AA2013-5

AIRCRAFT ACCIDENT INVESTIGATION REPORT

CHUBU REGIONAL BUREAU, MINISTRY OF LAND, INFRASTRUCTURE, TRANSPORT AND TOURISM

(OPERATED BY CONTRACTED NAKANIHON AIR SERVICE)

J A 6 8 1 7

June 28, 2013

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.

Norihiro Goto
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

HARD LANDING
CHUBU REGIONAL BUREAU, MINISTRY OF LAND,
INFRASTRUCTURE, TRANSPORT AND TOURISM
(OPERATED BY CONTRACTED NAKANIHON AIR SERVICE)
BELL 412EP (ROTORCRAFT), JA6817
UPSTREAM OF NAGASHIMA DAM TEMPORARY HELIPAD
KAWANEHON-CHO, HAIBARA-GUN, SHIZUOKA PREFECTURE,
JAPAN
12:54 JST, JUNE 29, 2012

June 7, 2013

Adopted by the Japan Transport Safety Board

Chairman	Norihiro Goto
Member	Shinsuke Endoh
Member	Toshiyuki Ishikawa
Member	Sadao Tamura
Member	Yuki Shuto
Member	Keiji Tanaka

SYNOPSIS

<Summary of the Accident>

On June 29 (Friday), 2012 at 12:54 Japan Standard Time (JST: UTC +9hrs, all times are indicated in JST on a 24-hour clock), a Bell 412EP, registered JA6817, owned by Chubu Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism (operated by contracted Nakanihon Air Service) experienced a hard landing when attempting to land at upstream of Nagashima Dam temporary helipad. 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 was no outbreak of fire.

<Probable Causes>

In this accident, it is highly probable that the injuries suffered by the Pilot were a result of the hard landing experienced when attempting to land.

It is probable that the cause of the hard landing was that during a high descent rate, the Helicopter's forward airspeed continued to decrease, causing its downwash to produce large vortices wrapping around the upper surface of the main rotor tip and resulting in a vortex ring state. It is probable that because of this, even if the collective pitch lever was pulled, a corresponding amount of lift could not be generated and it was not possible to decrease the Helicopter's rate of descent.

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.

Abbreviations used in this report are as follows:

A F L	: Above Field Level
C V R	: Cockpit Voice Recorder
C P	: Collective Pitch Control
C S	: Cyclic Stick
D F D R	: Digital Flight Data Recorder
E G P W S	: Enhanced Ground Proximity Warning System
G P S	: Global Positioning System
MR	: Main Rotor
T Q	: Torque
V F R	: Visual Flight Rules
V R S	: Vortex Ring State

Unit Conversion Table

1 lb	: 0.4536 kg
1 ft	: 0.3048 m
1 kt	: 1.852 km/h （0.5144 m/s）
1 in	: 25.4 mm
1 slug	: 14.594 kg

1. PROCESS AND PROGRESS OF THE AIRCRAFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident

On June 29 (Friday), 2012, a Bell 412EP, registered JA6817, owned by Chubu Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism (operated by contracted Nakanihon Air Service) experienced a hard landing when attempting to land at upstream of Nagashima Dam temporary helipad at 12:54 Japan Standard Time (JST: UTC +9hrs, all times are indicated in JST on a 24-hour clock). 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 was no outbreak of fire.

1.2 Outline of the Accident Investigation

1.2.1 Investigation Organization

On June 29, 2012, the Japan Transport Safety Board designated an investigator-in-charge and two other investigators to investigate this accident.

1.2.2 Representatives of the Relevant State

An accredited representative of the United States of America, as the State of Design and Manufacture of the Helicopter involved in this accident, participated in the investigation.

1.2.3 Implementation of the Investigation

June 30 and July 1, 2012:	On-site investigation, helicopter examination and interviews
July 23 and 24, 2012:	Helicopter examination and interviews

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 State

Comments on the draft report were invited from the relevant State.

2. FACTUAL INFORMATION

2.1 History of the Flight

On June 29, 2012, the Bell 412EP, registered JA6817, (hereinafter referred to as "the Helicopter"), owned by Chubu Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism (hereinafter referred to as the "Chubu Bureau") (operated by contracted Nakanihon Air Service (hereinafter referred to as "the Company")) departed from the Shizuoka Heliport at 11:55 with the Pilot, two crews and five passengers on board. After completing a flight to confirm the situation of damage from natural disasters in the area of the Oi River basin, the Helicopter began an approach to land at the upstream of Nagashima Dam temporary helipad (hereinafter referred to as "Nagashima Helipad").

The flight plan of the Helicopter after leaving the Shizuoka Heliport was as follows.

Flight rules: Visual flight rules, Departure aerodrome: Shizuoka Heliport
Estimated off-block time: 12:00, Cruising speed: 100 kt, Cruising altitude: VFR
Route: Ikawa Dam, Transit point: Nagashima Helipad, Destination: Nagoya Airfield
Total estimated elapsed time: 2 hours, Fuel load expressed in endurance: 2 hours 40 minutes
Persons on board: eight (four after Nagashima Helipad)

The history of the flight up to the accident is summarized as follows, based on the recorded data of the digital flight data recorder (hereinafter referred to as "DFDR"), cockpit voice recorder (hereinafter referred to as "CVR"), airborne imagery transmission system, and portable GPS, and the statements of the Pilot, crew and passenger.

2.1.1 History of the Flight before Landing, Based on Data of DFDR, CVR, Airborne Imagery Transmission System, and Portable GPS

12: 52: 40	At about 800 meters east of Nagashima Helipad, with a forward airspeed of 81kt and from about 2,200 ft above field level of the helipad(hereinafter referred to as "AFL"), the Helicopter was descending in the south-southwest direction.
12: 54: 09	At about 250 meters south-southwest of Nagashima Helipad and from an altitude of about 320 ft AFL, while performing a left descending turn with a left roll angle of about 6°, the collective pitch lever (hereinafter referred to as "CP") position was about 29%, the No.1 engine torque[1] (hereinafter referred to as "TQ1") was about 10%, and the No.2 engine torque (hereinafter referred to as "TQ2") was about 24%.
12: 54: 12	The mechanic who was on board (hereinafter referred to as "the On Board 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%, TQ1 began increasing from about 12%, and TQ2 began increasing from about 5%.

[1] "Engine torque" refers to the rotational moment generated by an engine to drive a rotor, etc. For the Helicopter, the engine torque values are 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%.

12: 54: 18	While descending from an altitude of 140 ft AFL with a magnetic course of about 006°, the CP position was being pulled from about 55%, and both TQ1 and TQ2 were increasing from about 35%.
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: 25	A television image of the time of touchdown, with an accompanying momentary image breakup, was recorded. The CP position was about 71%, TQ1 was about 57%, and TQ2 was about 63%. These were the maximum values recorded for both CP position and engine torques for this landing.
12: 54: 27	The television image showed the Helicopter bouncing once before coming to a stop. The CP position was being lowered from about 20%, TQ1 was decreasing from about 5%, and TQ2 was decreasing from about 10%.

(See Figure 1: Estimated Flight Route, and Diagram 2: DFDR Data at the Time of Accident (p.11))

2.1.2 Statements of Pilot, Crew and Passenger

a. Pilot

On the day of the accident, the Pilot showed up at the Company at around 06:15, and after making pre-flight preparations, moved the Helicopter from its hangar to the apron and performed a preflight inspection together with the On Board Mechanic, confirming that there were no anomalies with the Helicopter.

After supplying the Helicopter with the maximum allowable amount of fuel, the Pilot, along with the On Board Mechanic and a camera operator, departed from Nagoya Airport at about 07:50. With a transit at a temporary helipad at Oi River Ryokuchi Park, the Oi River downstream basin, the Helicopter made the first landing at Nagashima Helipad at about 10:00. Because this was the Pilot's first time to land at Nagashima Helipad, while passing over the vicinity of the helipad to check the surrounding terrain, he determined that the wind was calm from the conditions of the surrounding trees and other things. He avoided a southward approach that would pass over hardly visible cableways to the north of Nagashima Helipad, deciding to use a northward approach instead. The Pilot flew in a southward direction above power transmission lines for the downwind leg, slightly wider than usual to allow for sufficient leeway, and with a base leg also slightly farther away than normal, made a final approach where obstacles were relatively low. The approach was made on a northward route with as shallow a pass as possible, and the Helicopter touched down slowly as though being suspended by the power at low speed.

At that point, while the Pilot still had the engines running, five passengers who were on board at the time of the accident embarked, and the Helicopter took off at about 10:10 with eight people total on board. Confirmation of the damage situation of the area of the Oi River basin was carried out, and then at about 11:06 the Helicopter landed at Shizuoka Heliport. After a brief rest, the maximum allowable amount of fuel was supplied and the Helicopter took off from Shizuoka Heliport at about 11:55.

After subsequent confirmation of the damage situation of the river basin, the Helicopter made a hard landing when attempting to return for landing at Nagashima Helipad at about 12:54, with the Helicopter sustaining damage.

Just as he had done during the first landing, the Pilot passed over the vicinity of Nagashima Helipad before making the approach prior to the accident. Because there were no windsocks set up on the Helipad, the Pilot could not make an accurate evaluation of the wind, but from the surrounding conditions determined that the wind was calm, just as during the first landing. With regard to traffic pattern, the Pilot knew the conditions of Nagashima Helipad from the first landing; consequently, flew at a normal width, slightly closer to the helipad than the first time. For the final approach, the Pilot passed through a relatively low area between a suspension bridge and a road, making the approach on a northward route with as shallow a pass as possible. The weather was clear, with a visibility range of 10 kilometers or more, and the airflow was not unfavorable.

The Pilot confirmed a forward airspeed of 40 kt just before the suspension bridge, and then just as during the first landing, began to descend while reducing speed.

Although the Pilot attempted to pull the CP and reduce the descent rate in order to transition to a hovering state from about 10 meters AFL, because this was unable to be performed as intended, he ultimately pulled the CP near to its overtorque limit. However, the Helicopter continued to sink as though its thrust was slipping away, and in the end the Helicopter touched down as though with a hard landing from a height of about five meters. Up until that time, there were no anomalies observed with the Helicopter and no warnings were given.

After touching down, the Pilot stopped the engines, and then performed to confirm the status of the passengers. Such experience, this was the first time for him.

After making the report of the accident to the Company, the Pilot felt backache. He was transferred to a hospital by an ambulance which arrived at the scene, and then he was diagnosed as bone fracture and was hospitalized.

b. On Board Mechanic

On the day of the accident, the On Board Mechanic sat in the co-pilot's seat on the left side of the cockpit, and was responsible for lookout and other duties.

During the second landing at Nagashima Helipad, transit was made with a right-hand turning pattern, and the approach was the same as usual.

After the Helicopter passed between a suspension bridge and a road, when it flew over a grassy area near Nagashima Helipad, the On Board Mechanic confirmed that there were no obstacles, and informed the Pilot "The left side is clear."

Since the descent speed could not be reduced before landing and the Helicopter continued to sink despite the Pilot increasing power, the On Board Mechanic braced for impact. At that time, something was apparently said by the Pilot.

At the time of touchdown, there were two impacts. Because the engines were still operating immediately after touchdown, the On Board Mechanic signaled the Pilot for the engines to be shut down, and then exited the Helicopter to inspect the condition of the airframe and other things.

When the rotor had slowed down, the On Board Mechanic guided the other passengers out of the Helicopter and checked for injuries.

Although the wind felt outside the Helicopter was not strong, there was a southerly wind acting as a tailwind.

c. Passenger A

Passenger A sat in a seat one row behind the cockpit facing forward, and was responsible for the confirmation of the damage conditions of the river basin.

Passenger A believed that landing would be just as usual, but before landing, the Helicopter did not reduce speed, as though it was being pushed, and it touched down in that state with two impacts. After touching down, Passenger A confirmed that there was nothing wrong with the rest of the passengers.

After this, Passenger A felt pain in the lower back, was transferred to a hospital by ambulance together with the Pilot, and was diagnosed with a sprain.

The accident occurred at about 30 meters south of Nagashima Helipad (35°10' 31" N, 138°11'17" E), at 12:54.

(See Figure 1: Estimated Flight Route, Figure 2: Accident Site Layout, and Photo: Accident Helicopter)

2.2 Injuries to Persons

The Pilot suffered serious injury with a bone fracture, and one of the passengers sustained minor injury with a sprain.

2.3 Damage to the Helicopter

2.3.1 Extent of Damage

The Helicopter was slightly damaged.

2.3.2 Damage to the Helicopter Components

a. Fuselage: The cockpit floor and the floor under the fuel tank were partially damaged. The antenna mounting surface of the underside of the fuselage was deformed and damaged.
The infrared camera mount was damaged.

b. Landing Gear: The cross tube was deformed outward, and the width of the left and right skids was enlarged by about 40 centimeters.

c. Equipment: The infrared camera was dropped, the external speaker was damaged, and the antenna equipment was damaged.

There were no recognizable anomalies with operation of the control systems.

(See Photo: Accident Helicopter)

2.4 Personnel Information

Pilot : Male, Age 59

Commercial pilot certificate (Rotorcraft)	November 18, 1976
Type rating for Bell 212	May 12, 1994
Class 1 aviation medical certificate	
Validity	December 5, 2012
Total flight time	9,263 hr and 46 min
Flight time in the last 30 days	6 hr and 49 min
Total flight time on the type of aircraft	3,629 hr and 10 min
Flight time in the last 30 days	6 hr and 49 min

2.5 Helicopter Information

2.5.1 Helicopter

Type	Bell 412EP
Serial number	36277
Date of manufacture	May 31, 2001
Certificate of airworthiness	No. Dai-2012-095
Validity	June 15, 2013
Category of airworthiness	Rotorcraft transport TA or TB, or special X
Total flight time	1,634 hr and 36 min
Flight time since last periodical check (25 hours inspection, June 9, 2012)	13 hr and 56 min

(See Figure 3: Three Angle View of Bell 412EP)

2.5.2 Weight and Balance

When the accident occurred, the weight of the Helicopter is estimated to have been 11,142 pounds and the position of the center of gravity (CG) is estimated to have been longitudinally at 137.6 inches aft of the reference plane (20 inches aft of the tip of the nose) and laterally at 1.9 inches to the right of the airframe symmetry plane, both of which are estimated to have been within the allowable limits (the maximum gross weight of 11,900 pounds, the minimum gross weight of 6,400 pounds, and the CG range of longitudinally 133.8 inches to 142.0 inches and laterally 4.5 inches to the left and 4.5 inches to the right in corresponding to the weight at the time of the accident).

2.6 Meteorological Information

The observed wind velocity (averages of previous 10 minutes and maximum m/s converted into kt) from anemometers set up on bridges #3 and #4 of the Oigawa (Oi River) Railway located about one kilometer to the south of Nagashima Helipad are as shown in Table 1.

However, no anemoscopes had been set up.

Table 1: Recorded Wind Velocity near Accident Site

Time	09:50	10:00	10:10		12:50	13:00	13:10
Maximum	7kt	7kt	5kt		9kt	11kt	10kt
Average	5kt	5kt	4kt		7kt	9kt	9kt

2.7 Accident Site Information

2.7.1 Outline of Nagashima Helipad

Nagashima Helipad is a temporary helipad located on the right bank of the bed of the Oi River, which flows between the Akaishi Mountains and Minobu Mountains in the northern part of Shizuoka prefecture. Its takeoff and landing direction follows the valley in a generally south-north direction. Chubu Bureau applied for the use of the temporary helipad to the Minister of land, Infrastructure, Transport and Tourism, and obtained permission.

Nagashima Helipad is located in an open grassy area on the river bed, with a helipad of 40 meters square, situating at about 80 meters north of a road on the outer perimeter of the open area. However, there are no markers indicating the boundaries of the helipad. Also, there are no windsocks or other equipment for judgment of wind direction and velocity.

There are utility poles and power lines about 20 meters in height located about 110 meters south of the southern edge of the helipad, and a suspension bridge about 30 meters in height located about 150 meters southeast of the helipad.

Also, both of the cableways indicated in the temporary helipad permission application form, noted at about 90 meters and 290 meters north of the northern edge of the helipad, with heights of 10 meters and 15 meters, had been removed.

2.7.2 Conditions of the Accident Site

The Helicopter had stopped about 30 meters south of the southern edge of Nagashima Helipad (about 50 meters south of the center), with its nose facing a magnetic bearing of 015°, having come to a stop with the rear portion of its fuselage nearly touching the ground. Also, touchdown marks corresponding to the left and right skids, and to the equipment on the lower surface of the fuselage (loudspeaker, infrared camera, plural antennas) had been left about 3.5 meters behind the fuselage.

The marks left by the skids on both sides were about 320 centimeters apart, which is about 40 centimeters wider than normal.

(See Figure 1: Estimated Flight Route, Figure 2: Accident Site Layout, and Photos: Accident Helicopter)

2.8 Information on Airborne Imagery Transmission System, DFDR, CVR, Enhanced Ground Proximity Warning System (hereinafter referred to as "EGPWS"), and Portable GPS

a. Airborne Imagery Transmission System

The optical camera of the airborne imagery transmission system made by Aero Asahi Corporation, mounted on the right-hand skid, retained video recording from the time of the accident. Also, the Japan Standard Time and position information of the GPS equipment mounted on the Helicopter were recorded in the optical camera video.

b. DFDR

The DFDR made by L-3 Communications (part number: S800-2000-00) of the United States of America retained data from the time of the accident. The time was identified by coordinating the time of the change in horizontal acceleration resulting from touchdown that was recorded in the DFDR with the time of touchdown from the optical camera video of the airborne imagery transmission system.

No data was retained relating to the vertical acceleration or the vertical position of the cyclic stick (hereinafter referred to as "CS").

c. CVR

The CVR made by L-3 Communications (part number: 2100-1010-50) of the United States of America retained data of the accident. The time was identified by coordinating the sound of the touchdown recorded in the CVR with the time of touchdown from the optical camera video of the airborne imagery transmission system.

d. EGPWS

The Helicopter was equipped with a EGPWS (HONEYWELL MK XXII) made by Honeywell of the United States of America, which retained position information and the like from ground proximity warnings generated during flight in mountainous areas and other areas on the day of the accident, but because no ground proximity alerts were provided at the time of the accident, no data was retained from that time.

e. Portable GPS

A portable GPS (eTrex Legend) made by Garmin Ltd. of the United States of America which was brought on board retained position data of the Helicopter, but its recorded data ended 16 seconds before touchdown during the accident.

2.9 Other Necessary Information

2.9.1 GPS Data

a. GPS Position Information from Airborne Imagery Transmission System

The GPS position retained in the airborne imagery transmission system optical camera video included numerical latitude and longitude information, both to units of seconds. After comparing the displayed GPS position with the actual touchdown position and the last position recorded by the portable GPS (16 seconds before touchdown), both of them included the same positional error of about 400 meters to the southeast. Therefore, the position of the Helicopter according to this GPS could not be identified, and the ground speed was calculated from the relative travel distance per unit of time.

Measuring the relative distance between two points of travel during the five second period from six seconds before touchdown to one second before touchdown gave a result of 30.82 meters. Calculating the ground speed from this travel distance and time gave a result of 11.98 kt. Calculating the speed of the final approach in the same manner, the travel distance of 97.79 meters measured over the six second period from 18 seconds before touchdown to 12 seconds before touchdown gave a ground speed of 31.68 kt.

b. Portable GPS Position and Other Information

The position data recorded in the portable GPS stopped at 16 seconds before touchdown (222.7 meters before the touchdown point). Comparing the positions recorded by the EGPWS, which provided EGPWS Alerts during a flight path through mountainous areas and other areas, and the portable GPS positions at the same times on the day of the accident showed almost no positional error.

A comparison of the approach routes during the first landing, according to the position information and altitude information of the portable GPS, with the approach route at the time of the accident, is as shown in the following diagram.

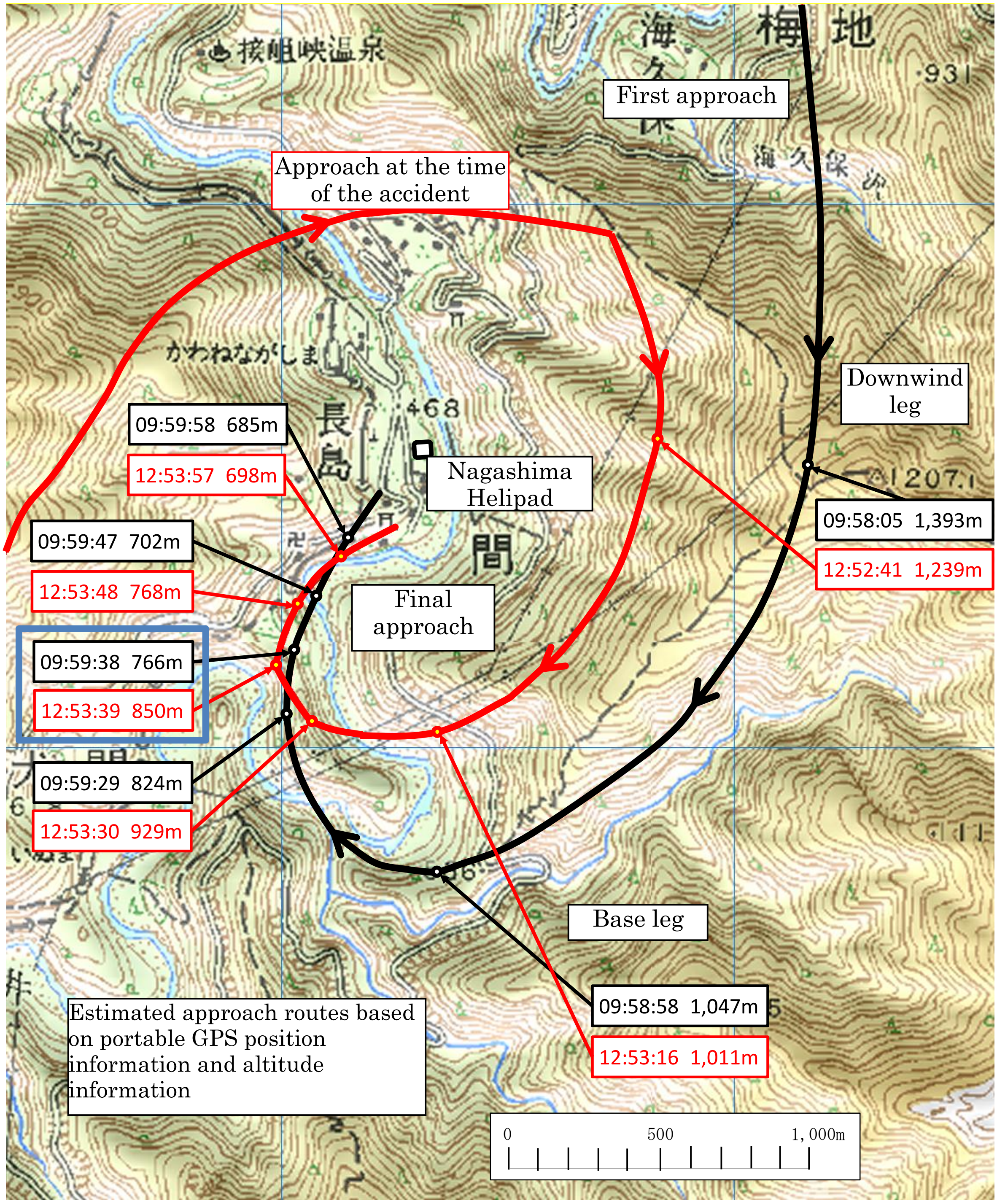


Diagram 1: Comparison with the Approach Route of the first Landing and the Approach Route at the Time of the Accident

According to these pieces of information, the Pilot took a relatively wide traffic pattern traveling along the river in the valley for the first approach, which was his first time to land there, descending in stages during the base leg. In comparison, at the time of the accident, he flew along a ridge where high-voltage lines were located, using a narrower traffic pattern and descending during the base leg in a shallower manner than in the first approach. Therefore, at 12:53:39, near the area where the Pilot transitioned to his final approach, the Helicopter was at about the same position as during the first landing but 84 meters (about 275 ft) higher in altitude.

2.9.2 DFDR Data of Landing

The data recorded in the DFDR related to the altitudes and the engine power outputs at the time of the accident is as shown in Table 2 and Diagram 2.

The time in Table 2 indicates the time in seconds calculated backwards from the touchdown time (12:54:25), while the altitudes indicate the relative altitudes derived from the value at the touchdown point (1,400 ft).

Table 2: Flight Parameters Based on DFDR Data at the Time of Accident

Time: seconds before touchdown	Altitude (ft)	CP Position (%)	TQ1 (%)	TQ2 (%)
50	1,090	26	11	6
40	840	24	4	1
30	600	22	4	11
15	310	34	13	13
10	210	45	22	26
05	100	56	45	30
02	40	64	47	47
00	0	71	57	63

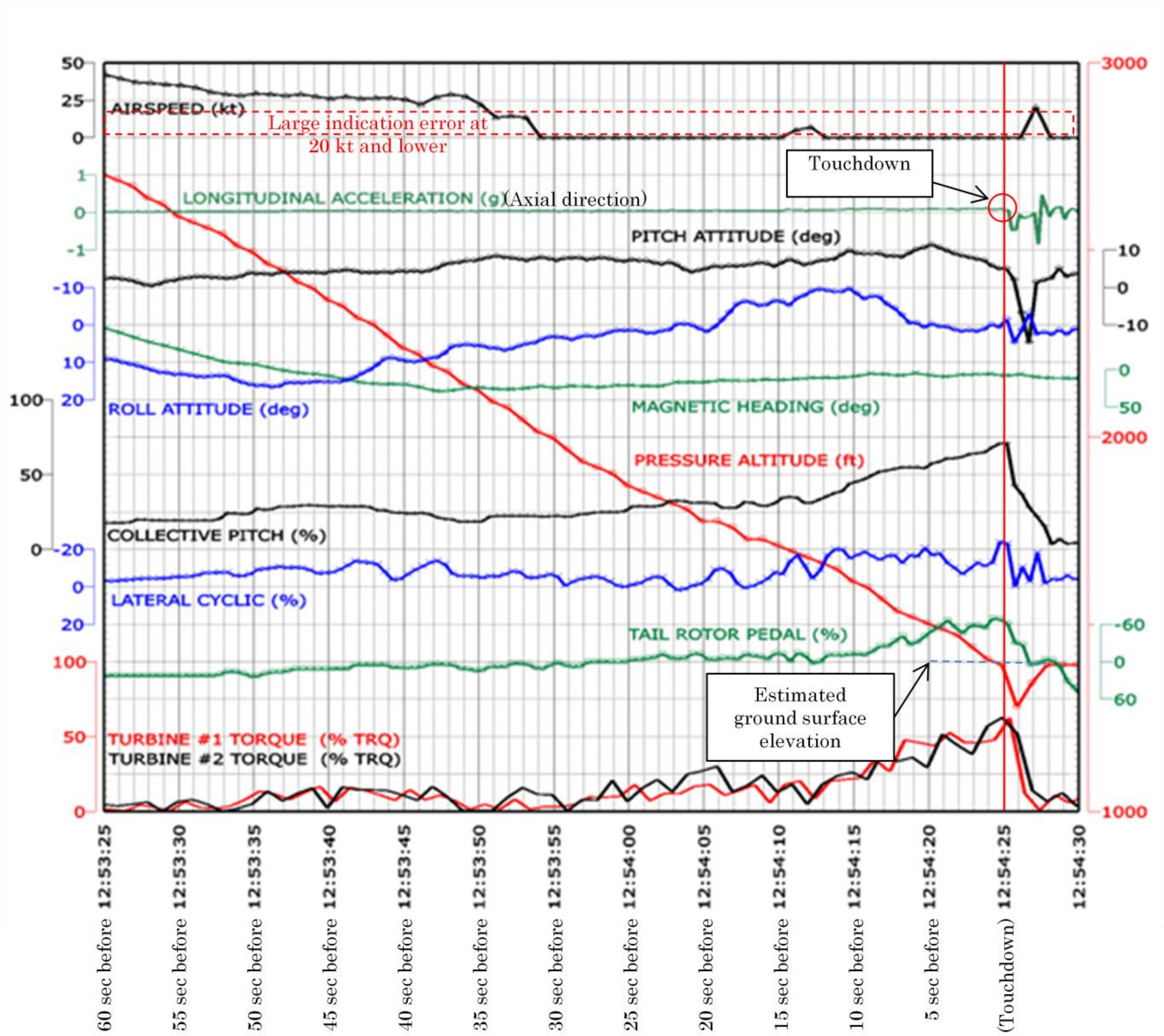


Diagram 2: DFDR Data at the Time of Accident

a. Utilized Power Output

At the time of the accident, in the latter half of the base leg 50 seconds before touchdown (The touchdown on Diagram 2 where sudden change in longitudinal acceleration is observed.), the Helicopter was in a low-power output state, with a CP position of about 26%, TQ1 of 11%, and TQ2 of 6%. From 15 seconds before touchdown, when the Helicopter was on a nearly straight-line route in its final approach, the CP position was 34% and had started to increase to 45% at 10 seconds before touchdown and to 56% at five seconds before touchdown, nearly reaching the maximum position it had attained during the first landing, with an accompanying increase in engine torque. Moreover, after this, two seconds before touchdown (the point at which the Pilot exclaimed “Ah…”), the CP position was 64%, and at the time of touchdown it was 71% and was still increasing when the Helicopter made contact with the ground.

During the first landing, although the CP position was about 26% at 55 seconds before touchdown (The touchdown on Diagram 3 where sudden change in longitudinal acceleration is observed.), it increased from that point just as for the landing during the accident, reaching 34% at 45 seconds before touchdown, 46% at 35 seconds before, 54% at 30 seconds before, and

58% at 20 seconds before, at that point reaching its maximum output position and then remaining at or near that position until touchdown.

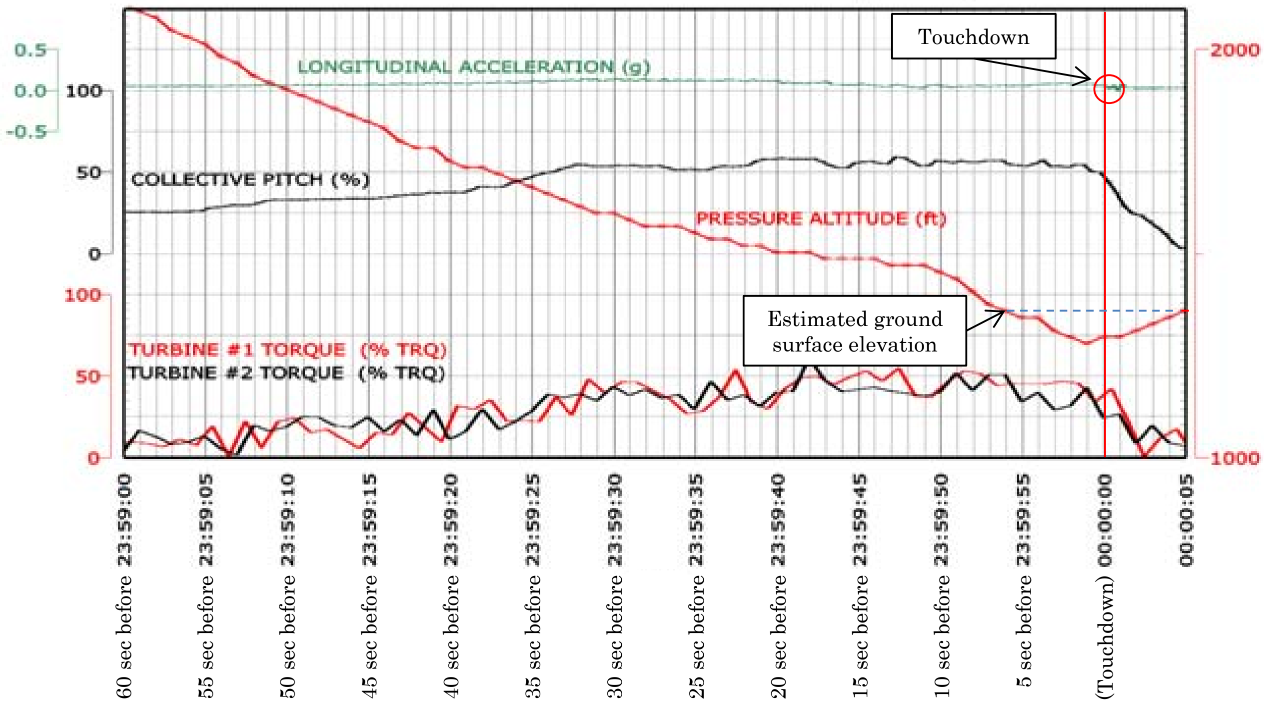


Diagram 3: DFDR Data at Time of the first Landing

b. Descent Rate

At the time of the accident, the Helicopter passed through about 1,090 ft AFL (the estimated ground surface elevation[2] at the time of the accident was about 1,400 ft) in the latter half of the base leg 50 seconds before touchdown, with the altitude graph line shown in Diagram 2 becoming the estimated ground surface elevation at the time of touchdown in a nearly linear line. After touchdown, the altitude graph line drops rapidly below the estimated ground surface elevation, then rises back to the estimated ground surface elevation within three seconds after touchdown, when the CP position had become nearly 0%, finally becoming a constant value.

The average descent rate from 50 seconds before touchdown until touchdown was about 1,300 ft/min. Also, the descent rate for the period from 10 seconds before touchdown (210 ft AFL), when the CP position was being pulled by a large amount, to five seconds before touchdown (100 ft AFL), was determined to be about 1,320 ft/min, based on the altitude and time differences.

During the first landing, the Helicopter passed through 560 ft AFL at 50 seconds before touchdown (the estimated ground surface elevation for the first landing was about 1,360 ft), 240 ft AFL at 30 seconds before, 140 ft AFL at 20 seconds before, and 100 ft AFL at 10 seconds before. Also, the altitude graph line shown in Diagram three drops rapidly below the estimated

[2] "Estimated ground surface elevation" refers to the altitude at which the DFDR barometric altitude data stabilizes to a constant value, when the effects on the barometric altimeter believed to stem from pressure generated by downwash contacting the ground surface disappear, due to the lowering of the CP after touching the ground.

ground surface elevation from 10 seconds before touchdown, then rises back to the estimated ground surface elevation within five seconds after touchdown, when the CP position had become nearly 0%, finally becoming a constant value.

The average descent rate from 50 seconds before touchdown until touchdown was about 690 ft/min, and the descent rate for the period from 30 seconds before touchdown, when the CP was pulled to its maximum position for the first landing, to 20 seconds before touchdown, was about 600 ft/min.

2.9.3 Vortex Ring State

a. Overall

In general, when a rotorcraft increases its descent rate at low speeds, the downwash from the main rotor (hereinafter referred to as “MR”) collides with the upward-flowing air currents generated by the descent, creating currents that flow from the MR’s lower surface around to its upper surface (vortices) at the MR tip. By attempting to increase lift under these conditions, even if the CP is pulled, the downwash will not move below the MR, instead flowing around from the lower surface to the upper surface of the MR and preventing an increase in lift. A helicopter will actually end up descending by its own downwash instead, possibly leading to an increase in descent rate. This condition is generally known as the vortex ring state (hereinafter referred to as “VRS”), or as settling with power, and the conditions for its occurrence are expressed as either a ratio between the induced velocity, which is the speed of the downwash, and the vertical velocity or a ratio between the induced velocity and the forward airspeed.

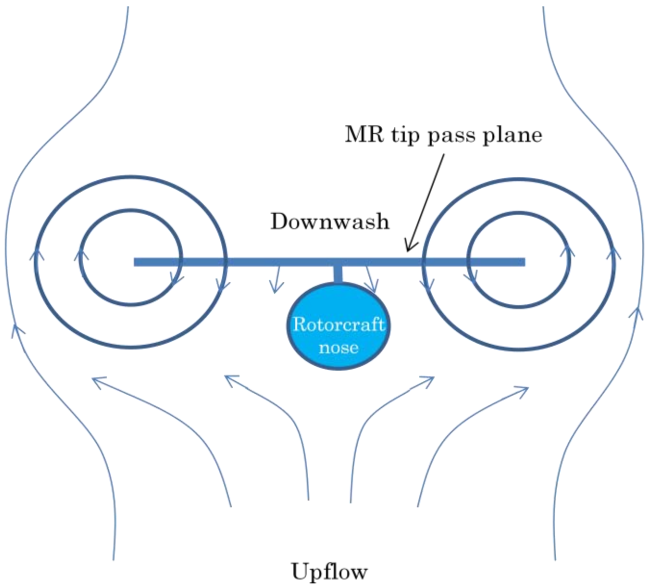


Diagram 4: Condition of Air Currents during Increasing Descent Rates at Low Speeds

The general method for escaping VRS is to temporarily lower the CP, increasing the vertical velocity in order to emerge below the vortex ring, and then when the CS has regained its effectiveness, to increase the forward airspeed and once again pull the CP. For this method, an altitude of 500 ft or greater is considered to be necessary for recovery from minor VRS, and an altitude of 4,000 ft or more for more severe conditions.

b.　VRS Occurrence

The occurrence of VRS is described in the following, from National Aeronautics and Space Administration STI (Scientific Technical Information) Report Series.

(Wayne Johnson, "MODEL FOR VORTEX RING STATE INFLUENCE ON ROTORCRAFT FLIGHT DYNAMICS" NASA/TP-2005-213477 December 2005,pp.1,11,13,25,49) (Excerpt)

OVERVIEW

A rotor is operating in vortex ring state when it is descending at low forward speed with a vertical velocity that approaches the value of the wake-induced velocity at the rotor disk. In this condition the rotor tip vortices are not convected away from the disk rapidly enough, and the wake builds up and periodically breaks away (Fig. 1).

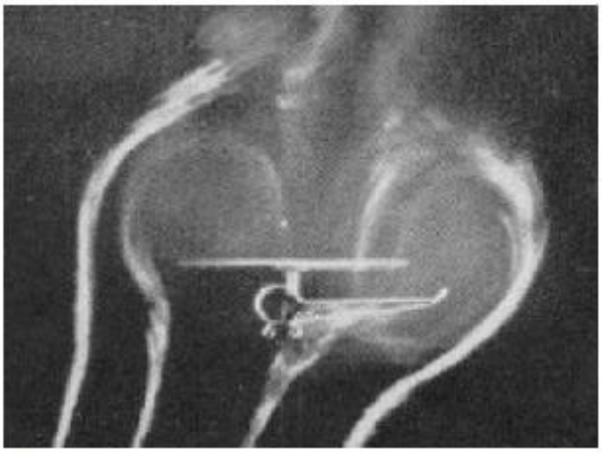


Figure 1. Smoke flow visualization of a rotor in vortex ring state (Dress, ref. 20).

The tip vortices collect in a vortex ring, producing a circulating flow down through the rotor disk, then outward and upward outside the disk. The resulting flow is unsteady, hence a source of considerable low frequency vibration and possible control problems. For descent at forward speeds sufficiently high enough that the wake is convected away from the rotor, vortex ring state does not develop. (omitted)

VRS BOUNDARIES

A number of the boundaries that have been proposed for vortex ring state are presented in Figure 33. The boundary from the ONERA VRS model is based on the Vz drop encountered in helicopter flight tests. The boundary for the VRS model of the present investigation is based on the flight dynamics stability of helicopters and tiltrotors. The other boundaries are based primarily on the vibration and roughness that a helicopter encounters in VRS. Of particular note are the boundaries that Washizu constructed for $\Delta T/T = 0.15$ *and 0.30 (ref. 30), which are found in numerous documents on VRS (including the U.S.Army Field Manual FM 1-203, Fundamentals of Flight).* (omitted)

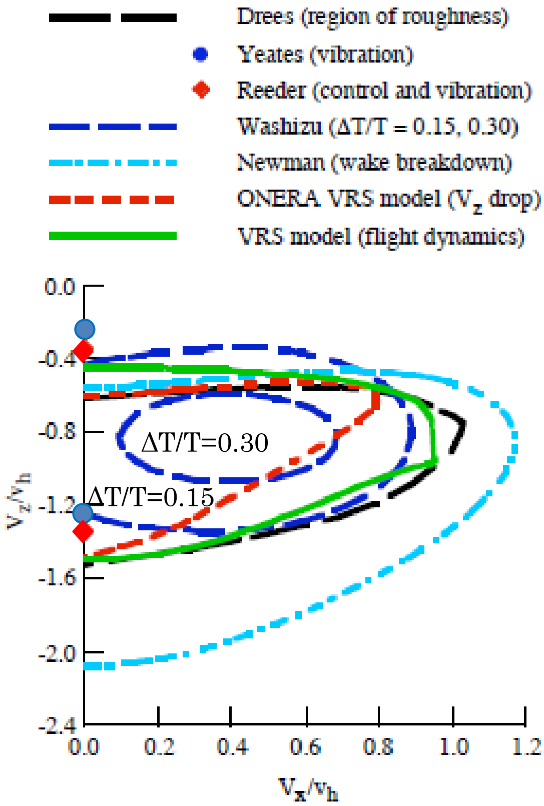


Figure 33. Vortex ring state boundaries.

[Notes: V_x: forward airspeed, V_z: vertical velocity, v_h: induced velocity]

c. Induced Velocity of the Helicopter

The formula for determining the induced velocity, which is the velocity of the rotor downwash, is expressed as $v_h = \sqrt{\text{thrust}/(2\times\rho\times\text{rotor disk area})}$ for the hovering condition. At this condition, thrust can be approximated by the Helicopter's own weight, and the calculation can be carried out using the Helicopter's weight at the time of the accident as indicated in 2.5.2 (11,142 pounds). Using the observed outside air temperature value of 25°C at Nagashima Dam (about three kilometers south of the accident site, at nearly the same elevation) at the time of the accident as the outside air temperature at the accident site, the density altitude of Nagashima Helipad is found to be about 3,100 ft (elevation of 1,561 ft + temperature correction value of 1,560 ft) and the density of air ρ at those conditions can be calculated to be 0.0021687 slug/ft^3. In addition, the Helicopter's MR disc area was 1661.9 ft^2.

Based on these data, the induced velocity while hovering can be calculated to be about 2,360 ft/min (about 23 kt).

2.9.4 Operation of Temporary Helipad, etc.

a. Ensure Safety during Operations

In contract related to the operations of the Helicopter, the Chubu Bureau requests contractors to designate an operation supervisor for conducting of duties from a technical perspective.

The content stipulated in such contract (2012 Aircraft Operation and Maintenance

Management Specifications) is as follows.

1. Operation Supervisor

(1) The contractor must designate an operation supervisor and must notify an orderer of it. It should be noted, the operation supervisor must possess experience in the operation and management of the same type of helicopter as applicable.

(2) The operation supervisor shall supervise the following operations.

1) Matters related to the operation and safety of the aircraft

2) Matters related to the inspection, maintenance, and storage of the aircraft

3) Matters related to instructional training on the operation, inspection and maintenance, and storage of the aircraft

4) Matters related to contact and coordination with the orderer

(3) When intending to operate the aircraft, the operation supervisor must consider the following carefully and, in addition to endeavoring to ensure safe operation, contact and coordinate with the officials in charge of operation, prepare operation plans, and submit those plans to the officials in charge of operation.

1) Inspection maintenance status of the aircraft

2) Meteorological conditions

(omitted)

7) Helipad conditions

(omitted)

b. Division of Roles, etc. during Operation

For the effective utilization of disaster prevention helicopters, the Chubu Bureau has established a "Manual for Helicopter Utilization" (hereinafter referred to as "Utilization Manual"), which defines the procedures to be followed when operating disaster prevention helicopters. Descriptions regarding the operation of temporary helipads and the like included in this manual are as follows.

Chapter 5: Actual Helicopter Operation (Excerpt)

2 Tasks before Actual Operation

(1-3) Points of Concern before Operation

1) Securing of helipads (heliports, etc.)

(omitted)

■ *Temporary helipads are recognized as adaptations to the detailed standards based on the Civil Aeronautics Act. Therefore, if there are changes to the site or other surrounding conditions (including construction of buildings, utility poles, steel towers, etc.), re-checking of their status will be necessary. Caution must be exercised on a routine basis.* (omitted)

3 Division of Roles during Operation

Ministry of Land, Infrastructure, Transport and Tourism personnel shall share in the execution of the following duties regarding helicopter operation.

(omitted)

(2) If heliports, etc. are required, the personnel in charge of the heliport, etc. shall perform the following preparations prior to the helicopter's takeoff or landing to ensure that there are no problems, be responsible for the safety management of the helicopter, and remove such preparations after the flight.

[1] Implement dust control measures for the helicopter such as sprinkling water.

[2] Clearly indicate the extents of the heliport, etc. and the markers for the takeoff and landing zone.

(perform marking of the heliport with line and other things)

(omitted)

[4] Set up wind direction indicators (windsocks).

[5] Monitor the heliport, etc. and ensure that people do not enter it without reason.

(deploy security guards if necessary)

[6] If there are any objects in danger of being blown about, move them outside the area whenever possible, and if not possible, lash them down.

(omitted)

[10] If there are roads in the vicinity, take measures to temporarily close them to traffic during takeoff and landing.

**The above shall be executed according to directions from the operation contractor. (they may not always be necessary)*

c. Conditions of Nagashima Helipad

On the day of the accident, the operation supervisor of the Company was somewhat inactive and so coordination involving indicators at the helipad to be requested of the Chubu Bureau, as well as requests for the installation of windsocks, etc. had not been carried out.

The use application procedures for Nagashima Helipad were the responsibility of the Company, and though updates to the appropriate applications were being carried out every three months, the removal of the cableways to the north of the helipad had not been confirmed during the application on April 24, 2012.

3. ANALYSIS

3.1 Qualification of Personnel

The Pilot held a valid airman competence certificate and a valid aviation medical certificate.

3.2 Airworthiness Certificate

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

3.3 Effects of Meteorological Conditions

According to the statements in 2.1.2 a. and b., and the anemometer observation data described in 2.6, it is probable that the weather conditions at Nagashima Helipad at the time of the accident were clear, with good visibility, smooth air, and a southerly tailwind with respect to the approach direction of the Helicopter was blowing at about 10 kt.

3.4 Damage to the Helicopter

According to the condition of the damage to the Helicopter as described in 2.3.2, it is highly probable that the Helicopter was damaged by external force accompanied by the accident. In addition, according to the statement in 2.1.2 a., it is highly probable that the Helicopter was operational with no anomalies until the event.

3.5 Development Up to Hard Landing

3.5.1 Initiation of Approach

According to the Pilot's statement in 2.1.2 a., when landing at Nagashima Helipad for the first time, he determined that the wind was calm from the conditions of the nearby trees, etc, and avoided a southward approach that would pass over hardly visible cableways indicated to the north of Nagashima Helipad, deciding to use a northward approach instead. For the approach at the time of the accident, because there were no windsocks set up on the Helipad, the Pilot could not make an accurate evaluation of the wind, but determined that the wind was calm just as during the first landing. From the south he passed through a relatively low area between a suspension bridge and a road, making the approach on a northward route with as shallow a pass as possible.

Judging from this, the Pilot probably believed from the conditions 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 as described in 3.3, passing over an easily-visible suspension bridge.

3.5.2 Conditions of Final Approach

a. Utilized Power Output

As described in 2.9.2 a., the Pilot continued to descend at low power output from the base leg 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 five 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, because this result could not be achieved, 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%.

For the first landing, the power output was raised starting from 45 seconds before touchdown, and at 30 seconds before touchdown the CP position was 54%, with the power output at a level allowing the Helicopter to transition to a hovering state, maintaining or remaining near this level until touchdown. This is considered to be consistent with the statement in 2.1.2 a. that the approach was made slowly, as though being suspended by the power at low speed.

b. Descent Rate

As described in 2.9.2 b., from the latter half of the base leg to the final approach, and up until the following transition to hovering, it is highly probable that the Helicopter made its approach with a descent rate of roughly 1,300 ft/min, and touched down while being unable to decrease this descent rate. This rate is considered to be significantly higher than that normally used for approaches.

For the first landing, the descent rate during the 10-second period from 30 seconds prior to touchdown, at which the maximum output of the engines was achieved for transition to a hovering state, to 20 seconds prior to touchdown, was about 600 ft/min. It is probable that after this, the transition to hovering was made while decreasing the descent rate until the estimated ground surface elevation.

3.5.3 Probable Causes of the Hard Landing

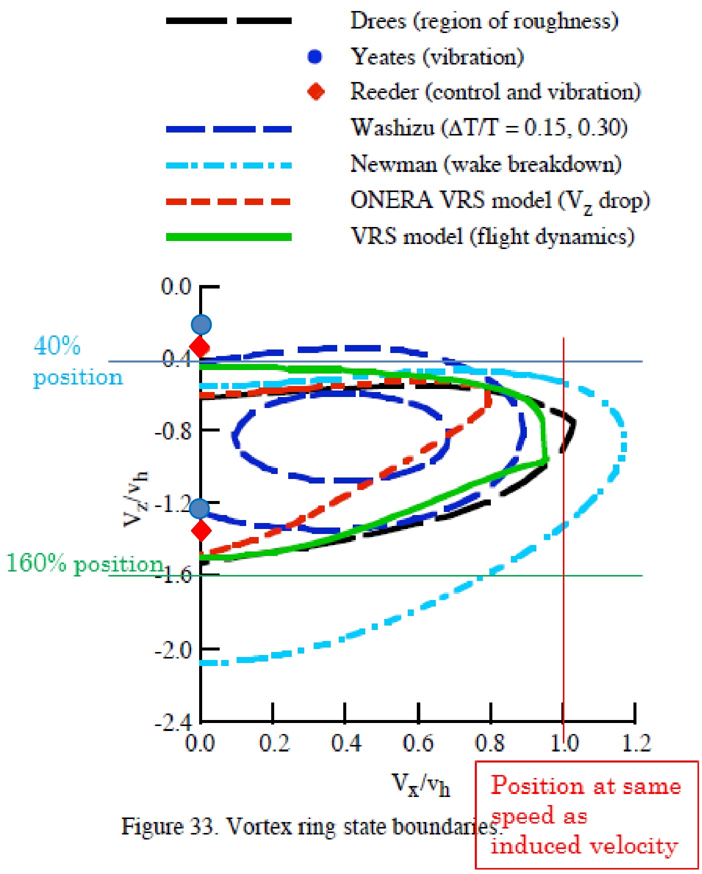
a. Conditions of the Hard Landing

According to the statement in 2.1.2 a., the Pilot was unable to decrease the descent rate by pulling the CP in order to transition to hovering as he intended; moreover, despite pulling the CP nearly to its overtorque limit, the sinking of the Helicopter could not be restrained, as though its thrust was slipping away, resulting in a touchdown as though it was a hard landing. The inability to decrease the descent rate despite pulling the CP is consistent with the results of the utilized power output and descent rate analysis described in 3.5.2. Judging from these results and from the fact that there were no anomalies with the Helicopter until the accident, it is highly probable that the injuries suffered by the pilot and the damage to the Helicopter were a result of the hard landing experienced when attempting to land.

As the airflow was smooth on the day of the accident, it is firstly possible that the cause of the inability to stop the sinking of the Helicopter due to its high descent rate, and of the resulting hard landing, could have been a failure to begin pulling the CP in enough time to allow sufficient compensation for the downward inertial forces on the Helicopter before touchdown. However, in this case, the Pilot began pulling the CP by a significant amount at 10 seconds before touchdown, and nearly sufficient power output for hovering was achieved at five seconds before touchdown at 100 ft AFL. Under normal conditions, the descent rate is reduced before touchdown by the ground effect generated as the Helicopter approaches the ground, and by the effects of increasing the power output, but as also shown by the DFDR data, in this case touchdown was made with no decrease in descent rate. Judging from this, it is probable that the cause of the hard landing was not a lateness in the pulling of the CP; on the contrary, a condition in which the power output was increased but there was no increase in MR lift, suggesting the occurrence of VRS as described in 2.9.3.

b. Relationship with VRS

Summarizing the individual models shown in the VRS Boundaries diagram of 2.9.3 b., as shown in Diagram 5, roughly speaking, when the forward airspeed is the same as or lower than the induced velocity, a helicopter will enter the VRS boundaries when the descent rate approaches 40% of the induced velocity. The center of the VRS boundaries will be located on the area from 60% to around 100%. Also, it is probable that a helicopter will exit the VRS boundaries when the descent rate reaches or exceeds roughly 160% of the induced velocity.



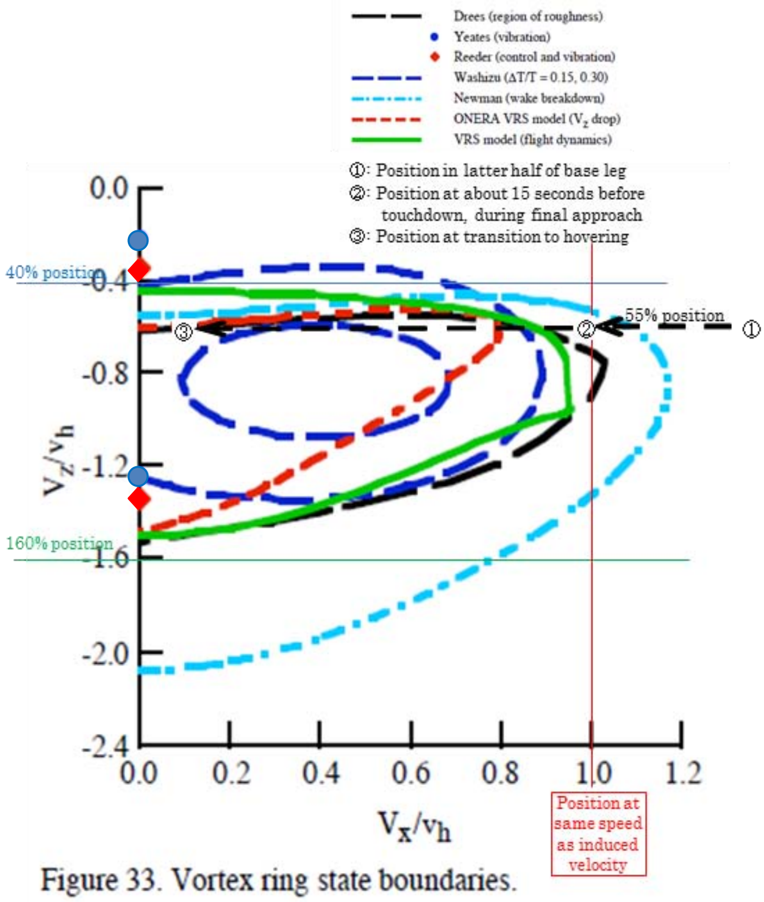
[Notes: V_x: forward airspeed, V_z: vertical velocity, v_h: induced velocity]

Diagram 5: VRS Boundaries

According to the DFDR data at the time of the accident in 2.9.2, and the descriptions in 2.9.2 b., 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 between the Helicopter's induced velocity described in 2.9.3 c. (about 2,360 ft/min: about 23 kt) and its descent rate becomes -0.55, and the ratio between the induced velocity and the forward airspeed becomes 1.3, which are outside of the VRS boundaries as indicated by ① in Diagram 6.

According to the descriptions in 2.9.1 a., it is considered probable that the ground speed at about 15 seconds before touchdown, during the final approach, was about 32 kt, and about 12 kt immediately before touchdown. Judging from the tailwind of about 10 kt as described in 3.3, it is probable that the forward airspeeds corresponding to these ground speeds were about 22 kt and about 2 kt respectively. During this time, considering that at about 15 seconds before touchdown the descent rate was about 1,300 ft/min and the forward airspeed was about 22 kt, their ratios with 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 Diagram 6.

Also, as described in 2.9.2 b., at five seconds before touchdown when the Pilot had raised the engine power output to hovering output, the descent rate was about 1,320 ft/min and the forward airspeed was about 2 kt. Therefore, the ratios of these with the induced velocity become about -0.56 and about 0.09 respectively, which are indicated by the position ③ in Diagram 6.



[Notes: V_x: forward airspeed, V_z: vertical velocity, v_h: induced velocity]

Diagram 6: Relationships with VRS Boundaries

After the Helicopter's flight at conditions outside of the VRS boundaries during the latter half of its base leg as indicated by ① in Diagram 6, it is probable that along with the decrease in speed it experienced when entering its final approach, the descent rate indicated by ② began to approach 55% of the induced velocity, entering into the VRS boundaries.

The position ③ is within the boundaries indicated by nearly all of the models described herein. When transitioning to a hovering state, at a descent rate of about 1,320 ft/min (about 56% of the induced velocity), which is significantly higher than the normal descent rate, the Helicopter's forward airspeed continued to decrease to about 2 kt, a value substantially lower than the induced velocity (about 23 kt). As a result, it is probable that the downwash moving past the MR collided with air currents from below which were generated by the high descent rate, producing large vortices wrapping around the upper surface of the MR tip and causing the condition of VRS. It is probable that because of this, even if the CP was pulled to near its overtorque limit, a corresponding amount of lift could not be generated and the Helicopter touched down violently without being able to decrease its rate of descent.

However, as described in 2.9.2 b., at the time of the first landing the descent rate from 30 seconds prior to touchdown, at which the transition to hovering was performed with the CP at its maximum value for that landing, to nearly 20 seconds prior to touchdown, was 600 ft/min (about 25% of the induced velocity), and the average descent rate from 50 seconds before touchdown to 10 seconds before touchdown was about 690 ft/min (about 29% of the induced velocity). It is highly probable from the VRS boundary diagram that at these descent rates, even if the forward airspeed had decreased to the induced velocity or lower, the helicopter would not have been entered in the VRS.

c. Causes of Entry into VRS Boundaries

As described in 2.7.2, the Helicopter stopped about 50 meters in front of the center of the helipad. Looking at this resting position suggests that as described in 2.7.1, because there were no helipad markers at Nagashima Helipad, in order to have some leeway regarding the hardly visible cableways to the north (which had actually been removed) when taking off to the north after landing, it is possible that the Pilot made an approach with a target slightly in front of the center of the open area. Also, as described in 2.9.1 b., because the Helicopter flew in a pattern along a ridge where high-voltage lines were located, it is probable that it could not lower its altitude sufficiently on the base leg, and near the point where it transitioned to its final approach, it was probably about 275 ft higher than it was during the first landing.

From these conditions, 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 the distance between the final portable GPS position data (16 seconds before touchdown) described in 2.9.1 b. and the touchdown point (222.7 m), and the altitude recorded by the DFDR at the same time (320 ft AFL), the approach angle for the final approach is estimated at about 23.7°, which is a considerably high angle when compared with the approach surface gradient (1/4) of about 14° of the Nagashima Helipad's

As described in 2.9.2 b., from a time of 50 seconds before touchdown during the latter half of the base leg, 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 the induced velocity. Also, as described in 3.3, the wind at the time of approach was a tailwind. Under such wind conditions, it is probable that maintaining a high approach angle would have led to a significantly high descent rate. Also, because the starting altitude of the final approach was high, it is probable that the Pilot would have needed to increase the descent rate to manage the Helicopter's altitude, and it is possible that he may not have noticed an unexpectedly large increase in descent rate arising from the tailwind conditions.

When there is a wind from behind, the ground speed increases due to the tailwind conditions, and it becomes necessary to reduce forward airspeed in order to maintain the approach angle. As described in 3.5.3 b., it is probable that when transitioning to a hovering state, the Helicopter's forward airspeed, which was about 30 kt in the latter half of the base leg, dropped to about 2 kt, a state with almost no forward airspeed at all. It is probable that this was because the Helicopter was attempting to land on steep approach path under tailwind conditions. As a result, it is probable that while experiencing a high descent rate of about 55% of the induced velocity, the Helicopter's forward airspeed continued to decrease even further despite dropping past the induced velocity, causing the occurrence of VRS.

(See Figure 4: Chain of Probable Causes of the Accident)

3.6 Management of the Temporary Helipad

As described in 2.9.4, along with establishing the "Utilization Manual" for effective utilization of disaster prevention helicopters, in contracts related to the operation of the Helicopter, the Chubu Bureau had requested the Company to designate an operation supervisor to support the Chubu Bureau's personnel in charge of operation, from the technical perspective of safe operation. The operation supervisor was to prepare operation plans for the Helicopter as well as consider the helipad conditions and carry out coordination with the Chubu Bureau's personnel in charge of operation.

Regarding the "Utilization Manual," the personnel in charge of the heliport, etc., were to clearly indicate the extents of the heliport, etc. and the markers for the takeoff and landing zone, (perform marking of the heliport with line and other things.), set up wind direction indicators (windsocks), and perform other preparations prior to the Helicopter's takeoff or landing. However, as described in 2.7.1, these preparations had not been performed.

The "Utilization Manual" includes provisions related to such matters, stating that these preparations are to be executed according to directions from the operation contractor, and as described in 2.9.4 c., it is highly probable that these preparations were not carried out at the time of the accident because there was no coordination involving them.

Regarding the conditions of the temporary helipad, although the operation supervisor was to coordinate with the Chubu Bureau's personnel in charge of operation when preparing operation plans, it is possible that the failure to request indication of the boundaries of the helipad as well as the setup of windsocks may reflect a disregard for their necessity. Also, although the coordination involving these requests was somewhat inactive as described in 2.9.4 c., because the management of the temporary helipad is the responsibility of the Chubu Bureau, it is possible that this is related to the fact that it is the contractor who would need to make a request to the orderer regarding items for preparation.

As 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, and because such preparations 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 contractors and orderers to exchange opinions on safety.

As described in 2.7.1, 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. Therefore, when updating applications it is a necessity 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.

3.7 Prevention of VRS during Landing Approach

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 the VRS boundaries during a landing approach.

a. Relationship between Forward Airspeed and Descent Rate

Because the conditions of VRS are determined by the ratio of induced velocity to forward airspeed and induced velocity to descent rate, it is necessary to make an approach so that the relationships with forward airspeed and descent rate do not become such that they enter the VRS boundaries, as indicated in the diagram in 2.9.3 b.. Specifically, as described in 3.5.3 b., 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 must be avoided.

The descent rate will increase during approach at a high angle with a tailwind. When approaching with a tailwind, the forward airspeed will become lower than the induced velocity at an early stage before the transition to hovering.

Consequently, it is necessary to select a traffic pattern that does not involve approach at a high angle with a tailwind.

b. Understanding of Wind Conditions when Landing

In order to accurately understand the wind conditions when landing, it is necessary to set up measuring equipment such as wind direction and speed indicators, and windsocks at the helipad. Also, during approach, if the ground speed does not decrease even when the forward airspeed decreases, and if the approach angle cannot be maintained without increasing the descent rate, there is likely to be a tailwind present. Under such conditions where there is the danger of entering VRS, it will be necessary to immediately execute a go-around and approach again from a direction where the tailwind's effect will not be felt.

4. CONCLUSIONS

4.1 Findings

a. It is probable that there was a southerly tailwind with respect to the approach direction of the Helicopter blowing at about 10 kt. (3.3)

b. It is highly probable that the Helicopter was damaged by external force accompanied by the accident, and was operational with no anomalies until the event. (3.4)

c. Conditions of Hard Landing

Judging from the Pilot's statement, DFDR data, and the fact that there were no anomalies with the Helicopter until the accident, it is highly probable that the injuries suffered by the Pilot and the damage to the Helicopter were a result of the hard landing experienced when attempting to land.

As the airflow was smooth on the day of the accident, it is possible that the cause of the inability to stop the sinking of the Helicopter due to its high descent rate, and of the resulting hard landing, could have been a failure to begin pulling the CP in enough time to allow sufficient compensation for the downward inertial forces on the Helicopter before touchdown. However, the Pilot began pulling the CP by a significant amount at 10 seconds before touchdown, and nearly sufficient power output for hovering was achieved at five seconds before touchdown at 100 ft AFL. Under normal conditions, the descent rate is reduced before touchdown by the ground effect generated as the Helicopter approaches the ground, and by the effects of increasing the power output, but as also shown by the DFDR data, in this case touchdown was made with no decrease in descent rate. Judging from this, it is probable that the cause of the hard landing was not a lateness in the pulling of the CP, but a condition in which the power output was increased but there was no increase in MR lift, suggesting the occurrence of VRS. (3.5.3 a.)

d. Relationship with VRS

It is probable that the Helicopter was outside of the VRS boundary conditions during the latter half of its base leg, and was near the entry point of the VRS boundaries during its final approach at about 15 seconds before touchdown. After this, when the Helicopter transitioned to a hovering state, at a high descent rate of about 56% of the induced velocity, which is significantly higher than the normal descent rate, its forward airspeed continued to decrease to about 2 kt a value substantially lower than the induced velocity. As a result, it is probable that the downwash moving past the MR collided with air currents from below which were generated by the high descent rate, producing large vortices wrapping around the upper surface of the MR tip and causing the condition of VRS. It is probable that because of this, even if the CP was pulled to near its overtorque limit, a corresponding amount of lift could not be generated and the Helicopter touched down violently without being able to decrease its rate of descent. (3.5.3 b.)

e. Causes of Entry into VRS Boundaries

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 the latter half of the base leg, 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 the induced velocity. Under tailwind conditions, it is probable that maintaining a high approach angle would have led to a significantly high descent rate. Also, because the starting altitude of the final approach was high, it is probable that the Pilot would have needed to increase the descent rate to manage the Helicopter's altitude, and it is possible that he may not have noticed an unexpectedly large increase in descent rate arising from the tailwind conditions.

It is probable that as a result of the Helicopter attempting to land on steep approach path under tailwind conditions, while experiencing a high descent rate of about 55% of the induced velocity, its forward airspeed continued to decrease even further despite dropping past the induced velocity, causing the occurrence of VRS. (3.5.3 c.)

f. Management of the Temporary Helipad

The Chubu Bureau personnel in charge of the heliport, etc. were to clearly indicate the extents of the heliport, etc., set up wind direction indicators, and perform other preparations prior to the Helicopter's takeoff or landing. However these preparations had not been carried out.

It is highly probable that these preparations were not carried out because there was no coordination involving them from the operation contractor.

Regarding the conditions of the temporary helipad, although the operation supervisor was to coordinate with the Chubu Bureau's personnel in charge of operation when preparing operation plans, it is possible that the failure to request indication of the boundaries of the helipad as well as the setup of windsocks may reflect a disregard for their necessity. Also, although the coordination involving these requests was somewhat inactive, because the management of the temporary helipad is the responsibility of the Chubu Bureau, it is possible that this is related to the fact that it is the contractor who would need to make a request to the orderer regarding items for preparation.

As 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, and because such preparations 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 contractors and orderers 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. There is a necessity when updating applications 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. (3.6)

g. Prevention of VRS during Landing Approach

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, 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. (3.7)

4.2 Probable Causes

In this accident, it is highly probable that the injuries suffered by the Pilot were a result of the hard landing experienced when attempting to land.

It is probable that the cause of the hard landing was that during a high decent rate, the Helicopter's forward airspeed continued to decrease, causing its downwash to produce large vortices wrapping around the upper surface of the MR tip and resulting in a VRS. It is probable that because of this, even if the CP was pulled, a corresponding amount of lift could not be generated and it was not possible to decrease the Helicopter's rate of descent.

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

5. SAFETY ACTIONS

5.1 Safety Actions Taken by the Company

Following this accident, the Company implemented safety actions including thoroughly assuring that during update procedures for the temporary helipads, 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.

a. 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

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

b. Translational Lift and Ground Effects

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 MR generated by forward airspeed of 15 kt or greater) is lost.

c. Other emergency procedures: Guidelines for collective bounce, dynamic rollover, and loss of tail rotor effectiveness

5.2 Safety Actions Taken by the Chubu Bureau

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

a. 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 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 preparations 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.

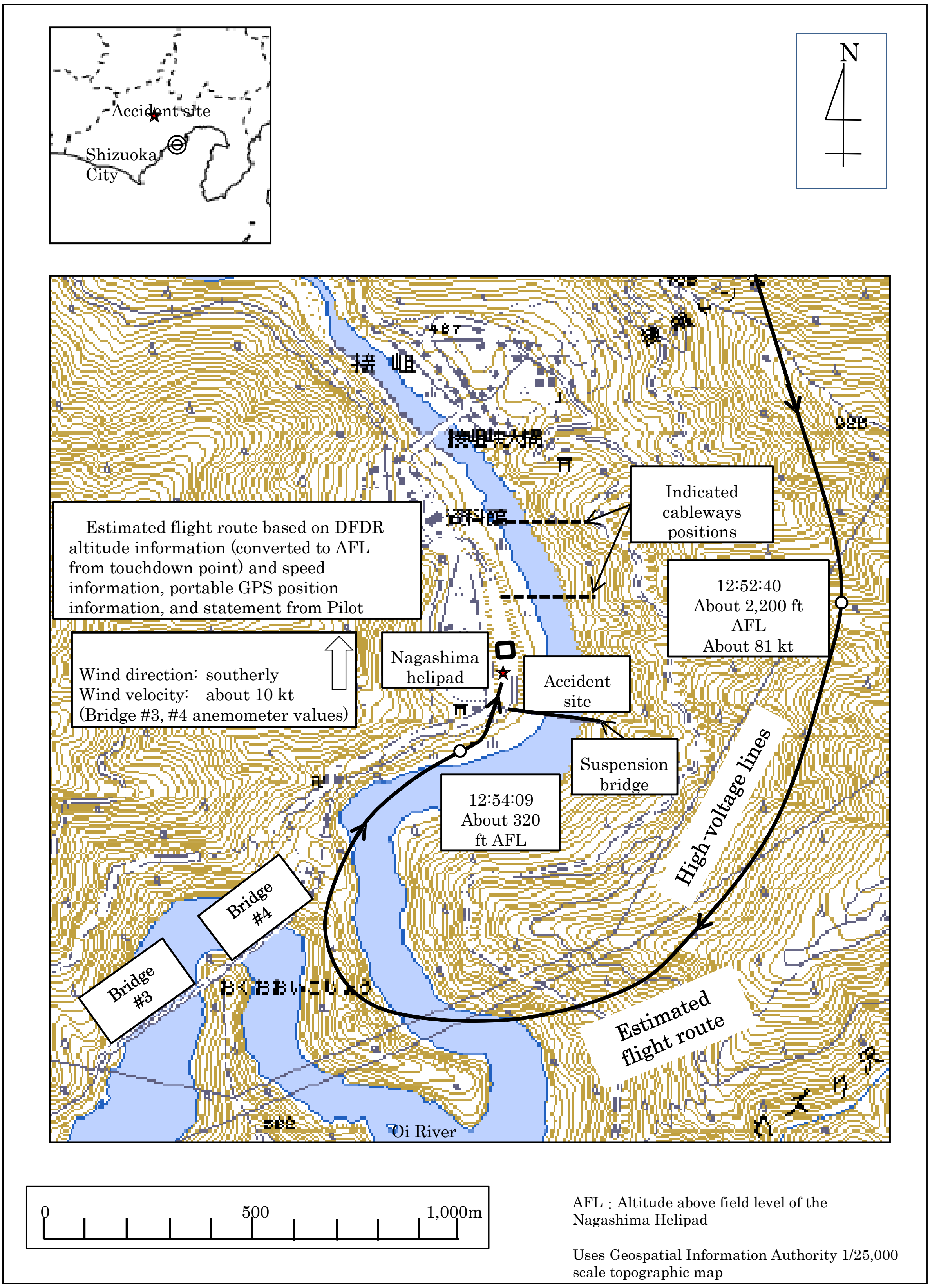
Moreover, it has become possible for the exchange of information regarding the status of preparations, etc. on the target day between the site observer and helicopter to be carried out and confirmed via the Disaster Prevention and Relief Division.

b. Notification of safety actions in writing was made within the Chubu Bureau divisions as well as at Chubu Bureau Internal Office Manager meetings.

c. Safety education regarding the use of helicopters was conducted at opportunities in Chubu Bureau Internal Office Disaster Prevention Representative Division Chief meetings.

d. Safety actions executed after the accident were presented by 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.

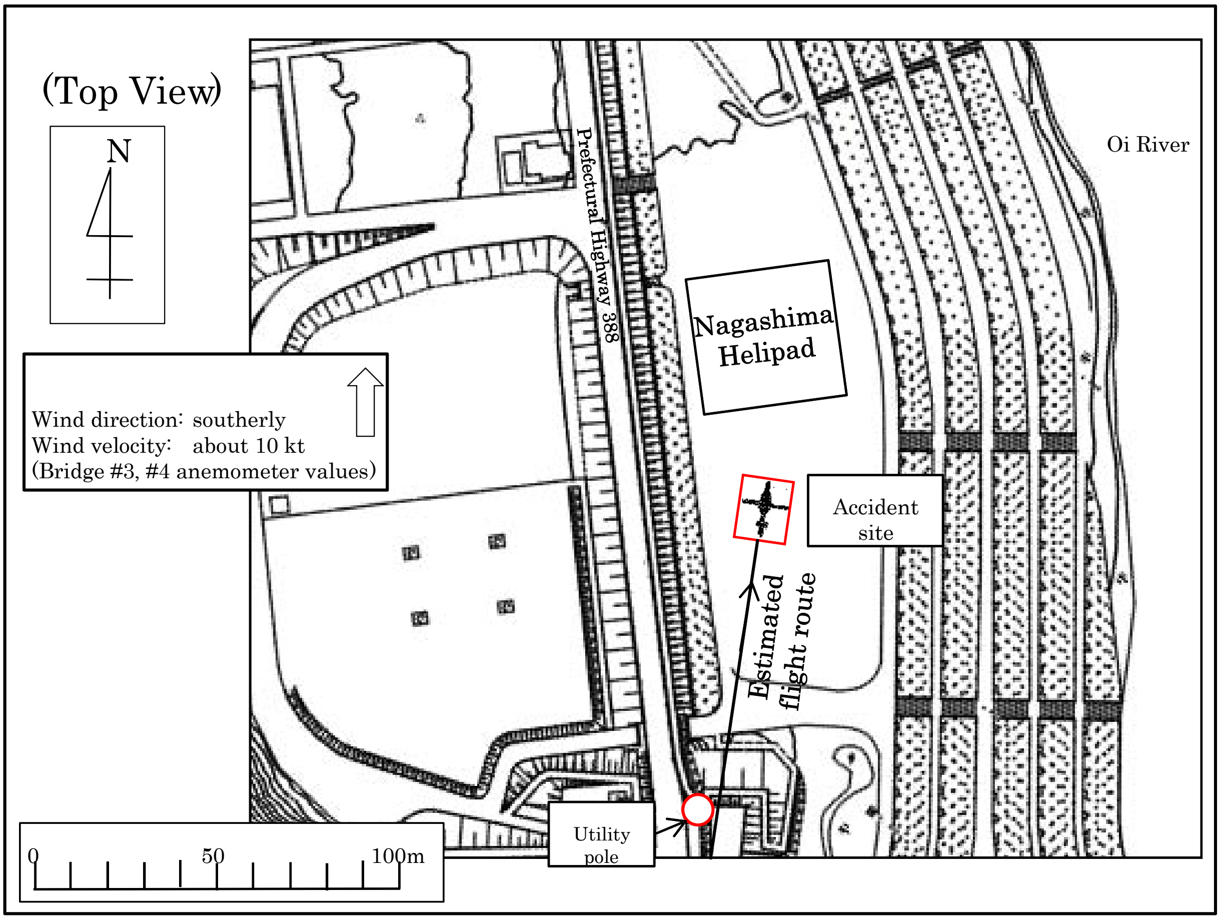
Figure 1: Estimated Flight Route



AFL : Altitude above field level of the Nagashima Helipad

Uses Geospatial Information Authority 1/25,000 scale topographic map

Figure 2: Accident Site Layout



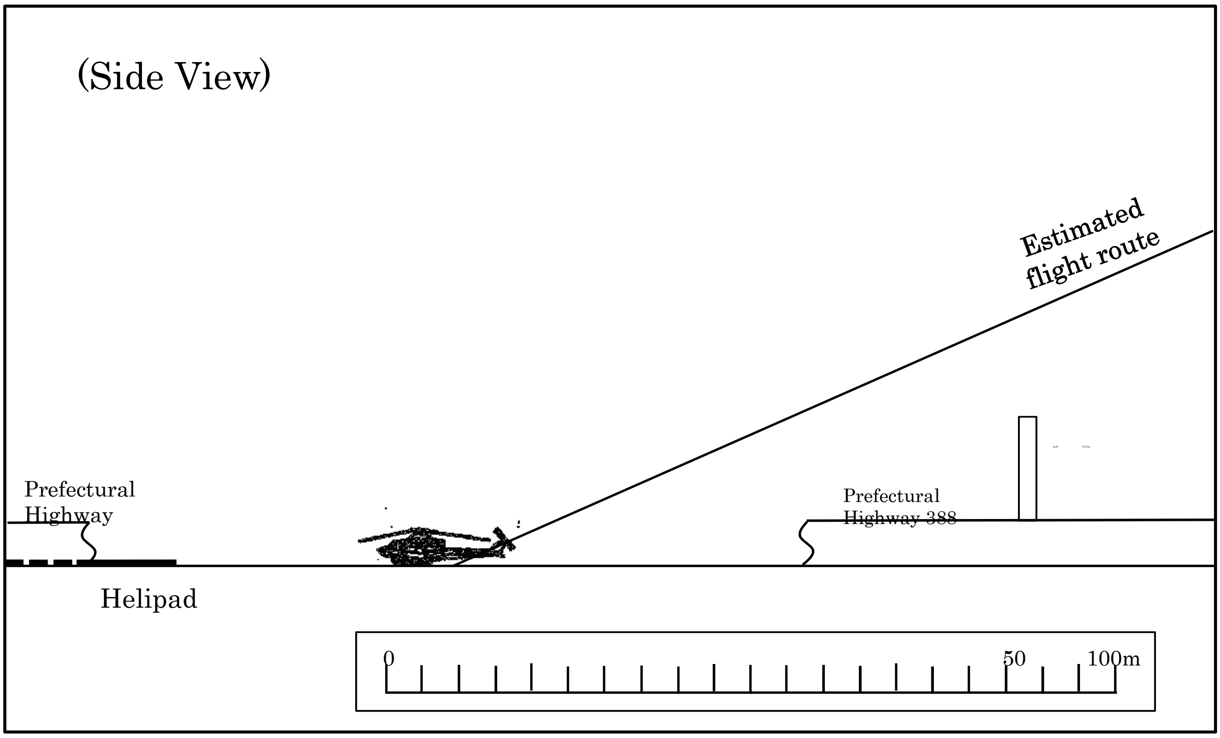


Figure 3: Three Angle View of Bell 412EP

Unit: m

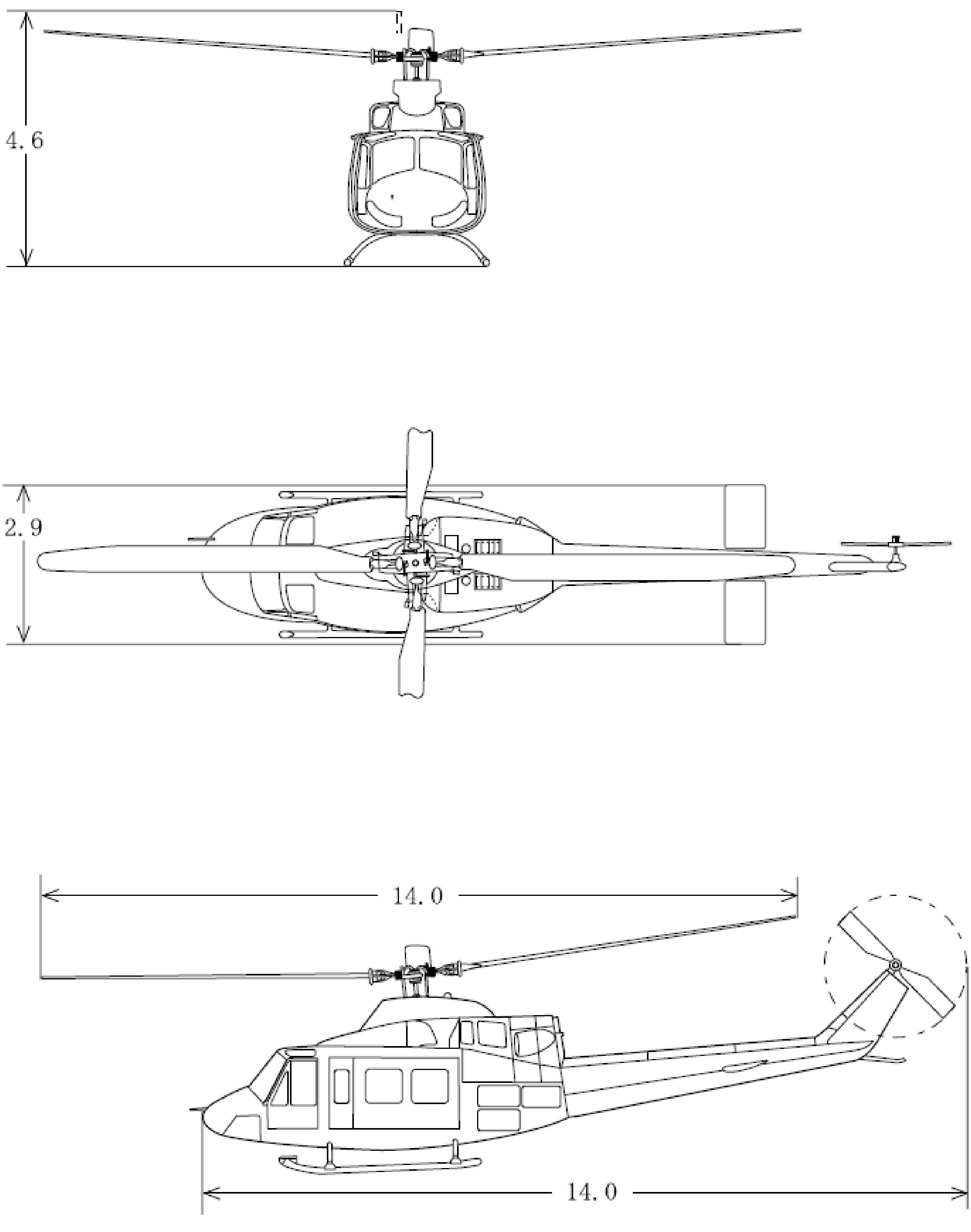
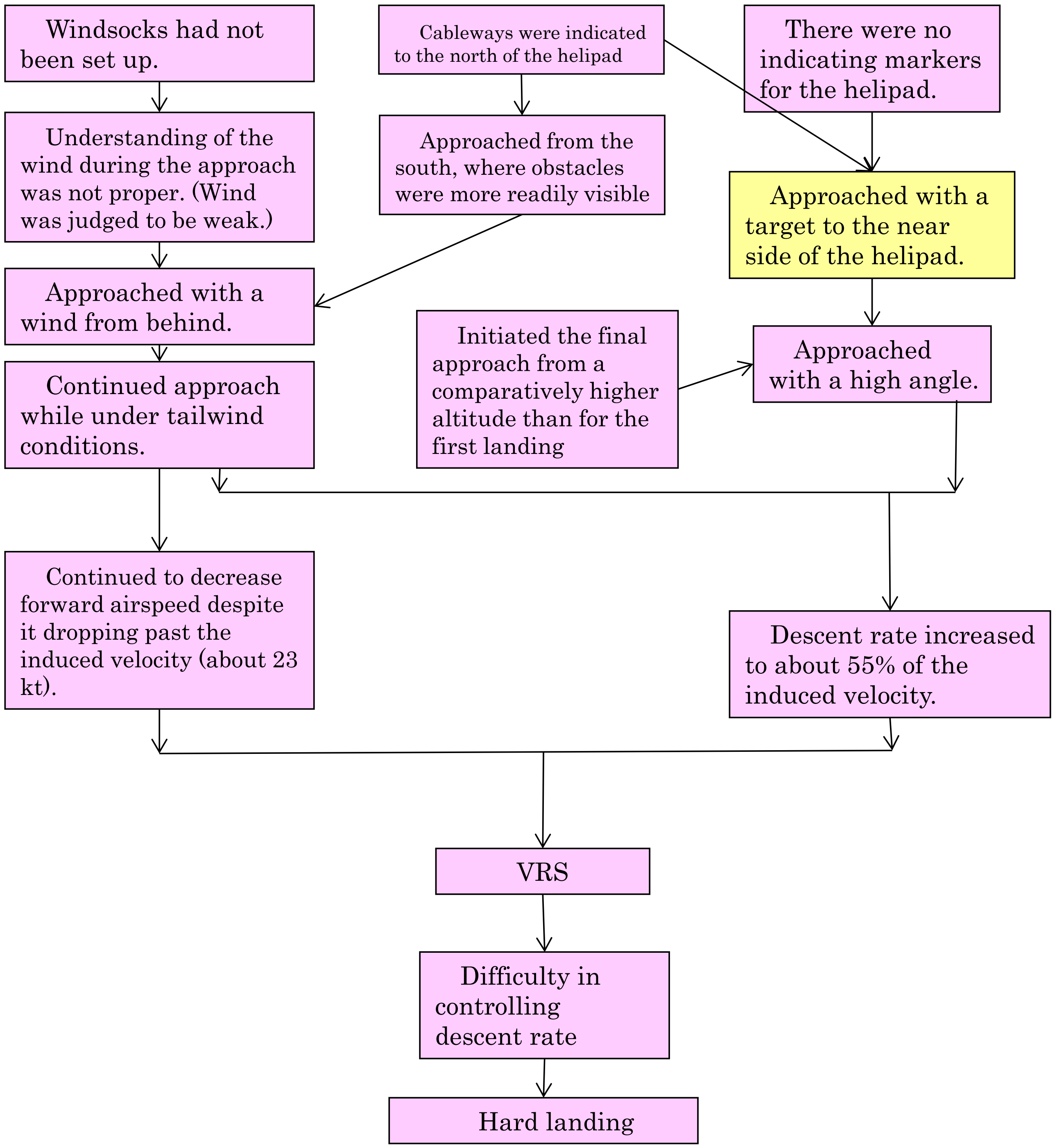


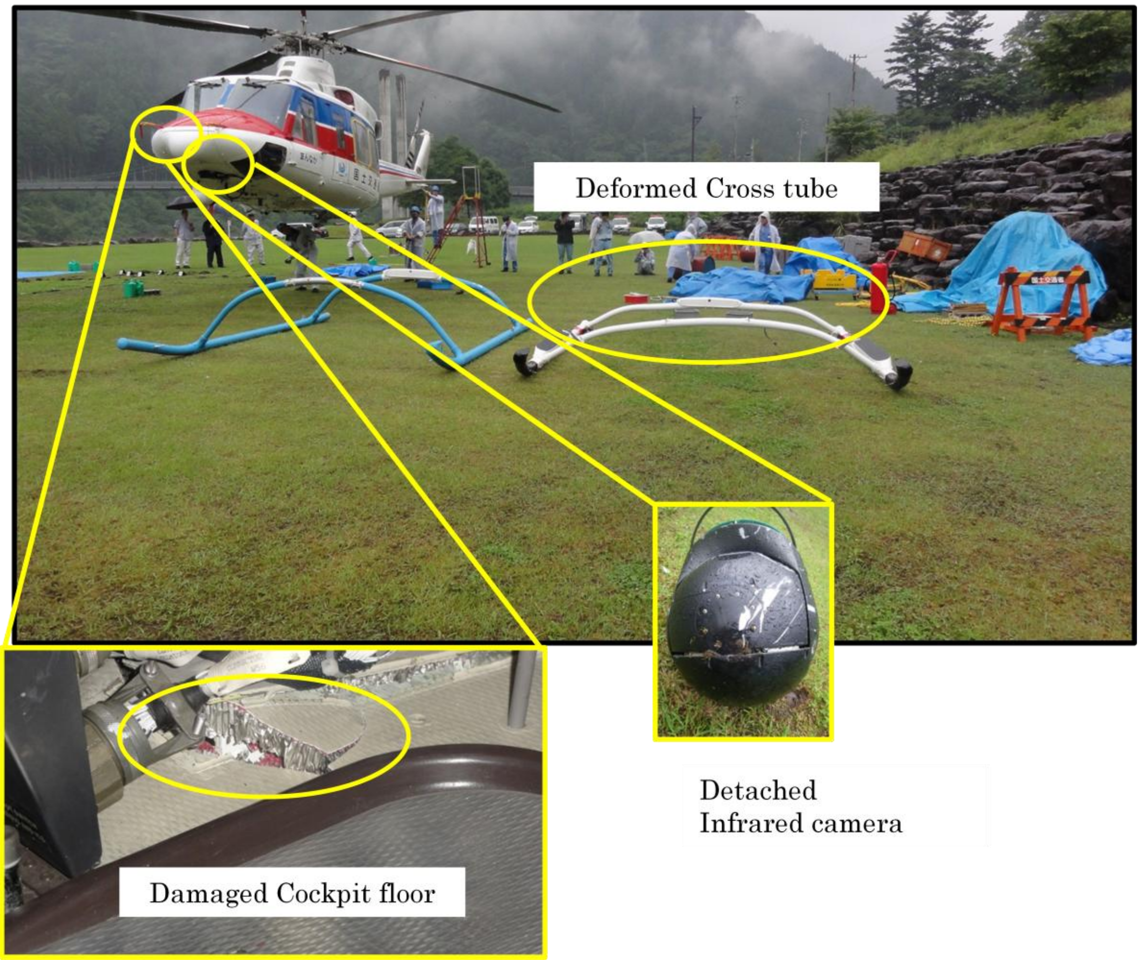
Figure 4: Chain of Probable Causes of the Accident



Event almost completely certain to have occurred, judging from conditions of accident site, statements from relevant parties, etc.

Event possible to have occurred, judging from related conditions, etc.

Photos: Accident Helicopter



Detached
Infrared camera