently possible for both operation contractor and contractee to exchange opinions on safety.

The cableways that the pilot had been concerned with during his approach had actually already been removed. If this information had been properly conveyed to him, it is possible that his judgments regarding the approach direction may have been different.

When updating applications, it is necessary to thoroughly confirm whether there are any changes in the application contents from the previous time, and if there is a need for changes, to accurately reflect them in the application contents.

In order to Prevent Recurrence

Following this accident, the Company A implemented safety actions including thoroughly assuring that during update procedures for the temporary helipad, responsible personnel are fully aware of any differences between previous and current application contents, and traveling to offices across the country to carry out the following safety education aimed toward pilots.

1. Settling with Power (synonymous with VRS)
   (1) Summary
   Under conditions where the forward airspeed is the same or less than the induced velocity, if the descent rate becomes 40% or more of the induced velocity, it becomes easier to enter VRS, and considerably more so if the descent rate becomes 60% or more.
   (2) Specific Examples for Models Owned by the Company A
   Bell 412Ep example: Likely to enter VRS with a forward airspeed of 23 kt or less and a descent rate of 935 ft/min or greater; extremely likely with a descent rate of 1,400 ft/min or greater.
   (3) Preventive Measures
   Avoiding a descent at 700 ft/min or greater with a forward airspeed of 25 kt or less.
2. Translational Lift and Ground Effect
   It should be kept in mind that decreasing speed under conditions where ground effects cannot be obtained will require appropriate power output control when translational lift (increase in lift accompanying an increase of inflow air currents to the main rotor generated by forward airspeed of 15 kt or greater) is lost.
3. Other emergency procedures
   Guidelines for collective bounce, dynamic rollover, and loss of tail rotor effectiveness.

Following this accident, the Chubu Bureau implemented the following safety actions.

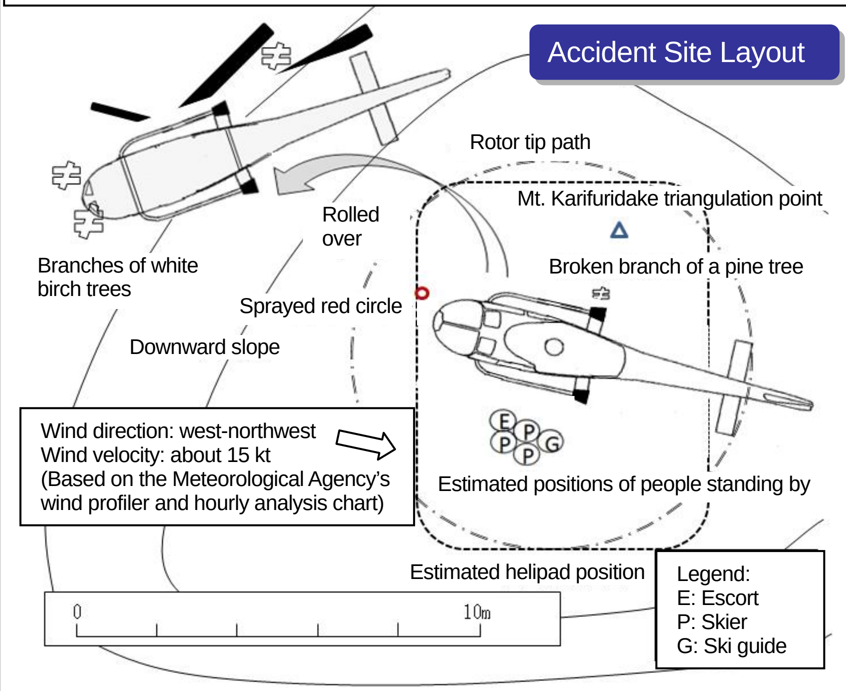
1. The "Helicopter User's Plan" which is to be prepared by rotorcraft users before operation has been revised so that the newly-defined "Temporary Heliport Pre-Operation Check List" is attached to it for submission to the Disaster Prevention and Relief Division of the Chubu Bureau. This allows advance confirmation among Helicopter Users (Chubu Bureau Internal Office), Operation Division (the Disaster Prevention and Relief Division of the Chubu Bureau), and operation contractors (operating company) to assure that the preparation for operation of temporary helipads (including heliport marking, setup of windsocks and other things) defined in the "Utilization Manual" are properly carried out. Alternative procedures have also been described for items whose preparation may not be feasible. Moreover, it has become possible for the exchange of information regarding the status of preparations, etc. on the target day between the site observer and helicopter to be carried out and confirmed via the Disaster Prevention and Relief Division.
2. Notification of safety actions in writing was made within the Chubu Bureau divisions as well as at Chubu Bureau Internal Office Manager meetings.
3. Safety education regarding the use of helicopters was conducted at opportunities in Chubu Bureau Internal Office Disaster Prevention Representative Division Chief meeting.
4. Safety actions executed after the accident were presented by the Chubu Bureau Disaster Prevention and Relief Division Chiefs at Regional Bureau Disaster Prevention Officer and Division Chief meeting, and provision of information and calls for attention were carried out to other regional bureaus.

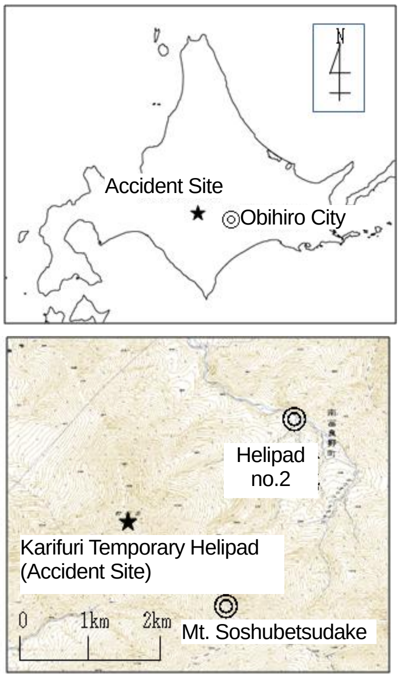
The investigation report of this case is published on the Board's website (issued June 28, 2013).
http://www.mlit.go.jp/jtsb/eng-air_report/JA6817.pdf
(This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.)

Case 5

The continued lift-off sequence while being caught by ground obstacles led to a dynamic roll over

Summary: On Sunday February 19, 2012, at around 13:25 local time (UTC+9 hours), Eurocopter EC120B, operated by Company A, rolled over during takeoff from Karifuridake temporary helipad in Minami-Furano Town, Sorachi-Gun, Hokkaido, and sustained substantial damage.
On board the helicopter was a pilot, but he suffered no injury. The helicopter sustained substantial damage, but there was no outbreak of fire.





Events Leading to the Accident

Around 13:25

As a service to transport skiers to a mountain top (Heli-skiing), the pilot transported skiers and guides to Karifuridake temporary helipad and disembarked them. Then, the helicopter was about to take off to return to the Helipad no.2.

As the pilot felt uneasy that the right skid (a landing gear) seemed to be caught by something, he immediately aborted the lift-off sequence and gave a small forward control input.

As the pilot felt that the restraint was cleared, he resumed the lift-off sequence.

Next moment, the helicopter abruptly rolled over to the right.

Causal Factors of the Accident

It is highly probable that obstacles, possibly branches of creeping pines (*1) covered with snow, restrained the right and left skids, and it continued the lift-off sequence with the right skid sill restrained. As a result, abrupt right role started and the roll angle exceeded the critical roll-over angle. The aircraft rolled over to the right in a state of dynamic roll-over, and sustained damaged.

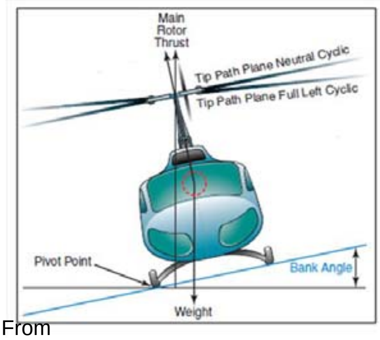
*1: A prostrate evergreen coniferous shrub which grows on high mountains in north-central Honshu and in Hokkaido.

Description of Dynamic-Rollover in "ROTORCRAFT FLYING HANDBOOK" compiled by the Flight Standard Service, Federal Aviation Administration (FAA)

◇ A helicopter is susceptible to a lateral rolling tendency, called dynamic rollover, when lifting off the surface.

◇ For dynamic rollover to occur, some factor has to first cause the helicopter to roll or pivot around a skid, or landing gear wheel, until its critical rollover angle is reached.

◇ If the critical rollover angle is exceeded, the helicopter rolls on its side regardless of the cyclic corrections made (*2) as main rotor thrust beyond this point continues the roll and recovery is impossible.



From
FAA "ROTORCRAFT FLYING HANDBOOK"

*2 : A maneuver to move an aircraft either forward, backward or sideways

The fact that Karifuridake Temporary Helipad being established on the pressed snow with creeping pines underneath has the potential of degrading the helipad requirements in case of protruding tree branches for possible left roll-over pivoting over the left skid where the skiers remained.

Takeoff/Landing Assisted by Escort

The escort was probably performing the safety check against obstacles before takeoff as stipulated by Company A. However, it is highly probable that the escort was unaware of the degraded helipad surface with the obstacles: possible pine branches protruded from beneath the surface.

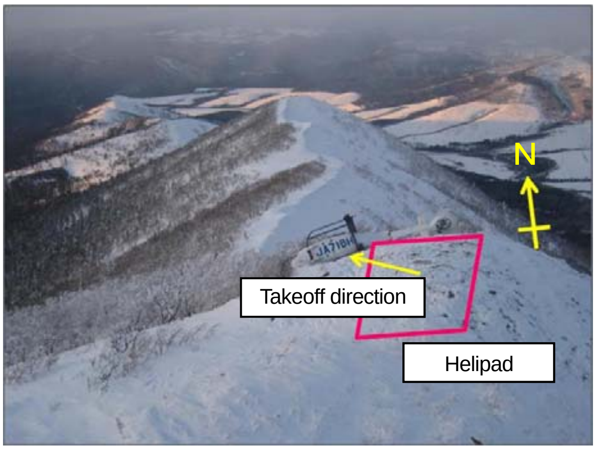
Some facts that there were no possible obstacles when the escort checked the helipad during landing before the occurrence of the accident, and he was occupied to pay attention to disembarked skiers who were staying near the helicopter, are considered possible contributing factors to the escort's lack of attention to the ground obstacles.

Regulations on Heli-skiing procedure "Work Standard" defined by Company A. (excerpt)

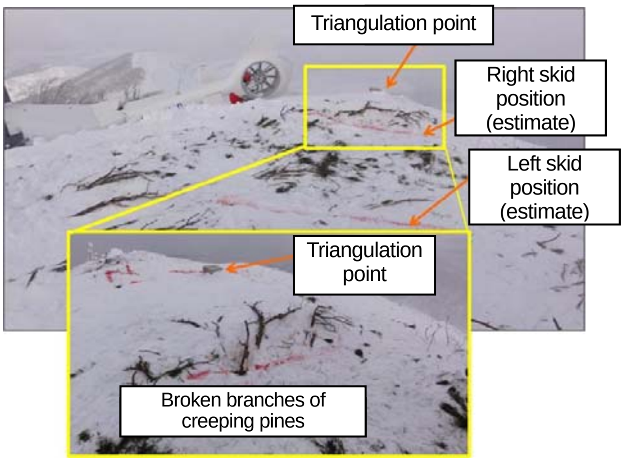
4-6-1 Engine Start
(4) When a skid is frozen to the ground, a dynamic rollover may develop into a serious accident. In case of frozen skid, remove ice completely with a shovel and/or de-icing chemicals.

4-6-2 Takeoff
*(2) When an assistant is on board, he/she should make sure before takeoff that skid skis or snowshoes (*3) are clear of obstacles (such as railroad ties) and check the condition of a ski rack.*

*3: A helicopter version of snowshoe attached under the rear part of a skid to prevent the skid from sinking into the snow.



Accident site (on the day of the accident)



Accident site (three days after the accident)

Involvement of Knowledge and Skills in the Roll-over

When a pilot aborts a lift-off sequence, it is desirable to ask the ground crew to check the skid situation and carefully resume the sequence confirming no indication of roll over. However, the pilot probably did not do so.

Training Provided by Company A to the Pilot

- ◇ The pilot boarded a Heli-skiing helicopter and observed Heli-skiing once in 2011 as observation. Also, before getting engaged in Heli-skiing in 2012, he received preliminary training for thrice (twice for terrain features familiarization flights) as a PIC.
- ◇ With the absence of the Heli-skiing related contents in Company A's regulations for training and qualification check, the company's instructions did not provide him with classroom lectures or actual flight training using snow-covered mountain tops.

Possible contributing factors for the PIC's lack of cautiousness against ground objects are lack of knowledge and skills against: mountain top operations under snow covered conditions; and unexpected situation where skids are restrained by obstacles protruding from beneath the snow surface.

In Order to Prevent Recurrence

The following are possible preventive measures against dynamic roll-over during takeoff form a snow covered helipad.

► Establish and maintain appropriate helipad

The shape, area and surface conditions of a helipad constantly change depending on the snow conditions. Thus, the close coordination of a pilot and ground crew is indispensable to check the helipad consistency with the requirements of approved temporary helipad. Paying special attention to obstacles and gradient which lead to dynamic roll-over is necessary.

► Countermeasures against abnormal helicopter behavior during lift-off

In case of abnormal helicopter behavior such as unexpected skid lift-off, immediately abort the lift-off. Coordination with the ground crew is necessary to make sure the skids are clean and cautiously resume the lift-off sequence.

► Takeoff and landing training on snow-covered mountain tops and others

Safe operations to and from snow-covered mountain tops require appropriate grasping of the changing situation of helipads and act accordingly.

The pilot who assumes the duties which include snow-covered mountain top operations must be properly trained and tested for required skills and knowledge. The same is true for the ground crew who support Heli-skiing. They must be trained to be properly fit for the duties thereof.

Following considerations are addressed for skiers' stand-by position during lift-off.

► Prohibit the access to the helipad

It is anticipated that skiers will have difficulty in moving away promptly from the helicopter after disembarking on a snow-covered mountain-top helipad.

In a case like this accident where passengers and others remained within the adjacent areas of a helicopter on a helipad, there was a possibility of a helicopter roll-over toward them. It is necessary to prohibit unauthorized access to the helipad and its adjacent area where it hampers the aircraft operation during helicopter lift-off/landing.

Following actions have been taken in response to the accident by Company A and by Civil Aviation Bureau (CAB), Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

○ Safety Actions Taken by Company A

(1) Appropriate Management of Temporary Helipads

The company has established the company rule of "Regulations for the Management of Temporary Helipads" while compiling a checklist for helipad use.

(2) Safety Management of Heli-skiing

The company has revised the "Operations in Snow-Falling Area" of the internal "Work Standard". The changes are as follows.

1. Established detailed procedures for examining changes by snowfall and corresponding restoring actions define to require periodic checks on the approved temporary helipads on mountain tops for changes and necessary restoring actions.
2. Revised to add provisions to clarify the escort's role and coordination with the pilot.

(3) Heli-skiing Training and Qualification Check

1. The company has added training and evaluation procedures for pilots on Heli-skiing as special training in "Training and Qualification Manual".
2. The company has added Heli-skiing training and check procedures on flight managers, mechanics, ground crew and escort in the internal "Work Standard".

○ Safety Actions Taken by Civil Aviation Bureau (CAB), MLIT

Based on the on-site safety audit for the company, CAB has ordered its Regional CABs which have jurisdiction over business license to instruct applicants of temporary helipad for Heli-skiing about the safety measures to be taken to prevent the same failure in line with the safety audit results.

The investigation report of this accident case is published on the Board's website (issued on January 25, 2013).
http://www.mlit.go.jp/jtsb/eng-air_report/JA710H.pdf

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

Case 6

Fire occurrence from rear hold during power transmission lines inspection flight led to a forced landing, followed by flames and destruction of the helicopter

Summary: On Thursday September 22, 2011, an Eurocopter AS350B3, operated by Company A took off from Takamatsu Airport at around 09:23 local time (UTC+9 hours) for power transmission lines inspection flight. A burnt smell and white smoke rose in the cabin during this flight, and at 10:10, the helicopter made a forced landing at a baseball field located at Hiketa, Higashikagawa City, Kagawa Prefecture.
On board the helicopter were a pilot and two passengers, but none of them suffered injury.
After the forced landing, the helicopter caught fire and was destroyed.

Events Leading to the Accident

Around 09:23

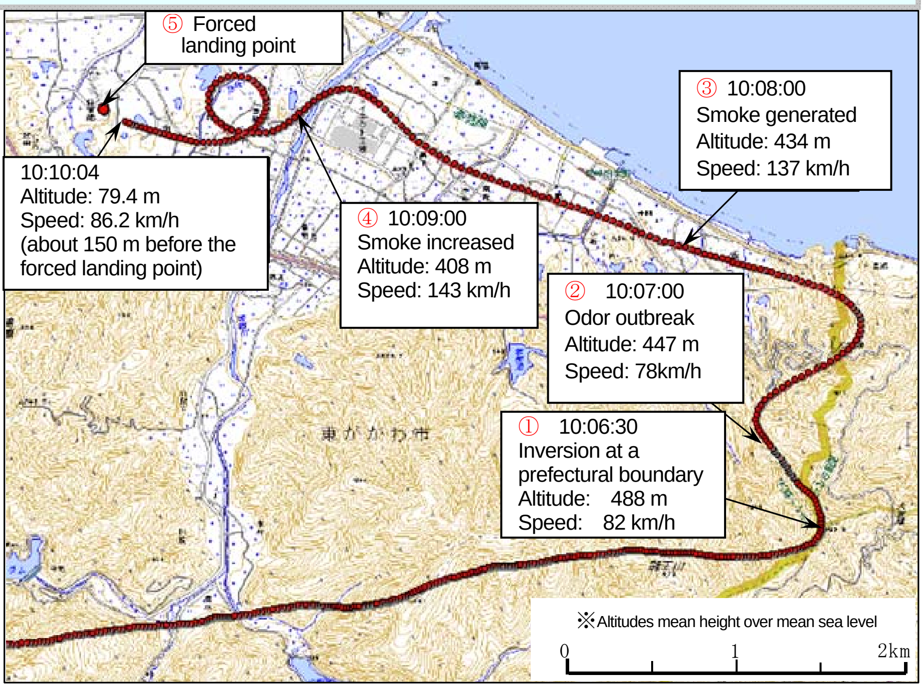
The helicopter took off from Takamatsu Airport to inspect power transmission lines, and flew eastward while inspecting the power transmission lines located to the south of the Airport, which extended from west to east.

① Around 10:06

The helicopter turned around at the prefectural border with Tokushima Prefecture and headed for another power transmission line extending to the northwest.

② Around 10:07

All members on board sensed a burnt smell in the helicopter. The pilot, who suspected that the smell had come from outside, checked how things were on the ground, but did not see anything unusual, including smoke. At the same time, he suspected a trouble in the electrical system and switched the generator on and off and tried other operations. Since the smell in the cabin continued, he decided to fly back to the airport.



Estimated Flight Route (From Geospatial Information Authority of Japan)

③ Around 10:08

Immediately after the helicopter turned its nose toward Takamatsu Airport, smoke started to rise from near the floor of the rear seats.

④ Around 10:09

The pilot attempted to increase speed and fly to wherever the landing, and he decided to land a baseball field.

⑤ Around 10:10

The cabin had been filled with white smoke that made instruments invisible, but it made a forced landing on the field.

Condition after the forced landing

Around 10:12

Flames and gray smoke were arising from near the rear hold and the tail boom fell off.

Around 10:19

The flames and black smoke became increasingly furious.

Around 10:23

Wrapped in roaring flames and large amounts of black smoke, the helicopter was no longer visible.

The pilot stopped the main rotor. But the tail rotor stopped before the main rotor did, and it is probable that before the main rotor stopped, the tail rotor drive shaft was severed and became stuck. Judging from these events, it is probable that it would have been difficult to land safely if the landing had been delayed by several seconds.

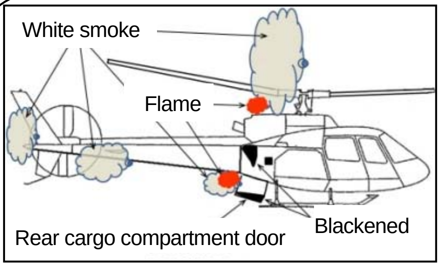
Condition of the fire during flight

Condition during the approach to the forced landing site

A continuous wisp of white smoke was coming out from near the floor of the rear hold of the helicopter and that part of the right external plates of the hold had become black.

Condition just before landing

The left door of the rear hold was open and dangling, and the hold was emitting white smoke upward with flames sometimes seen to come out. White smoke was blowing out from also the horizontal stabilizer and the back end of the tail boom. Part of the rear hold door also became black.



Condition just before landing (depicted based on a video image by an eyewitness)

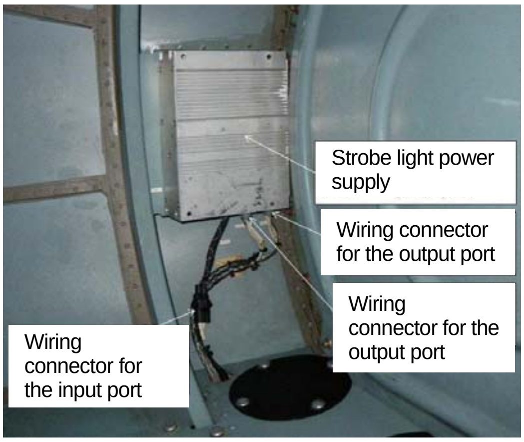
Based on situation immediately after landing and condition of the fire during flight , it is highly probable that the fire occurred at around the rear hold of the helicopter.

Analysis on Fire Outbreak in the Rear Hold

【 Condition of the Strobe Light Power Supply 】

The strobe light power supply (*1) was installed at the back of the right side in the rear hold with its input and output wiring extending from the main body of the power supply to the floor. The wires were not protected by rigid housing or similar goods from contact with the embarkation.

*1: A device which supplies power to strobe lights installed in both ends of a horizontal stabilizer to prevent collisions.

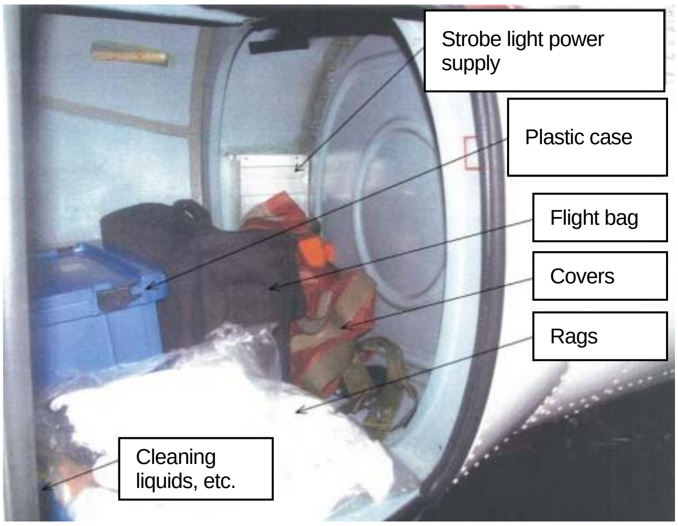


The airworthiness standards applicable to the helicopter type require for wiring in a compartment not to be damaged by the movement of cargo in the compartment, and their breakage or failure will not create a fire hazard.

It is highly probable that wiring came into contact with embarkation when the latter was moved inside or brought into or out of the hold.

【 Condition of embarkation in the rear hold 】

The rear hold was filled with so many inflammable items such as extra oils, plastic cases, documents, flight bag, covers, rags and cleaning liquids that are almost no room to stand, and they were not covered with a floor tie-down net to prevent them from moving. However, it was confirmed no abnormality by the flight mechanics during the preflight inspection.



Condition of embarkation in the rear hold (Reproduced based on the mechanic's memory using the type of helicopter)

The flight manual for the helicopter requires for the external checks that "*if applicable: open door, net hooked in place, close door*".

It is probable that the embarkation moved unrestrictedly if the airframe was vibrated or accelerated violently. It is highly probable that the fire spread to these items after it occurred.

Probable Causes

Regarding a fire in the rear hold, it could not be identified the ignition source; nevertheless it is possible that a fire occurred from the wiring connected to the strobe light power supply, which was installed in the rear hold, and that it spread to inflammables placed around the power supply.

This is because the wiring was not designed and structured so that it was fully protected so as to prevent it from being damaged due to the movement of embarkation and preclude a risk of occurring a fire even if it was damaged or destroyed.

It is also possible that since the embarkation was not covered with nets to prevent its movement, embarkation in the rear hold damaged the wiring, which was not fully protected from damage due to the movement of the embarkation.

Other Safety Related Findings

【 Transport of Explosives and Other Goods 】

In the rear hold of the helicopter, there were four items which fell into the category of "explosives and other goods" as provided in Article 194 of the Ordinance for Enforcement of the Civil Aeronautics Act. It is probable that one of the four items was not transported using the method prescribed by the standards.

When transporting explosives and other goods applicable, the relevant standards should be followed after confirming what is prescribed in the notification.

【 Information on Emergency Procedure in the Flight Manual 】

It is probable that the pilot did not remember the procedures he should follow when it was not identified where the smoke arose because he assumed that it would be sufficient to look at the checklist for necessary operations.
The Flight Manual does not specify emergency procedures that should be memorized so that they can be performed immediately.

It is probable that the pilot would have memorized them and could have performed appropriate procedures swiftly and reliably in the state of emergency he experienced if the Flight Manual had specified procedures that should be memorized.

In order to Prevent Recurrence (Recommendations)

In order to contribute to prevention of reoccurrence of similar accidents, based on the result of investigation of the accident, the Japan Transport Safety Board recommended, in accordance with the provisions of Article 27 Paragraph 1 of the Act for Establishment of the JTSB, Company A as follows.

(1) Embarkation on board

When having embarkation in the rear hold of Eurocopter AS350B3, Company A should take measures to prevent its movement as provided in the Flight Manual in order to prevent an unforeseen event due to the movement of embarkation. In addition, when transporting items that fall into the category of explosives and other goods, the company should confirm the content of the pronouncement and meet the standards specified therein.

(2) Establishment of a system that enables pilots to perform emergency procedures of aircraft without failure

The company should establish a system that enables pilots, when operating helicopter, to perform appropriate emergency procedure of the helicopter swiftly and reliably even in a state of emergency mainly by memorizing those which must be performed immediately.

Meanwhile, the JTSB recommended following to the European Aviation Safety Agency (EASA) which has a responsibility for airworthiness of the type of the helicopters.

(1) Electrical equipment and its wiring in the baggage compartment

The EASA should make it mandatory to modify the rear hold of the Eurocopter AS 350 series so that electrical equipment and its wiring are fully protected.

(2) Establish the system to ensure emergency procedures take place

The EASA should provide instruction to the designer and manufacturer of the helicopter to specify items in the emergency procedures requiring memorization so that they can be performed immediately.

Safety Actions Taken in Response to the Recommendation (Completion Report)

Company A has taken following actions in response to the recommendations.

Recommendation (1)

- Company A has re-disseminated to relevant personnel in its Aviation Headquarter the requirements to implement necessary actions to prevent embarkation movement as stated in the Flight Manual, and for a pilot to open a rear hole door and check to ensure net(s) are secured in place prior to his/her flight.
- The company has re-disseminated to relevant personnel in the Aviation Headquarter that in case transporting items that fall into the category of explosives and other goods, the content of the pronouncement as well as the observance to the standards specified therein are confirmed.

Recommendation (2)

In terms of a periodic check, the company has instructed to all pilots and ensured awareness to verify an immediate execution of appropriate operation in a state of emergency as one of the periodic checklists. The company has also instructed the designated qualified auditors to perform verification to the checklist.

The investigation report of this accident case is published on the Board's website (issued on June 28, 2013).
http://www.mlit.go.jp/jtsb/eng-air_report/JA6522.pdf

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

4. Conclusion

Based on our investigation reports on accidents (six cases) mentioned in this digest and other helicopter accidents, we summarized how these accidents and serious incidents occurred, and lessons which will help prevent recurrence as follows.

How "helicopter accidents and serious incidents" occurred

◆Breakdown of type of accidents

By the type of accidents and serious incidents, the number of crashes was 27 (42.9%) in accidents, and the number of near misses with another aircraft was 6 (42.9%) in serious incidents, each of which accounts for nearly half of the total accidents and serious incidents.

◆Breakdown of operation phase

By the operation phase at the time of accidents and serious incidents, the number of accidents during cruising was 47 (67.1%), during landing phase 14 (20.0%), take-off phase 7 (10.0%). The occurrence during cruising accounts for nearly 70% of all operation phases.

◆Breakdown of cause categories

Approx. 80% of accidents and incidents are caused by human factors

The number of accidents and serious incidents caused by human factors and by human/environmental factors is 16 (22.9%) each, and human/organizational factors is 8 (11.4%). Approximately 80% accounts for "human factors or combination of multiple factors involving human factors".

Among various classifications of human factors, there are 19 (33.3%) of "Inappropriate actions" cases, which include carelessness, omission of confirmation and sloppy operational practices and this type of human factors accounts for the highest number in all human factors.

Lessons from accident investigation

Lesson 1. Flight operations should be reviewed to check whether there were non-compliance activities against laws and regulations. Personnel engaged in safety-related works including pilots and mechanics should be reminded of the importance of observing fundamental safety standards such as minimum safe altitudes, and internal emergency communication procedures should be reviewed.

Lesson 2. If towing a sling cable without any attached load, an appropriate amount of ballast should be attached to the hook to maintain the balance of the sling cable. Sudden sharp movements, a reduction in load factor and sudden lowering of the tail section should be avoided during flight.
When towing a sling cable, it should be appropriately monitored with a rearview mirror or other device, and an appropriate airspeed should be maintained so as to ensure appropriate distance between the airframe and the cable being towed.

Lesson 3. In case for the tail rotor loosing the thrust, it is necessary to select appropriate emergency landing sites in advance, and to sustain necessary skills through periodical training on emergency procedures.

Lesson 4. When a helicopter hovers in a small confined area, it is imperative to keep close watch against obstacles to maintain safe distance between the obstacles and a main rotor and Fenestron.

Lesson 5. Because it becomes easier to enter VRS boundaries roughly when the descent rate is a large value between about 40% and about 160% of the induced velocity and the forward airspeed becomes smaller than the induced velocity, flight within this range of conditions needs to be avoided.

Lesson 6. During lift-off and landing of a helicpter, access to a helipad and its surrouding area, where it might hamper aircraft operations, needs to be prohibited.

Lesson 7. A system should be established to allow a pilot to perform appropriate emergency procedure that must be performed immediately in a prompt and certain manner through his memory in a state of emergency.

A word from Director for Analysis, Recommendation and Opinion

In helicopter accidents, human factors, such as carelessness and inappropriate operational discipline, seem to be a prominent factor, while a combination of other factors such as weather conditions and operational system also appears to contribute to the accidents in many other cases.

Because of a wide variety of flight purposes in helicopter flights, it is expected that accident prevention measures are based on various aspects. This means that besides a skill enhancement system for pilots and a perfect aircraft maintenance system, various aspects on accident prevention measures, such as training on appropriate responses to climate changes and equipment failures and an emergency communication system, are also expected.

We welcome your comments on "JTSB Digests" and inquiries for on-site trainers

Japan Transport Safety Board (JTSB)
2-1-2, Kasumigaseki, Chiyoda-ku
Tokyo, 100-8918 Japan
JTSB Secretariat
(Staff in charge: Director for Analysis, Recommendation and Opinion)
TEL: +81-3-5253-8824
FAX: +81-3-5253-1680
URL: http://www.mlit.go.jp/jtsb/index.html
e-mail: jtsb_analysis@mlit.go.jp