AI2021-5

AIRCRAFT SERIOUS INCIDENT
INVESTIGATION REPORT

TOHO AIR SERVICE CO., LTD.
J A 6 6 9 7

May 27, 2021

JTSB 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 prevent future accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

TAKEDA Nobuo
Chairperson
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 SERIOUS INCIDENT INVESTIGATION REPORT

DAMAGE OF ENGINE
(LIMITED TO SUCH A CASE WHERE FRAGMENTS PENETRATED THE CASING OF SUBJECT ENGINE)
TOHO AIR SERVICE CO., LTD.
AEROSPATIAL AS355F2, JA6697
OVER AN AREA NEAR AIKAWA-CHO, AIKO-GUN, KANAGAWA PREFECTURE, JAPAN
AROUND 17:55 JST, JUNE 19, 2019

May 10, 2021
Adopted by the Japan Transport Safety Board
Chairperson TAKEDA Nobuo
Member MIYASHITA Toru
Member KAKISHIMA Yoshiko
Member MARUI Yuichi
Member NAKANISHI Miwa
Member TSUDA Hiroka

1. PROCESS AND PROGRESS OF THE INVESTIGATION

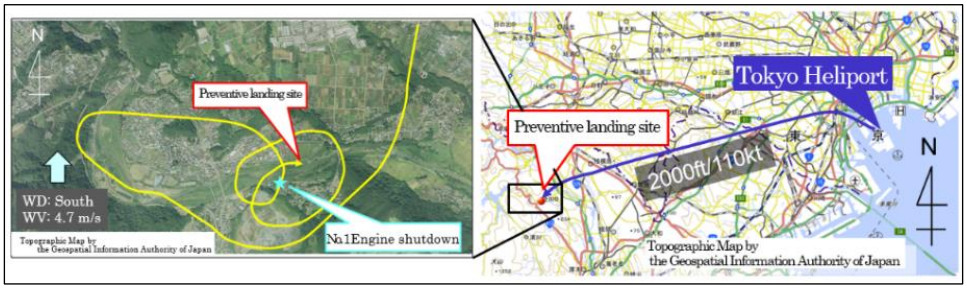
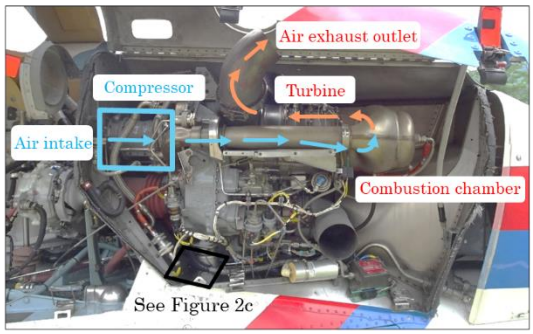
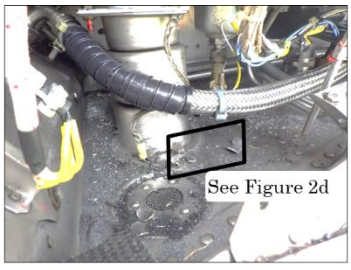
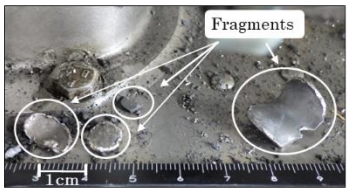
1.1 Summary of the Serious Incident	On Wednesday, June 19, 2019, an Aerospatial AS355F2, registered JA6697, operated by Toho Air Service Co., Ltd., took off from Tokyo Heliport for press and news coverage. While flying over an area near Aikawa-cho, Aiko-gun, Kanagawa Prefecture, the No.1 Engine (left engine) was shut down. The helicopter made a preventive landing on a riverbed of the Nakatsu River in Aikawa-cho. During an inspection after landing, it was confirmed that fragments of the No. 1 Engine penetrated the engine case.
1.2 Outline of the Serious Incident Investigation	The occurrence covered by this report falls under the category of "Damage of engine (limited to such a case where fragments penetrated the casing of subject engine)" as stipulated in Article 166-4, Item (vi) of the Ordinance for Enforcement of Civil Aeronautics Act (Ordinance of Ministry of Transport No. 56 of 1952) prior to revision by the Ministerial Ordinance on Partial Revision of the Ordinance for Enforcement of Civil Aeronautics Act (Ordinance of Ministry of Land, Infrastructure, Transport and Tourism No. 88 of 2020), and is classified as a serious incident. On June 20, 2019, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and two other investigators to investigate this serious incident. An accredited representative and an advisor of the French Republic, as the State of Design and Manufacture of the helicopter involved in the

	serious incident as well as an accredited representative and an advisor of the United States of America, as the State of Design and Manufacture of the engine involved in this serious incident, participated in the investigation. Comments were invited from parties relevant to the cause of this serious incident and the Relevant States.

2. FACTUAL INFORMATION

2.1 History of the Flight	According to the statements of the Pilot in Command (PIC) and records of the portable GPS that the PIC had brought in the cockpit, from the take-off from Tokyo Heliport to the serious incident, the history of the flight of JA6697 (hereinafter referred to as "the Helicopter") is summarized as below. Besides, according to the statements of the mechanic and the records in the flight logbook, there were no anomalies in the aircraft during the pre-flight inspection. At 17:35 Japan Standard Time (JST, UTC+9 hours, unless otherwise stated all times are indicated in JST on a 24-hour clock) on June 19, 2019, the Helicopter took off from Tokyo Heliport for press and news coverage, with a PIC sitting in the right seat, a mechanic engineer (in charge of keeping watch) in the left seat, and a passenger (press cameraperson) in the rear seat. After that, the Helicopter flew at an altitude of approximately 2,000 ft to the reporting location in Aikawa-cho, Aiko-gun, Kanagawa Prefecture. When the Helicopter was flying over the reporting location while maintaining an altitude of approximately 2,100 ft and a speed of about 60 kt, the live coverage started from 17:51. Around 17:55, when sensing a single boom erupted, the PIC felt a vibration and recognized that the "GEN caution light*1" and the "AUTO caution light *2" of the No.1 Engine (left engine) were turned on, and that the indicated value of N1 (the rotation speed of compressor and gas producer turbine) of the No. 1 Engine was zero. As judging that the No.1 Engine was shut down, the PIC conducted emergency procedures for a single engine failure during the flight as specified in the flight manual. Besides, as recognizing that the No. 2 Engine (right engine) power output was radically increased almost at the same time as No.1 Engine shut down, the PIC lowered the collective pitch lever so as not to exceed the operating limits.

*1 "GEN caution light" refers to the caution light of the generator driven by the engine, which is illuminated at the time of power voltage falls coupled with lowering of the engine rotation speed. In the flight manual, it is specified as one of signs of engine failure.
*2 "AUTO caution light" refers to the caution light indicating that the engine automatic rewriting system is activated. This system is a device to detect a power drop due to flame-out and automatically activate the exciter igniter for the power recovery.

	The PIC had been operating up to almost operating limits of the No.2 Engine power available, thus he judged that it would not be appropriate to continue a long-duration flight like this and decided to make a preventive landing at the site where the Helicopter would be able to land safely. After that, from nearby open areas, the PIC selected the site no one there and possible for the Helicopter to land in headwind, made a preventive landing on the riverbed of the Nakatsu River in Aikawa-cho (Latitude 35°31'34"N, Longitude 139°17'57"E) around 18:01.  Figure 1: Estimated flight route
2.2 Injuries to Persons	None
2.3 Damage to the Aircraft	(1) Extent of damage: Slightly damaged (a major damage occurred inside the engine) ① The No.1 Engine of the Helicopter (hereinafter referred to as "the Engine") There were no traces of absorbed birds or foreign objects on the metallic mesh cover installed on the front of the engine air intake and no anomalies such as damage, impurity and scratch marks observed on the intake air path from engine air intake to engine. Fragments of the stator vanes and blades of compressor were scattered inside the engine compartment. (See Figure 2) The engine cowl partially turned black in the interior areas.  Figure 2a The Helicopter exterior (Location of engine compartment)  Figure 2b Engine compartment interior (Engine cowl is opened)  Figure 2c Undersurface of engine compartment (fragments of blades etc. were scattered)  Figure 2d Fragments of (typical) blades penetrated the compressor case Figure 2: Fragments of the blades scattered inside the engine compartment

② The No. 2 Engine

There were no anomalies in appearance of the No.2 Engine.

There were no corrosion found in the compressor interior.

(2) The Engine interior damage

The Engine is turboshaft engine and consists of Compressor, Combustion Chamber, Turbines (Two-stage gas producer turbine and Two-stage power turbine).

Besides, the compressor is an axial centrifugal combined compressor that consists of six axial stages and a single centrifugal stages. The material of the rotor blades is stainless steel on whose surface aluminide coating is applied in order to prevent degradation of the base metal.

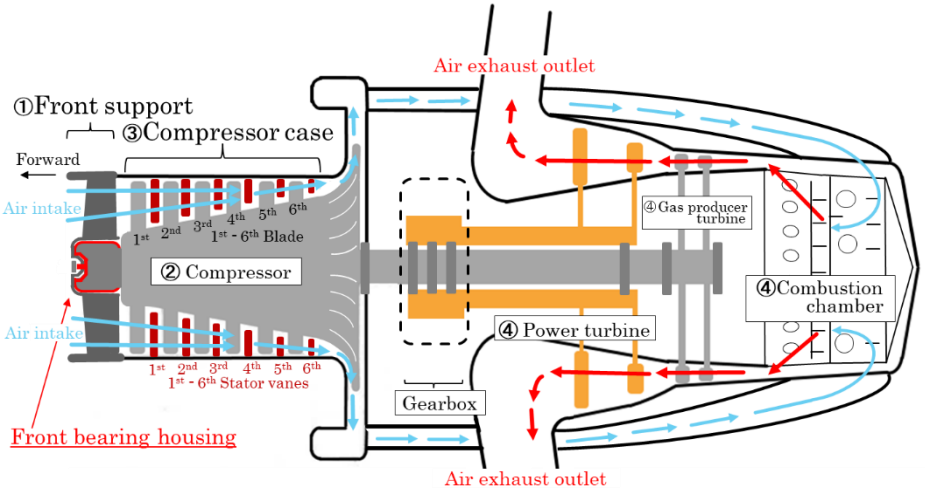


Figure3: Engine configuration

The teardown inspection of the engine revealed the following damage.

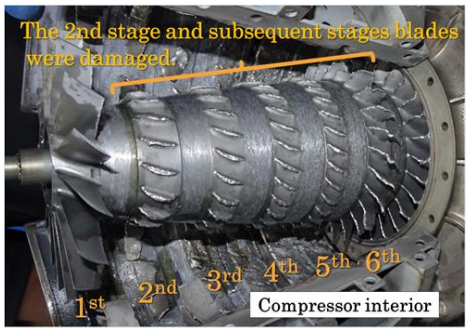
① Front support

The front support was deformed.

② Compressor

The 1st stage blades of compressor had no major damage, but the 2nd stage and subsequent stages blades, and stator vanes were remarkably damaged. (See Figure 4)

The 1st stage stator vanes in front of the 2nd stage blades were bent in the direction of rotation. (See Figure 5)



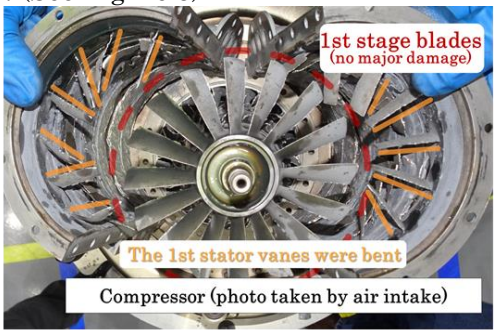


Figure 4: Compressor interior Figure 5: Leading edge of compressor

③ Compressor case

On the compressor case, there were 11 openings cracking toward the outside, and deformation and dents were observed all around. (See Figure 6)

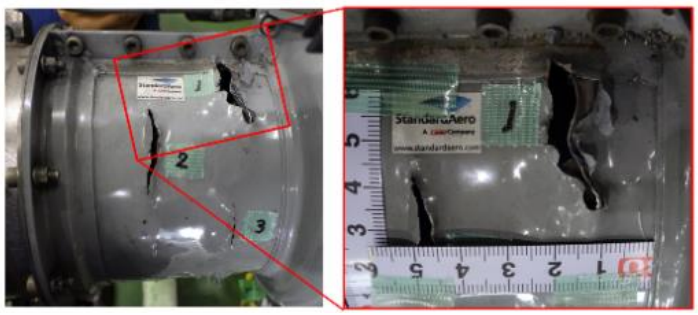


Figure 6: Compressor case

④ Combustion chamber, gas producer turbine, and power turbine

On the inner surface of the air duct from compressor to combustion chamber, there were scratch marks in the direction to the combustion chamber and dents.

In interior areas of the combustion chamber, gas producer turbine, and power turbine, there remained fragments of the compressor blades and stator vanes, and there were scratch marks in the direction to the exhaust outlet.

2.4 Personnel Information

PIC: age 56

Commercial pilot certificate (Rotorcraft)	March 24, 1989
Type rating for multi-engine turbine (land)	April 21, 1995
Specific pilot competence expiry of practicable period for flight	April 4, 2021
Class 1 aviation medical certificate	Validity: April 8, 2020
Total flight time	7,134 hours 02 minutes
Total flight time on the type of aircraft	475 hours 47 minutes
Flight time for the last 30 days	43 hours 56 minutes

2.5 Aircraft Information

(1) Aircraft

Type	Aerospatial AS355F
Serial number	5524
Date of manufacture	June 17, 1993
Certificate of airworthiness	No. TOU-30-507
	Validity: February 4, 2020
Category of airworthiness	Rotorcraft, Normal N or Special Aircraft X
Total flight time	4,751 hours 24 minutes

(2) Engines

Attached position	No. 1 (on the left)	No. 2 (on the right)
Type	Alison 250-C20F	
Serial number	CAE-840936	CAE-836327
Date of manufacture	November 15, 1989	March 13, 1989
Total time in service	3,650 hours 36 minutes	4,139 hours 07 minutes

	<table><tr><td>Engine compressor Total time in service (Total time since overhaul)</td><td>3,650 hours 36 minutes (276 hours 40 minutes)</td><td>4,139 hours 07 minutes (2,962 hours 27 minutes)</td></tr><tr><td>Total cycles in service</td><td>3,996</td><td>3,800</td></tr><tr><td>Engine compressor Total cycles in service (Total cycles since overhaul)</td><td>3,996 (268)</td><td>3,800 (2,600)</td></tr></table> (3) Weight and balance When this serious incident occurred, the helicopter's weight was estimated to have been 2,385 kg and the center of gravity (CG) was estimated to have been longitudinally 3.32 m aft of the datum (3.4 m forward from the center of the main rotor), and laterally roughly in the center of the airframe symmetry plane, both of which were estimated to have been within the allowable ranges (maximum take-off weight of 2,540 kg and the CG range for the weight at the time of the serious incident: longitudinally from 3.23 to 3.48 m aft of the datum and laterally from 0.16 m to the left to 0.09 m to the right).
2.6 Meteorological Information	(1) According to the statement of the PIC, the meteorological conditions in the vicinity of the serious incident site were as follows. Wind direction: South to southeast over the site, East around the preventive landing site, Wind velocity: 4 to 5 kt Visibility: 20 to 30 km, Weather: Cloudy, Temperature: 20 to 21 ℃ (2) The weather values observed by Aikawa-cho Fire Department Headquarters located about 2.2 km of the serious incident were as follows: 18:00 Weather: Fair, Wind direction: South, Average wind velocity: 4.7 m/s Maximum instantaneous wind velocity: 7.9 m/s, Temperature: 24.7 ℃, Precipitation: 0 mm
2.7 Additional Information	(1) History of the Engine According to the maintenance record of the Engine, before having been installed in the Helicopter, the Engine was installed as the No. 1 Engine in JA9647, which is another helicopter for press and news coverage, owned by the Operator. JA9647 was operated and based at the Helipad, located in the mountain areas about 10 km west of Sendai Airport in Miyagi Prefecture. In August 2017, it was observed that the stud for the front bearing housing (See Figure 3 and 7) of compressor was broken during the post-flight inspection, therefore, the Engine was removed from JA9647. After repair, in January 2019, the Engine was installed as the No. 1 engine in the Helicopter (JA6697). See the table below for details. The Helicopter was stationed at Tokyo Heliport located next to the Tokyo Bay, in Tokyo, and operated and based at the Heliport.

Confirmation date of the work	Total time in service	Details of work
April 9, 2015	3379:56	Overhaul was carried out at the engine repair facility.
April 25, 2015	3379:56	Installed in JA9647 (operated and based in Miyagi Prefecture).
August 8, 2017	3592:39	The Engine was removed because it was found that the stud was broken (Note 1).
September 22, 2017	3592:39	Repair work was carried out at the engine repair facility (Note 2). Stored in the Operator's hanger as a spare engine after repair.
January 25, 2019	3592:39	Installed in the Helicopter (operated and based in Tokyo).
June 19, 2019	3656:16	The aircraft serious incident occurred.

Note 1: A mechanic conducted an inspection on the front bearing housing of compressor and found that the stud of the housing was broken.

Note 2: During the teardown inspections of the compressor at the engine repair facility, it was found that the front bearing housing of the compressor was remarkably corroded centering on its stud, thus, it was replaced.

Figure 7: Corrosion on the front baring housing

Besides, the compressor blades were slightly damaged by the corrosion removable by cleaning, and the compressor case was damaged by the corrosion required to replace. According to each section in the Maintenance Manual of Design and Manufacture of the engine (hereinafter referred to as "the Engine Manual"), they were cleaned and replaced. In addition, inspections of every 300 flight hours or every 12 months, whichever occurs first, for the compressor case, blades and vanes was performed and it was confirmed that there were no other anomalies in the compressor.

(2) Operating environment of the Engine

According to the flight logbook and the operation services log, during the period between April 2015 and August 2017 when the Engine was installed in JA9647, and during the period between January and June 2019 when installed in the Helicopter (JA6697), there were no such records that the Engine was operated in special environment such as flying over the sea or getting close to volcano crater.

However, during the period between April 2015 and August 2017 when the Engine was installed in JA9647, JA9647 was stationed at Temporary Helipad located in the mountain areas about 10 km west of Sendai Airport in Miyagi Prefecture and performed a new coverage flight based at the Helipad, in addition, during the period from January to June 2019 when installed in the Helicopter, the Helicopter was stationed at Tokyo Heliport located next to the Tokyo Bay, in Tokyo, and operated based at the Heliport. In these cases, the helicopters flew over the land closed to the coast line, or flew over the sea during a short period for take-off and landing.

(3) Storage condition of the Engine

According to the storage record of the Engine and the statement of the mechanic, the Engine was transported from the engine repair facility to the hangar of the Operator in September 2017, and stored there as a spare engine until it was installed in the Helicopter as the No. 1 Engine in January 2019. During storage, it was stored according to the requirements specified in the Engine Manual, and there were no anomalies in the Engine condition during periodic inspections on its appearance and storage condition (environmental requirements and others).

(4) Engine's installation in the Helicopter

According to the flight logbook, the maintenance record and the statement of the mechanic, the Engine was installed in the Helicopter in January 2019 according to the Aircraft Maintenance Manual and the Engine Manual, after visual examination of the Engine was performed. At that time, there were no anomalies in the Engine condition.

(5) Instruction on compressor cleaning of Engine

① Compressor cleaning instructed by the Design and Manufacture of the Engine

The instruction in the Engine manual are as follows.

250–C20 SERIES OPERATION AND MAINTENANCE MANUAL

72-30-00 6. Compressor Cleaning

- Omitted –

WARNING: SALT LADEN HUMIDITY AND CHEMICALS WILL CORRODE COMPRESSOR BLADES AND VANES AND CAUSE THEM TO FAIL.

- Omitted –

(1) Compressor Contamination Removal

Engines subjected to salt water or other chemically laden atmosphere (including pesticides, herbicides, industrial pollutants, sulfur laden atmosphere, etc.) shall undergo water rinsing after shutdown following the last flight of the day. Perform the rinse operation as soon as practical after flight, but not before the engine has cooled to near ambient temperature.

NOTE: Operators should be aware that salt or chemically laden air may be encountered for 75–150 miles (121–241 km) from the

source under certain weather conditions. If there is any doubt about the condition in which your engines are operated, the compressors should be given a daily water rinse. Water will not damage the engine but salt and chemicals will.

② Compressor cleaning instructed by Airworthiness Directive of Japan

According to Service Bulletin SB-250-096C (issued in 1982 by the service center of Design and Manufacture of the engine) quoted in the Airworthiness Directive 1593-1-82 issued (on September 16, 1982) by the Civil Aviation Bureau of Japan, regardless of the descriptions in the Engine Manual, for engines subjected to salt water in flight over the sea etc., water rinsing shall be performed after the last flight of the day, and for engines in other cases, water rinsing and rinse operation shall be alternately performed earlier timing of either 15 days or 15 flight hours.

(6) Compressor cleaning performed by the Operator

With regard to engine compressors of the same type of helicopters, according to the Airworthiness Directive issued by the Civil Aviation Bureau of Japan, for engines subjected to salt water in flight over the sea etc., the Operator performed water rinsing, and performed water rinsing and rinse operation alternately for engines in other cases earlier timing of either 15 days or 15 flight hours.

As, the Helicopter and JA9647 were not operated in special environment such as flying over the sea (except flying over the sea during a short period for take-off and landing) and getting close to volcano crater, therefore, water rinsing and rinse operation were performed alternately earlier timing of either 15 days or 15 flight hours.

(7) The Engine inspections performed by the Operator

The Engine Manual contains a description of the instruction to perform inspections of the compressor case, rotor blades and stator vanes every 300 flight hours or every 12 months, whichever occurs first. And it recommended to use the 10 times magnifier in order to conduct the corrosion pit inspection when engines are operated under a corrosive environment.

According to the Maintenance Manual of the Operator, the flight logbook and the operation services log, the Engine was installed in the Helicopter in January 2019. When the serious incident occurred, five months had passed since its installation and the total flight hours were 63 hours 37 minutes (total flight hours since overhaul: 276 hours 20 minutes), and thus it had not reached the due date for the inspection. As a result, the above-mentioned inspection of compressor was not performed for the Engine.

(8) Teardown inspection of the Engine, detailed inspection of compressor

At the repair facility approved by the Design and Manufacture of the Engine, teardown inspection of the Engine was carried out, afterwards, at the facility of Design and Manufacture of the Engine, detailed inspection of compressor was conducted.

The results of those teardown inspection of the Engine and detailed inspection of compressor revealed that from the overall damage to the structure, the Engine was likely damaged due to fracture of the compressor's 2nd stage blades caused by corrosion developed on the compressor blades.

The blades, which were the starting point for the Engine damage, could not be identified due to the secondary damage to the Engine, however, a development of corrosion on leading edge of the 1st stage blades of compressor and fragments of other fractured blades were observed (See Figure 8 and 9).

Besides, there was no trace of the Engine damage inflicted by outside foreign objects.

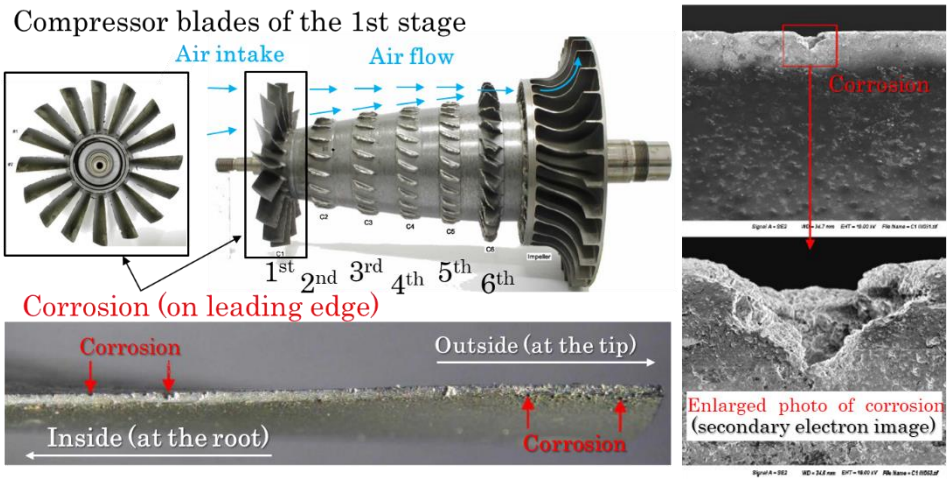


Figure 8: Corrosion developed on leading edge of the 1st stage blades of compressor

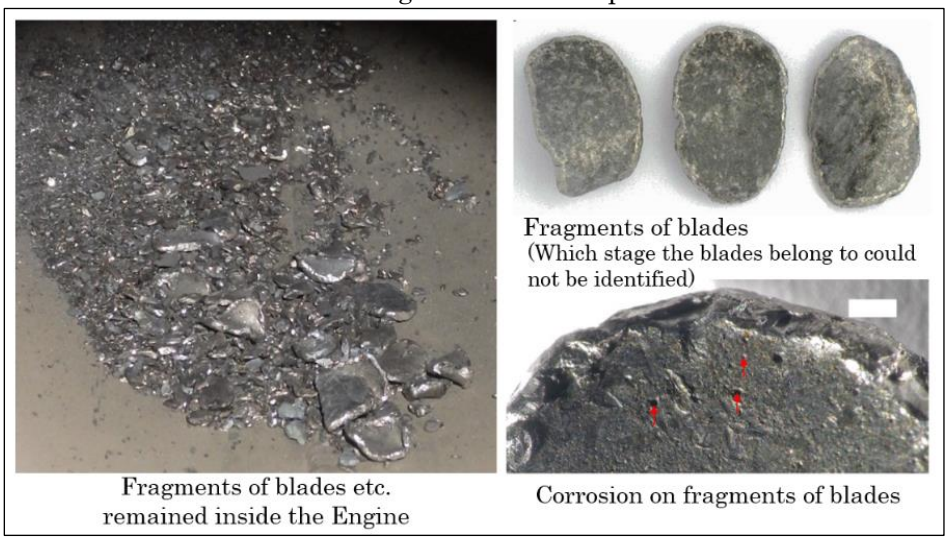


Figure 9: Corrosion on fragments of blades remained inside the Engine

	(9) Condition of the other Engine installed together with the Engine The No. 2 Engine of JA9647 was continuously operated without any special failures until it was removed in September 2017 because of having reached its service time limit, after it was confirmed that the stud for the front bearing housing of compressor of the Engine (No. 1 Engine) was broken in August 2017. The condition of the No. 2 Engine compressor could not be identified because it was disposed as having reached its service time limit. The No. 2 Engine of the Helicopter had been operated without any special failures until the serious incident occurred. In addition, after the serious incident, the compressor case, rotor blades and stator vanes were inspected as described in the Engine Manual, however, there was no corrosion observed. (10) Occurrence of similar incidents According to the Design and Manufacture of the Engine, with regard to the same type of engines, it was confirmed that there occurred four similar incidents (including this incident) where the compressors were damaged by corrosion in about 24,370,000 hours operation in the past 10 years.

3.1 Involvement of Weather	None
3.2 Involvement of Pilots	None
3.3 Involvement of Aircraft	Yes
3.4 Analysis of Findings	(1) Shutdown of the Engine According to the condition of damage to the Engine and the statement of the PIC, it is highly probable that after the engine was damaged and abnormal sound was produced, the Engine was shut down even though the PIC did not perform shutdown procedures. (2) The Engine interior damage The Engine interior damage was observed remarkably in the 2nd stage and subsequent stages blades of the Engine compressor (See Figure 4), therefore, it is highly probable that the fracture of the 2nd stage blades of compressor was the starting point of the damage occurred inside the Engine. (3) Fracture of the 2nd stage blades of compressor With regard to fracture of the 2nd stage blades of compressor, there were no traces of foreign objects ingested into the Engine, and a development of corrosion on leading edge of the 1st stage blades of compressor and fragments of other fractured blades was observed (See Figure 8 and 9), therefore, it is probable that the damage caused by corrosion reduced the robustness of the blades. However, the mechanism of corrosion developed in the 2nd stage blades

	of compressor and finally led to the fracture could not be clarified because the fracture origin of the Engine damage could not be identified due to the serious damage inside the compressor. (4) Corrosion environment of the Engine ① Operating environment of the Engine According to the history of the Engine, during the period between April 2015 and August 2017, the Engine was installed to be operated as the No. 1 Engine for JA9647 which was operated by the Operator and based in Miyagi Prefecture. And in August 2017, as the stud for the front bearing housing of compressor was broken, the Engine was removed from the airframe. On this occasion, at the engine repair facility, in addition to the remarkable corrosion developed centering around the stud for the front bearing housing, the corrosion on the compressor case were observed, therefore, they were replaced with new ones. (See Figure 7) Judging from above these, it is probable that the Engine was operated actually under a severely corrosive environment, although there were no such records that the Engine was operated in special environment such as flying over the sea and getting close to volcano crater while installed as the No. 1 Engine for JA9647. Besides, it is somewhat likely that this kind of corrosion was developed because it is not known that the Engine was operated under a severely corrosive environment, and because salt and chemicals were not removed by cleaning, therefore, it is probable that water rinsing for the compressors should have been performed properly even after the last flight of the day. ② Corrosion on the 2nd stage blades of compressor The Engine was transported from the engine repair facility to the hangar of the Operator in September 2017, and stored there as a spare engine until it was installed as the No. 1 Engine for the Helicopter in January 2019. When five months (approximately 64 flight hours) had passed since the Engine was installed as the No. 1 Engine for the Helicopter in January 2019, the Engine was damaged. As mentioned above, it is probable that the Engine was damaged due to fracture of the compressor's 2nd stage blades caused by corrosion developed on the compressor blades, however , no corrosion was observed on the compressor blades of the Helicopter's No.2 Engine that had been operated under the same maintenance and operating environment as the Engine. The corrosion on the 2nd stage blades of compressor was not developed after January 2019 when the Operator installed the Engine in the Helicopter, but remained there because it was not completely removed in September 2017 when the repair work for the compressor was conducted at the engine repair facility, in addition, the Engine store management by the Operator and water rinsing after installation in the Helicopter were not good enough, thus it is somewhat likely that all these things added up to the development of corrosion.

	(5) Importance of inspection and maintenance During storage of the Engine, the Operator performed periodic inspections on the appearance and storage condition (environmental requirements) of the engine in accordance with the requirements specified in the Engine Manual. In addition, when the Engine was installed in Helicopter, the Operator performed visual examination of the Engine in accordance with the Aircraft Maintenance Manual and the Engine Manual. However, in the investigation of the Engine compressor, corrosion was also found on the leading edge of the first stage compressor blade, which could be checked from the air intake without removing the compressor case. Therefore, it is somewhat likely that with a visual inspection focusing more on the corrosion on compressor blades, any corrosion on the leading edge could have been noticeable leading to the detection of any signs of corrosion etc. on the 2nd stage and subsequent stages blades by undertaking a further inspection. (See Figure 8). In case of observing corrosion so remarkable that the stud for the front bearing housing of compressor could be broken, it is important for the Operator to properly perform maintenance by fully considering that engines might have been exposed to a severely corrosive environment and carefully inspecting components subjected to corrosion during visual examination at the time of the engine storage management and installation, even if engines have been repaired at an engine repair facility. (6) Damage to compressor case On the compressor case there were 11 openings cracking toward the outside in the 2nd stage and subsequent stages of compressor, and deformation and dents were observed all around (See Figure 6). It is highly probable, therefore, that fracture of the 2nd stage blades was the starting point of the continuous damage to the subsequent stages blades and stator vanes etc., and those fragments penetrated the compressor case.

4. PROBABLE CAUSES

It is highly probable that fracture of the 2nd stage blades of the Engine (left engine) compressor during the flight, which resulted in damage to the subsequent stages blades and stator vanes etc., and those fragments penetrated the compressor case.

It is probable that fracture of the 2nd stage blades of compressor was caused by damage due to corrosion, which reduced the robustness of the blades.

5. SAFETY ACTIONS

Safety actions taken by the Operator

On June 20, 2019, the Operator decided to conduct occasional inspections for the same type of helicopters in operation as temporary safety actions for this serious incident, and confirmed there were no anomalies in the overall airframes and engines.