AIRCRAFT ACCIDENT INVESTIGATION REPORT

AIRCRAFT DAMAGE DURING LANDING

NAKANIHON AIR SERVICE CO., LTD.

FUJI-BELL 204 B-2 (ROTORCRAFT), JA9383

TAKAOKA OPERATION SITE, FUKUSAKI-CHO,

KANZAKI-COUNTY, HYOGO PREFECTURE

AT ABOUT 09:30 JST, JUNE 29, 2020

March 7, 2025

Adopted by the Japan Transport Safety Board

Chairperson	TAKEDA Nobuo
Member	TAKANO Shigeru
Member	MARUI Yuichi
Member	SODA Hisako
Member	TSUDA Hiroka
Member	MATSUI Yuko

1. PROCESS AND PROGRESS OF THE AIRCRAFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident	On Monday, June 29, 2020, a Fuji-Bell 204B-2, JA9383, operated by Nakanihon Air Co., Ltd., took off from Nara Prefecture Heliport for a ferry flight, and experienced a hard landing when landing at Takaoka operation site in Fukusaki-cho, Kanzaki-county, Hyogo Prefecture, as the engine power suddenly decreased, resulting in a hard landing and damage to the helicopter.
1.2 Outline of the Accident Investigation	On June 30, 2020, the Japan Transport Safety Board (JTSB) upon receiving a report of the aircraft accident, designated an investigator-in-charge and an investigator to investigate the accident. An accredited representative and advisor from the United States of America, as the State of Design and Manufacturer of the helicopter involved in the accident, an accredited representative and advisor from Canada, as the State that maintained the engine, participated in the investigation. Comments on the draft Final Report were invited from the parties relevant to the cause of the accident and Relevant States.

2. FACTUAL INFORMATION

2.1 History of the Flight	According to the flight plan of the helicopter and the statements of the pilot and the mechanic, the history of the flight was summarized as follows:

On June 29, 2020, a Fuji-Bell 204B-2 aircraft, JA9383, operated by Nakanihon Air Co., Ltd., took off from Nara Prefecture Heliport at around 08:49 Japan Standard Time (JST: UTC + 9hrs, unless otherwise stated all times are indicated in JST on a 24-hour clock) and headed for Takaoka operation site (hereinafter referred to as "the Operation Site") for a ferry, with four people on board, including the pilot and three mechanics.

The helicopter passed 9 nm north of Osaka International Airport at a pressure altitude of about 2,000 ft, and as shown in Figure 1, gradually descended from the east side of the Operation Site to the north side, made a left turn, and approached from the west side. As shown in Figure 2, while approaching the Operation Site from the southwest at an altitude of about 40 ft above ground level, an engine abnormality was confirmed and a prompt landing attempt was made, resulting in a hard landing and damage to the aircraft.

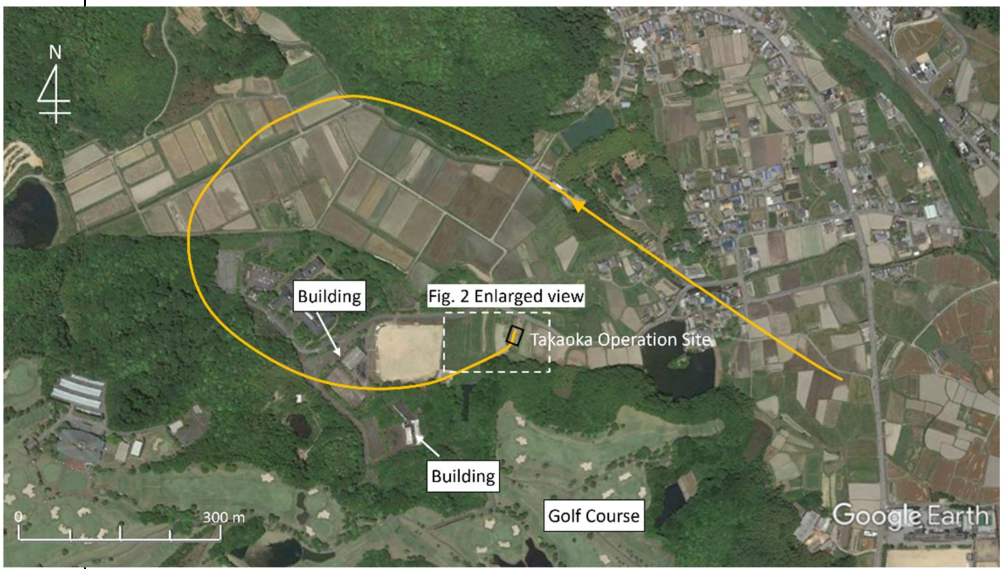

Figure 1: Estimated approach route of the helicopter

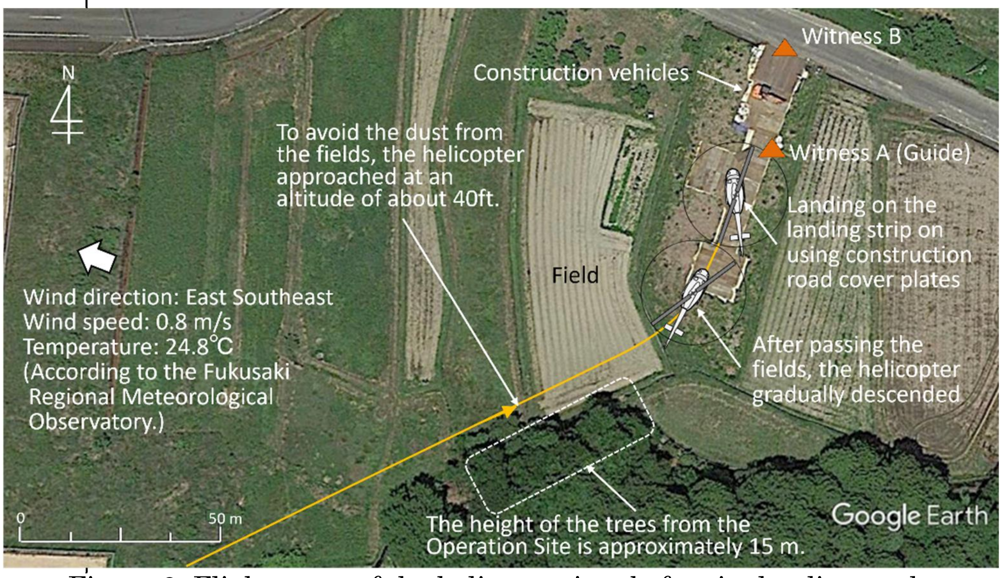

Figure 2: Flight route of the helicopter just before its landing at the Operation Site

(1) The pilot statement

	After taking off from Nara Prefecture Heliport, the helicopter passed north of Osaka International Airport and flew to over Fukusaki-cho at a pressure altitude of approximately 2,000 ft. There were no signs of engine abnormalities during the flight. The pilot sighted the Operation Site from above, made a left turn from the north, and began its approach from the southwest. It confirmed the presence of a ground guide about 200 to 150 m before the Operation Site, and seeing a dry field on the approach route, passed over the field at an altitude of approximately 40 ft above ground level to avoid stirring up dust caused by the downwash. Just before the helicopter was about to enter hover after aligning the nose towards the landing strip just before the planned landing point, a "Kyuin, Kyuin, Kyuin" sound started coming from the rear of the aircraft. As the pilot asked Mechanic A, who was sitting next to the pilot, what the sound was, mechanic A and the two mechanics sitting in the back seat, both heard a continuous "bang, bang, bang" sound from the rear, and Mechanic A advised the pilot that surging[*1] had occurred. After confirming that the torque meter was fluctuating between 20 and 40 psi, the pilot consulted with Mechanic A and decided to maintain attitude and land vertically. When the pilot lowered the collective pitch control[*2] (hereafter referred to as "collective"), the helicopter suddenly began to sink. The pilot tried to maintain the helicopter's attitude to avoid its rolling over. The pilot judged that the helicopter would be able to land safely at this descent speed, but the descent speed increased midway through the descending, and by the time the pilot realized it, the helicopter had already landed. When the helicopter landed, the engine was running and the "ENG CHIP DET" warning light[*3] was illuminated. After confirming that there was no engine fire, the pilot shut off the fuel and stopped the engine. (2) Mechanic statements (based on the statement of Mechanic A, with some additions from Mechanic B and Mechanic C) While trying to avoid standing trees, the helicopter approached at an altitude of about 12 m (40 ft) above the ground, and just before hovering at an altitude of about 7 to 8 m (25 ft) directly above the landing strip, a periodic "Kyuin, Kyuin, Kyuin" sound began to come from the rear of the helicopter. When the Mechanics tried to determine what it was, the sound changed to a continuous "bang, bang, bang." The Mechanic A confirmed that the torque meter was fluctuating between 20 and 40 psi and determined that it was engine surging. The Mechanic A informed the pilot that surging had occurred and recommended that the helicopter continue to land. After descending and touching down, the sound had changed to a "hyuun" sound. After closing off

*1 “Surging” refers to the phenomenon in which the air flow inside the engine becomes unstable, causing unstable operation (continuous abnormal noise, changes in engine speed, etc.) that affects not only the compressor but the entire engine. It occurs when the air flowing from the compressor to the combustion chamber becomes unstable or when the air flow is reversed due to damage to downstream of the combustion chamber.

*2 “Collective pitch control” is one of helicopter control devices that controls vertical movement by moving the lever up and down, to increases or decreases the thrust of the main rotor.

*3 “ENG CHIP DET” warning light is a warning device that uses a magnetic chip detector attached to the bottom of the engine to magnetically attract and detect metal filings contained in the oil returning to the engine and gearbox, and then lights up a warning panel in the cockpit.

the fuel and shutting down the engine, the Mechanic A noticed that the "ENG CHIP DET" warning light was on when the Mechanic A turned off the battery. Afterwards, the Mechanic A looked at the engine above and saw white smoke coming from near the engine compressor. The ELT (Emergency Location Transmitter) was also activated, so the Mechanic A shut it off.

(3) Video taken by Witness B

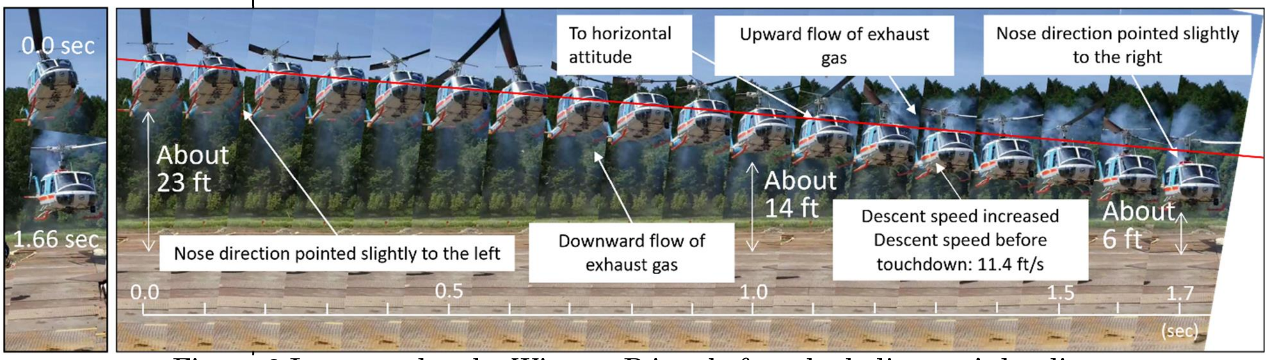

Figure 3 Images taken by Witness B just before the helicopter’s landing
(Comparison of sequential photographs)

Figure 3 shows a sequence of photographs clipped every 0.1 seconds from a 1.7 second video which was taken by Witness B, who was about 30 m north of the site where the helicopter touched down. The vertical height in the figure is the ground altitude during descent, estimated from the overall height of the helicopter.

The accident occurred at about 09:30 on June 29, 2020, in Takaoka, Fukusaki-cho, Kanzaki-county, Hyogo Prefecture (34° 57' 43” N, 134° 44' 10" E).

2.2 Injuries to Persons	None
2.3 Damage to the Aircraft	(1) Extent of Damage: Substantially damaged a Primary structural components of the lower fuselage were buckled (cross tube attachments and others). b The cross tubes of the landing gear (skid) had extended outward by approximately 10 cm. c The left and right steps attached to the landing gear were damaged and there were contact marks on the cross tube. d The speaker mounted in the centre of the forward cross tube had fallen and been damaged. e Upon receiving the impact of the ground, the ELT (Emergency Locator Transmitter) was activated (threshold 6-8G).

* Ground clearance when the helicopter is in a normal condition: Speaker 220mm, Front mirror 200mm (full fuel load)

Figure 4: Damage to the helicopter and its touchdown conditions

(2) Damage to the Exterior of the Engine (see Figure 5, for damage inside the engine, see the attached Appended Figure)

a There was no deformation or damage to the exterior of the engine.

b The exhaust duct was discolored, but there were no signs of impact.

c A large amount of engine oil was leaking into the bottom of the compressor.

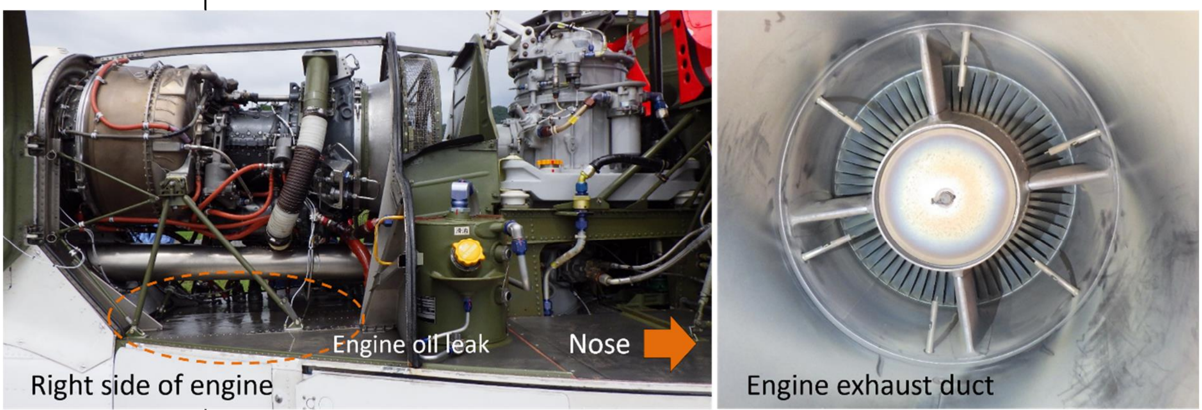

Figure 5: External engine damage

(3) Conditions around the accident site

Outside of the Operation Site, there were fields to the east and west of the site, and to the south was a small hill of woods. Construction vehicles were parked on the north side of the landing strip, and the landing strip was a take-off and landing area built with construction road surface covering plates.

2.4 Personnel Information	Pilot: Age 57 Commercial pilot certificate (rotorcraft) March 15, 1991 Pilot competency assessment/confirmation

	Expiration date of piloting capable period March 17, 2023 Type rating for land single-engine turbine March 15, 1991 Type rating for Fuji-Bell 204-B February 6, 2013 Class 1 aviation medical certificate Validity: April 2, 2021 Total flight time 15,565 hours 9 minutes Total flight time in the last 30 days 32 hours 47 minutes Flight time on the type of rotorcraft 497 hours 52 minutes Total flight time in the last 30 days 6 hours 24 minutes
2.5 Aircraft Information	(1) Aircraft Type: Fuji-Bell 204B-2 Serial Number:CH-54 Date of Manufacture: June 22, 1984 Airworthiness Certificate: No. Dai-2019-789 Validity: April 15, 2021 Total flight time: 11,156 hours 13 minutes (2) Engine Type: Textron Lycoming T5313B Serial number: LE-07213X Date of manufacture: May 27, 1969 Total time in service: 15,049 hours 21 minutes The total time since last overhaul (carried out on March 14, 2014): 1,931 hours 09 minutes The total time since periodic inspection (50 hours, carried out on May 30, 2020): 34 hours 39 minutes The total time since replacing No.1 bearing: 1,931 hours 09 minutes (3) When the accident occurred, the weight of the helicopter was estimated to have been 6982.4 lb, and that the position of center of gravity (CG) was estimated to have been at 129.5 in, both of which are estimated to have been within the allowable range (the maximum take-off weight of 8,500 lb and the CG range of 125.0 to 136.1 in corresponding to the weight at the time of the accident).
2.6 Meteorological Information	(1) Values Observed at the Regional Weather Station The weather observations at the Fukusaki Regional Meteorological Observatory Station, located about 2 km southeast of the accident site, around the time of the accident were as follows: 09:30 Wind direction: East-Southeast, Wind velocity: 0.8 m/s Temperature: 24.8°C Sunshine duration: 10 minutes Precipitation: 0.0 mm (2) Statements of the Pilot and Witness A The wind was almost calm.
2.7 Teardown Investigation of the Engine and Maintenance Information	(1) Overview of Engine Damage In order to make a detailed examination for causes of the engine's power loss the disassembly investigation of the engine was performed. Under the witness of an accredited representative of the United States of America, the investigations were performed in the facility of the design and manufacturer company. The summary of the result was as follow:

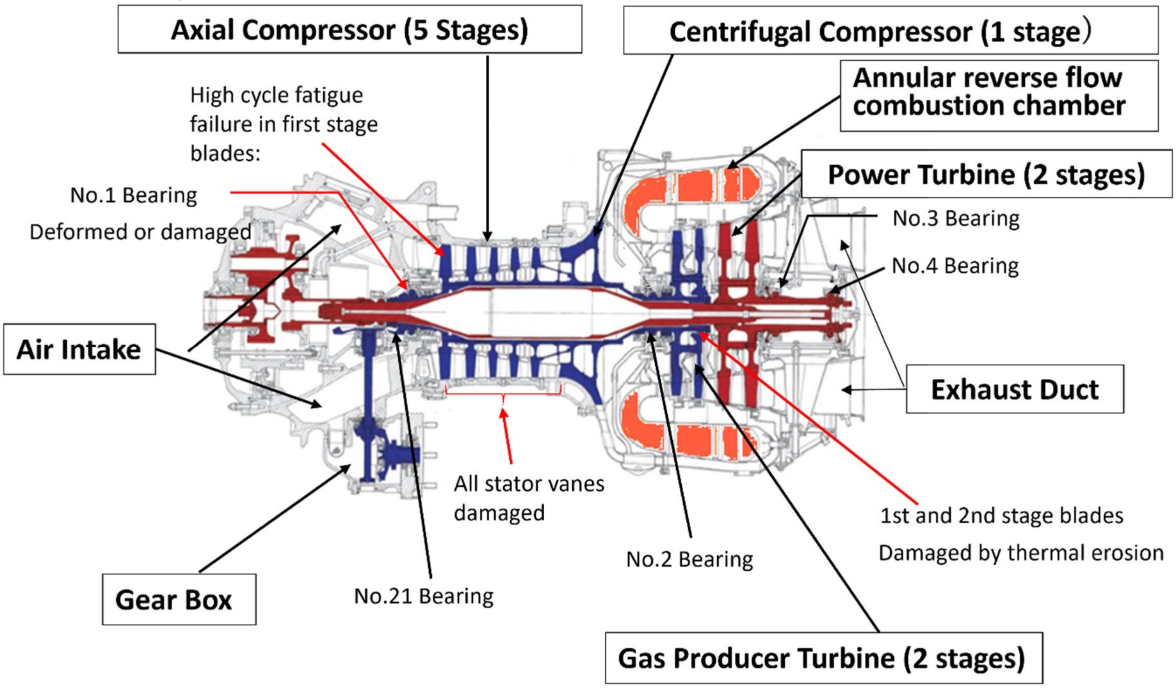

Figure 6: Engine structure and damaged areas

a. Axial compressor (Appended Figure A)

(a) First stage blades:

a) One blade was fractured near the blade platform while all the remaining blades exhibited a combination impact damage, missing material, bent airfoils in the direction opposite of rotation, and blade tip rub and roll-over. No cracks were found in any other compressor blade. (Appended Figures B)

b) Fracture surface of the broken blade (Appended Figure C)

- The fracture surface of the broken blade had a flat appearance, from the leading edge to the mid-chord of the blade, beach marks indicating high cycle fatigue failure were observed. (Yellow arrows and dotted lines).
- From mid-chord to the trailing edge, there were ductile dimples indicating eventual overload delamination, and shear failure (green arrows) was observed.
- The fracture characteristics of the blade fracture surface, there were dents observed at the front blade leading edge, were indicative of high cycle fatigue originating from subsurface damage at the leading edge (red arrow).

(b) Blades downstream from the second stage blades: There were deformation and contact marks.

(c) Stator vanes: There were deformation and contact marks.

b. Centrifugal compressor (Appended Figure D)

(a) All the impeller blades were intact.

(b) There were exhibited rub/scoring along the tops of the impeller airfoils.

(c) The impeller shroud had areas of scratches, material transfer and thermal damage consistent with contact with the impeller.

c. Gas producer turbine (Appended Figure E)

(a) The first and second stage blades all exhibited the same characteristics, including thermal distress with material tip loss and erosion.

(b) The first and second stage nozzle guide vanes exhibited material loss and heat damage, as did the blades.

d. Power turbine (Appended Figure F)

(a) The first stage nozzle guide vane airfoil was present and covered with material deposits. The leading edge showed heat damage and the trailing edge had impact damage and some missing material.

(b) The annular plates, including the inner and outer combustion liners and the conical swirl plate, were intact and showed no signs of seizure or thermal damage.

e. No. 1 bearing (Appended Figure G)

(a) All ball bearings were within their cages. Several of the roller ball elements were no longer round and exhibited a combination of thermal distress, material loss, flat spots, or smeared material consistent with skidding [*4]damage.

(b) There was no damage to the bearing cage.

(c) There was no damage to the front side of the inner race.

(d) The rear side of the inner race exhibited smearing, material transfer, raised metal around the edges, and bluing consistent with thermal distress.

f. No.2 bearing (Attached Figure H)

(a) All roller bearings were oil wetted, appeared undamaged, and the bearing rotated freely by hand.

(b) All of the roller bearings were covered in debris and had a dark black appearance.

g. No.21 bearing (Attached Figure I)

The roller bearing was shiny, oil wetted and spun freely in the bearing support housing.

h. Engine lubrication system (Appended Figure J)

(a) The magnetic chip detector detected metal particles on the tip of the plug that were ferrous, but did not detect any materials than those engine related.

(b) The red button on the oil filter bypass indicator did not pop out and did not indicate a higher than normal pressure differential.

(c) Metal particles were found on the mesh screen of the oil filter.

(2) Engine Maintenance Status

a. Operating time of each engine part

The overhaul interval for the same type of engine involved in the

[*4] “Skid” is a condition where a part that is intended to rotate or roll instead slips entirely without rotation.

	accident is 3,500 hours, and the inspection interval was observed. In addition, although there is no limit on the number 1 bearing's service time, it had been replaced during the previous overhaul in accordance with the relevant technical bulletin (T5313B-0179 R0 Improved No.1 & No.4 Bearing, 26 Sep 2011). b. Checking the magnetic chip detector plug The magnetic chip detector plug is required to be checked for foreign objects before the first flight of the flight day. On the day of the flight, the checking was carried out before take-off from the Nara Prefecture Heliport, and it was confirmed that no foreign objects were present. In addition, when checking the history of when the "ENG CHIP DET" warning light was turned on, a thin metal piece approximately 7 mm long was detected on November 12, 2019 (approximately 125 flight hours ago). In accordance with the maintenance procedure, the company inspected the magnetic chip detector plug, changed the engine oil, and inspected the filter, then conducted a ground test run and a hovering inspection, confirmed that there were no abnormalities, and then continued normal operations. Although images of the detected metal piece were kept, because the quantity and size were within the allowable limits, it was disposed of without being subjected to material analysis.
2.8 Additional Information	(1) Touchdown Procedure when Engine Power Drops during Hover The touchdown procedure when engine power drops during hovering, as occurred in this accident, is the same as the touchdown procedure for an autorotation landing as specified in the emergency procedure, and is stipulated in the flight manual for the Fuji-Bell 204B-2 as follows: Emergency procedures for touchdown during autorotation landing *At about 4 feet above surface, increase collective pitch to cushion landing.* (2) Design Loads for Landing Gear Structural Members The skid landing gear (Figure 7, left) cushions the impact load by elastic deformation of the cross tube during normal landing, and absorbs the impact energy by plastic deformation of the cross tube during violent impacts such as hard landings. As a crashworthiness design to increase the survival rate of crew and passengers, the underfloor structure is designed with thin, strong parts and thick parts that collapse and absorb energy, and the beams in the strong parts protect the cockpit and passenger cabin. In addition, the seats are equipped with a device called a load limiter which deforms at a certain load.

In this accident, the cross tubes had undergone plastic deformation, and the passenger compartment floor above the forward cross tube had deformed upwards, so a calculation of the estimated destruction load was made by the design and manufacturer company (Evaluation location: Figure 7, right).

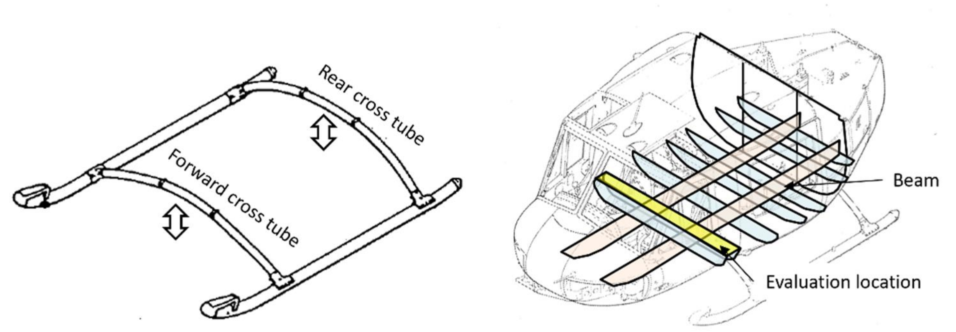

Figure 7: Deformation of cross tube and evaluation location of structural members

a. Total estimated loads acting on the evaluation location: 7,754 lb.

b. Maximum design load on forward cross tube: 6,416 lb.

(Descent rate for maximum design load calculation: 10.22 ft/s, from 204B strength calculation data)

(3) Similar Defects

Fuji-Bell 204B-2 model is a general-purpose helicopter of which over 10,000 have been produced worldwide, including its successor models. According to the helicopter manufacturer, there have been no reports of engine failures due to surging resulting in a loss of engine power.

3.ANALYSIS

(1) Engine Damage Analysis

The JTSB concludes as follows regarding “Engine Damage Analysis”.

Based on the crew's statements that surging occurred first, the internal structure of the engine, and damage conditions, it is more likely that the following two cases are possible as an abnormal symptom of the engine.

a. Case 1: No. 1 bearing fails first

(a) First, the No. 1 bearing failed, causing an imbalance in the rotating shaft of the axial compressor.

(b) The first stage blades of the axial compressor came into contact with the stator vane, causing surging accompanied by a periodic abnormal noise of "kyuin, kyuin, kyuin."

(c) Due to high cycle fatigue failure, the first stage blades broke off and, as they shattered, collided with the blades and stator inside the compressor, producing a continuous "bang, bang, bang" noise.

(d) Pressure fluctuations (surges) inside the compressor resulted in airflow disruptions resulting in higher temperatures in the gas producer turbine. These higher temperatures caused airfoil thermal damage and erosion resulting in a reduction in engine power.

b. Case 2: Fatigue failure of the first stage blades of an axial compressor occurs first.

(a) One of the first stage blades was found to have a pre-exiting fatigue crack. The crack grew from subsurface damage associate with a surface dent. The source of the surface damage could not be identified. The crack grew, became unstable, and contacted the stator vane, causing surging accompanied by a cyclical "kyuin, kyuin, kyuin" noise.

(b) The subsequent released one of the first stage blade caused downstream damage resulting in a compressor rotator imbalance and compressor surges accompanied by a continuous “bang, bang, bang” sound.

(c) An imbalance occurred in the axial compressor, causing damage to the No. 1 bearing.

(d) Pressure fluctuations (surges) inside the compressor resulted in airflow disruptions resulting in higher temperatures in the gas producer turbine. These higher temperatures caused airfoil thermal damage and erosion resulting in a reduction in engine power.

The engine failure in this accident is considered to have been one of the two cases above, with the majority similar failures to Case 1. Bearings are generally designed to be very robust and can withstand higher than normal loads for a short period of time before starting to fail. It is also known that bearing failures occur when foreign matter such as metal particles or contamination is present causing the rolling elements to skid instead of rotating. Skidding of the rolling bearing elements create high temperatures that damage the bearing. In this accident, because of the short time between the onset of the surge and the drop in engine power, it was unlikely that the No. 1 bearing would have been damaged in a manner similar to Case 2, failure of the No. 1 bearing following a compressor blade failure and release. It is more likely that, as in Case 1, a failure of the No. 1 bearing first, leading to a compressor blade release and subsequent surges resulting in a loss of engine power, but it was not possible to determine which was the cause. The metal fragment detected 125 flight hours earlier had been disposed of, so its relevance to this incident could not be confirmed.

(2) The Pilot's Control Operations During Landing

The JTSB concludes as follows regarding “the Pilot's Control Operations During Landing.”

The sequence of photographs in Figure 3 shows that the descent rate was roughly constant from the start of shooting until 0.9 seconds later, and then increased from 1.0 second later due to a decrease in engine power, but the helicopter was operated to maintain the attitude horizontal. In addition, the nose of the helicopter, which was turning to the left at the start of the video, was turned back to the right, there was no sideslip, and the helicopter was basically descending vertically. Therefore, it is probable that the cyclic[*5] and rudder pedals were operated appropriately, allowing the helicopter to land vertically without rolling over. According to the pilot's statement, no collective was operated at the time of touchdown, so it is probable that the descent rate did not decrease just before touchdown. However, as the helicopter touched down without skidding, it is probable that it did not roll over and only the helicopter was damaged.

According to the flight manual, in order to minimize landing loads, it is necessary to operate the collective upward to cushion the landing at an altitude of about 4 ft just before touchdown. However, if the descent speed increases, this becomes an extremely difficult operation, so it is important to prioritize attitude control.

(3) Analysis of Aircraft Damage During Landing

The JTSB concludes as follows regarding “Analysis of Aircraft Damage During Landing.”

The reason for the damage to the helicopter upon landing is that, as the load on the cross tubes of the landing gear system were transmitted to the helicopter 's structural members (main beams), it is probable that a destructive load of 7,754 lb or more was applied to the landing gear forward cross tube, exceeding the maximum design load of 6,416 lb (assumed vertical descent speed

*5 “Cyclic” is an abbreviation for cyclic pitch control and is one of the control devices used in helicopters. It is a device that is mainly operated to the direction to tilt the helicopter's attitude to control it.

of 10.22 ft/s) as calculated by the design and manufacturer. In addition, the descent speed just before touchdown, calculated from the sequence of photographs in Figure 3, was 11.4 ft/s, which exceeded the vertical descent speed of 10.22 ft/s for the design load. Therefore, it is highly probable that a landing load exceeding the maximum design load was applied and the load was transferred from the forward cross tube to the bulkhead between the cockpit and the passenger cabin, resulting in a hard landing that caused destruction all the way down to the passenger cabin floor.

Regarding the hard landing, it is possible that the failure to raise the collective before touchdown, the heavy weight of the helicopter, reduced engine power which caused the rotor speed to decrease, and the fact that the landing strip was not pressurized but consisted of construction road cover plates, all contributed.

4. PROBABLE CAUSES

It is highly probable that in this accident, an engine surge occurred as the helicopter was approaching the Operation Site, causing a sudden drop in engine power during descent, and the helicopter touched down at a high rate of descent in excess of allowable rate, resulting in a hard landing and substantial damage to the helicopter.

The sudden drop in engine power is most likely due to the fatigue failure of some of the blades in the axial compressor, but with regard to the fatigue failure of the blades in the axial compressor, it was not possible to determine whether the malfunction of the No. 1 bearing occurred first or the fatigue failure of the blades.

5. SAFETY ACTIONS

5.1 Safety Actions Required	For single-engine helicopters, prompt landing operations are required, especially if engine failure occurs at low speed or while hovering. When landing, it is important to anticipate an increase in descent speed due to a reduction in engine power, prioritize attitude control to prevent the aircraft from rolling over on touching down, and it is important to raise the collective before touchdown as close as possible to the touchdown in order to reduce the touchdown speed.
5.2 Safety Actions Taken after the Accident	Following this accident, the company took the following measures to prevent recurrence: Helicopter operation staff were given an overview of the accident and were given a review of the flight manual. The company instructed that if any metal fragments were detected by the magnetic chip detector plug, the maintenance department shall take action in accordance with the maintenance procedure manual in coordination with the quality control department and retain any metal fragments detected, for example, by putting them into a plastic bag and taping the bag to the defect record sheet.

Appended Figure: Damage inside the engine

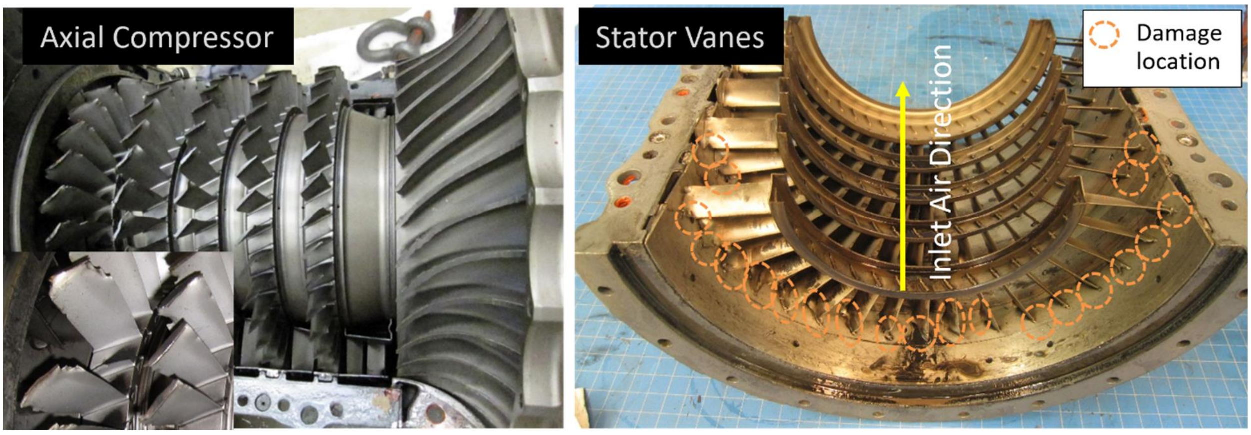

Figure A: Damage to axial compressor

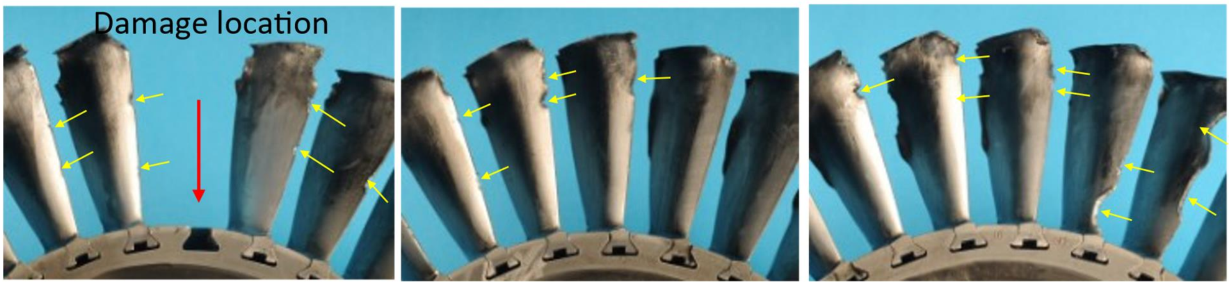

Figure B: Damage to the first stage blades of an axial compressor

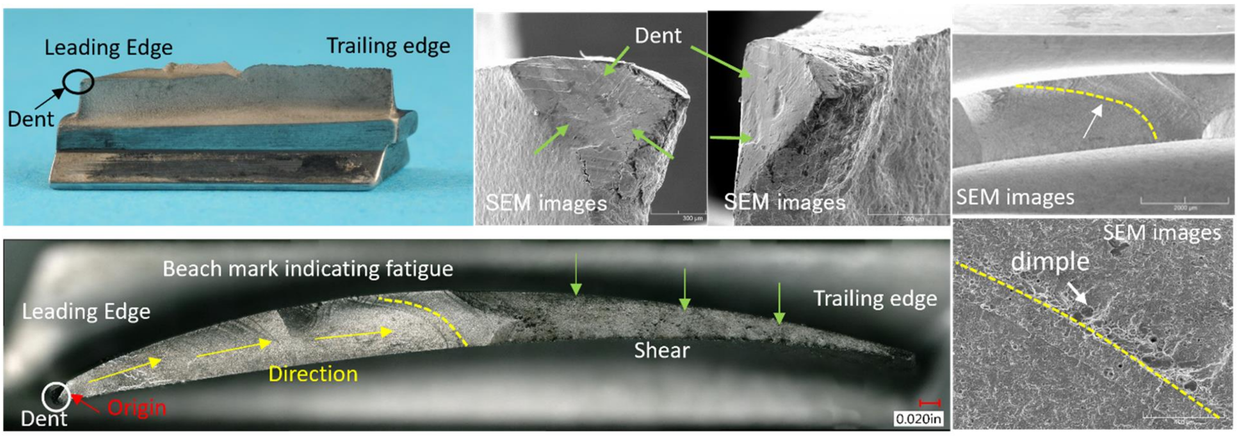

Figure C: Cross section of damaged area of first stage blades of axial compressor

Figure D: Scratch marks on a centrifugal compressor

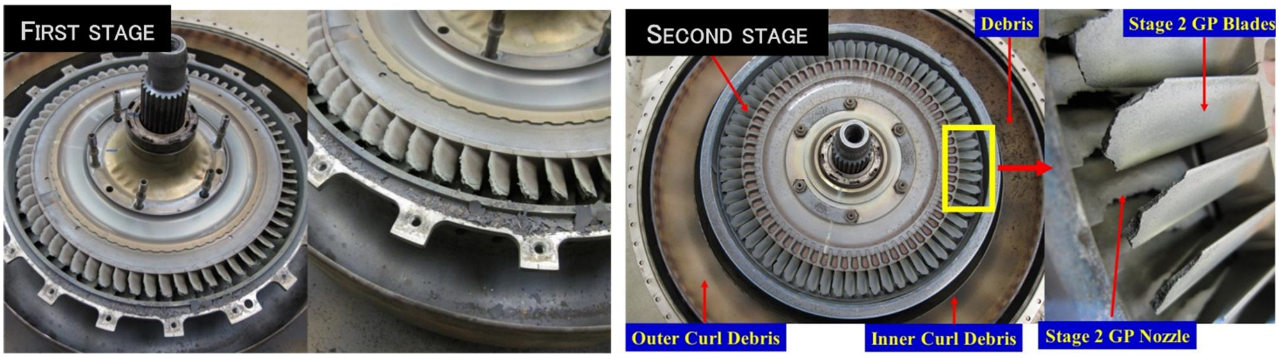

Figure E: Damage to Gas Producer Turbine

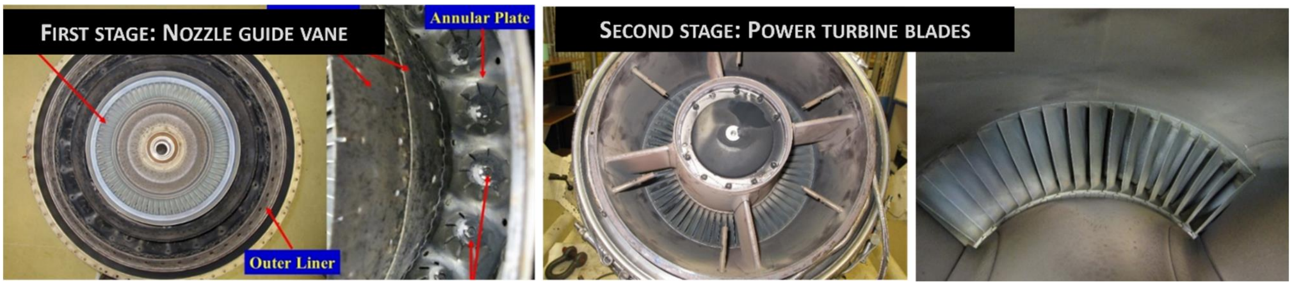

Figure F: Power Turbine Condition

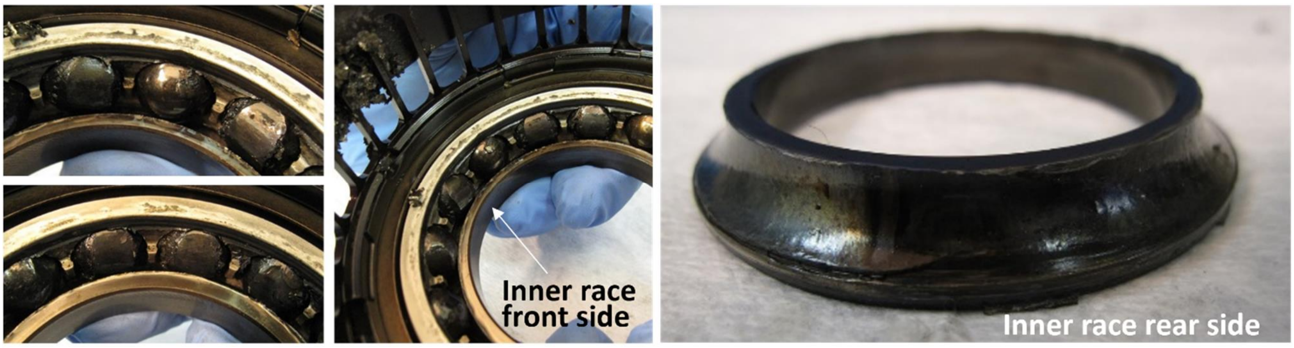

Figure G: Damage to No.1 Bearing

Figure H: No.2 Bearing condition

Figure I: No.21 Bearing condition

Figure J: Oil contamination status