

AI2018-7

**AIRCRAFT SERIOUS INCIDENT
INVESTIGATION REPORT**

**KLM ROYAL DUTCH AIRLINES
P H - B Q C**

November 29, 2018

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.

Kazuhiro Nakahashi
Chairman
Japan Transport Safety Board

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

PARTS DROPPED FROM AIRCRAFT COLLIDED WITH A VEHICLE ON THE GROUND AT OSAKA CITY, OSAKA, JAPAN AT AROUND 10:57 JST, SEPTEMBER 23, 2017

KLM ROYAL DUTCH AIRLINES BOEING 777-200, PH-BQC

October 26, 2018

Adopted by the Japan Transport Safety Board

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

1. PROCESS AND PROGRESS OF INVESTIGATION

1.1 Summary of the Serious Incident	<p>On Saturday, September 23, 2017 a Boeing 777-200, registered PH-BQC, and operated by KLM Royal Dutch Airline, took off from Kansai International Airport for Amsterdam Schiphol International Airport on a scheduled Flight 868 of the Operator. A right aft wing-to-body fairing panel was dropped from the aircraft climbing while accelerating over Osaka city. The dropped fairing panel collided with a vehicle driving on a road in Kita-ku, Osaka City.</p>
1.2 Outline of the Serious Incident Investigation	<p>This event falls under the case equivalent Item (xvii) corresponds to “Case where parts dropped from aircraft collided with one or more persons” as stipulated in Item (xvi), Article 166-4 of the Ordinance for Enforcement of the Civil Aeronautics Act (Ordinance of the Ministry of Transport of Japan No. 56 1952) (Item (xvii) of the same Article), and is therefore classified as an aircraft serious incident. The Japan Transport Safety Board designated an investigator-in-charge and an investigator on September 24, 2017 to investigate this serious incident.</p> <p>An accredited representative of the Kingdom of the Netherlands, as the State of Registry and State of Operator, and an accredited representative of the United States of America, as the State of Design and Manufacture of the aircraft involved in this incident, participated in this investigation.</p> <p>On November 8, 2017, factual information on the conditions of the panel that fell as well as the attaching bolts and screws that were obtained from a</p>

fact-finding investigation were submitted to the Civil Aviation Bureau.

Comments were invited from parties relevant to the cause of this incident and the Relevant State.

2. FACTUAL INFORMATION

2.1 History of the Flight

According to the statements of the captain, relevant parties of KLM Royal Dutch Airline (hereinafter referred to as "the Operator"), and the records of the flight data, the history of the flight up to the serious incident is summarized as below.

On September 23, 2017, at about 10:39 Japan Standard Time (JST: UTC+9hrs, unless otherwise stated all time are indicated in JST on a 24-hour clock), a Boeing 777-200, registered PH-BQC, and operated by KLM Royal Dutch Airline, took off from Kansai International Airport for Amsterdam Schiphol International Airport (hereinafter referred to as "the Airport") on a scheduled Flight 868 of the Operator with 321 people on board, consisting of the Captain, eleven other crew members, and 309 passengers. At about 10:57, a panel assumed to belong to the Aircraft fell from the sky and struck a vehicle that was running in Kita-ku, Osaka City.

At around 12:55, the Operator's Kansai Airport branch obtained photographic information on the fallen panel from the police and immediately sent it to the Operator's head office.

At about 14:27, the Operator head office's Operations Control Center (hereinafter referred to as "OCC") informed the crew by ACARS that a fuselage panel may have fallen off. After receiving this information, the Captain contacted OCC by conference call and obtained information that a panel bearing the Operator's paint scheme (hereinafter referred to as "the Panel") had struck a vehicle that was running in Osaka City. The Captain checked the cabin pressurization, flight control system, fuel system and consumption, and others, and instructed the Senior Purser and the Cruise Relief Pilot to check for abnormal noise, vibrations, and others, emanating from the area where the Panel was attached. Because no abnormalities to the aircraft were observed as a result of these checks, the Captain judged that the situation was not one that required emergency action, decided to continue the flight to the Airport, and waited for more detailed information from OCC and the Aircraft's manufacturer.

From the obtained photographic information, the Operator's head office Maintenance Control Center (hereinafter referred to as "MCC") identified the Panel as Panel 198AR, which is a right aft wing-to-body fairing. MCC contacted the Aircraft's manufacturer in order to make a decision on whether safe flight was possible. According to the Aircraft's manufacturer, incidents in which the similar panel departed several times among operators of the same type of aircraft, and in all of those cases, there was no effect on other surrounding panels or the aircraft's structure after the panel fell. OCC communicated this information to the Crew and conducted a discussion on continuing the flight with the Captain

At about 15:46, as a result of the discussion, the Captain made a final

decision to continue the flight to the Airport.

After the aircraft landed at the airport at about 21:38, a mechanic of the Operator confirmed that the right aft wing-to-body fairing panel (Panel 198AR) was missing from the Aircraft.

This serious incident occurred around 10:57 on September 23, 2017, above National Route 1 in Nishitenma 3-chome, Kita-ku, Osaka City (Latitude 34° 41' 51" N, Longitude 135° 30' 27" E).

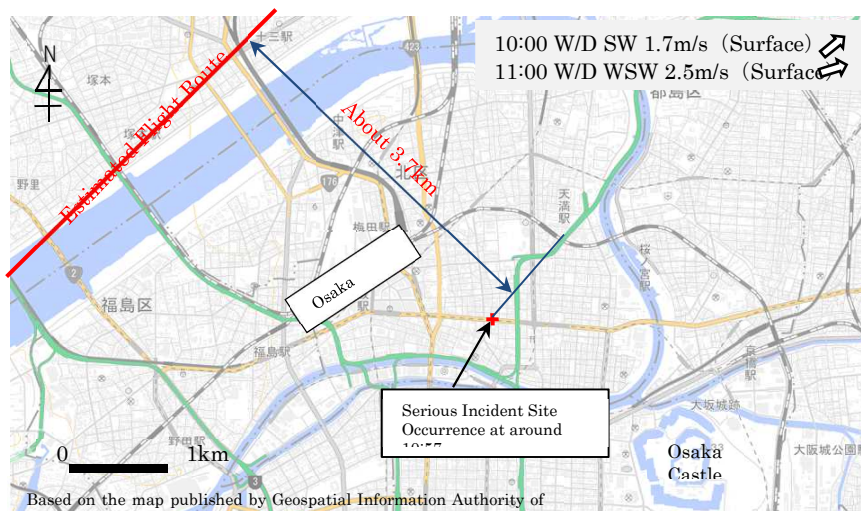
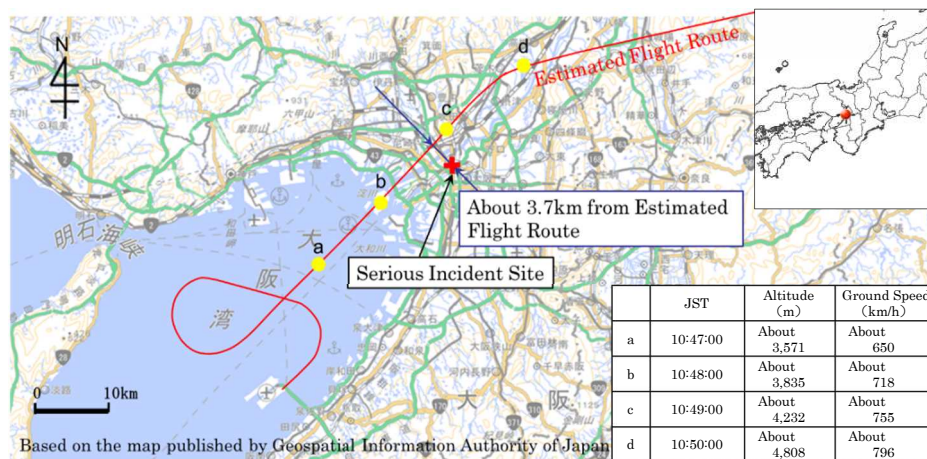



Figure 1 Estimated Flight Route & Serious Incident



Figure 2 Location of the Serious Incident

2.2 Injuries to Persons	None
2.3 Damage to Aircraft and Vehicle	<p>(1) Extent of Damage: Slightly damaged (Appendix Figure 1-2)</p> <ol style="list-style-type: none"> 1) Panel 198AR detached and missing from aircraft. 2) The bracket that fixes Panel 198AR in place was cracked. 3) The bolt and screw holes of Panel 198AR were damaged. 4) The mounting screws were broken. <p>(2) Damage of the vehicle</p> <ol style="list-style-type: none"> 1) The roof was dented. 2) The right-side rear window was broken. <div style="text-align: center;">  <p>Photo 1 Damage of the vehicle</p> </div>
2.4 Personnel Information	<p>(1) Captain Airline transport pilot certificate (Airplane) Type rating for Boeing 777 Total flight time 18,042 hours 16 minutes Total flight time on the type of aircraft 7,509 hours 16 minutes Flight time in the last 30 days on the type of aircraft 81 hours 16 minutes</p> <p>(2) First Officer Airline transport pilot certificate (Airplane) Type rating for Boeing 777 Total flight time 11,975 hours 16 minutes Total flight time on the type of aircraft 7,815 hours 16 minutes Flight time in the last 30 days on the type of aircraft 53 hours 51 minutes</p>
2.5 Aircraft Information	<p>(1) Type: Boeing 777-200 Serial number: 29397, Date of manufacture: November 24, 2003 Certificate of airworthiness: No. 63478 Validity: November 6, 2017 Total flight time: 74,891 hours 45 minutes Flight cycle: 8,738 Line number: 461</p>
2.6 Meteorological Information	<p>Observations at Osaka District Meteorological Observatory (Approximately 2 km northeast of the serious incident site, ground observations)</p> <p>10:00 Southwesterly wind at 1.7m/s, Temperature 24.1 °C 11:00 West-Southwesterly wind at 2.5 m/s, Temperature 24.0 °C</p>
2.7 Additional Information	<p>(1) General Description of the Fallen Panel The Panel had a honeycomb sandwich structure made of glass-fiber-reinforced plastic that comprises a corner of a fairing for rectifying at the wing-to-body connection of the right wing. The part number 149W5242-2 was</p>

mounted on the right-hand side of the fuselage. The panel number was 198AR. The location where it was attached to the Aircraft can be easily identified from the panel number. The Panel can be removed in maintenance work when conducting a structural examination of the aircraft. The Panel's dimensions and weight are shown in Photo 2.

(2) Method of Fixing the Panel in Place and Conditions

The Panel is secured to the Aircraft with seven screws (S1 to S7 in Photo 2) and thirty bolts (B1 to B30 in Photo 2).

Limited space between the fuselage and the panel's forward upper corner (between S7 and B5 in Photo 2) precludes attachment of the panel by the use of fasteners in this area. Instead the panel is attached to a forward upper bracket (hereinafter referred to as "the Bracket"). This bracket provides support for the forward upper corner and allows the panel to be mounted under certain preload, so that the panel smoothly lines up with the surrounding panels.

The aircraft examination revealed that all of the seven screws remained on the aircraft side. Of them, the heads of two (S6 and S7 in Photo 2) were broken.

Regarding the bolts, 26 bolts remained on the aircraft side and three bolts (B1, B2, and B4 in Photo 2) on the Panel side remained. One bolt (B3 of Photo 2) was not there.

Regarding the part numbers of the aforementioned seven screws and 29 bolts, it was found in a cross-check with the parts table of the AIPC that the proper parts were used for all of the screws. However, regarding the bolts, five bolts with parts number BACB30XD3K5 (hereinafter referred to as "the Improper Bolt") were used where parts number BACB30LH3-4 (hereinafter referred to as "the Proper Bolt") should have been used. Paint was not applied to the heads of the five Improper Bolts.

Almost all of the holes for securing the Panel were enlarged greatly and bore marks where the bolt and screw heads passed through. (Appendix Figures 1 and 2)

A protective film made of Teflon was affixed to the inboard side of the Panel; the film located in the forward upper corner had peeled off. (Photo 2)

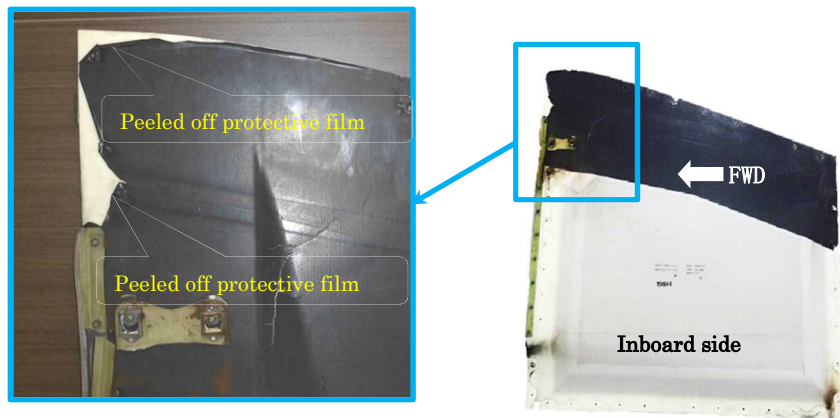
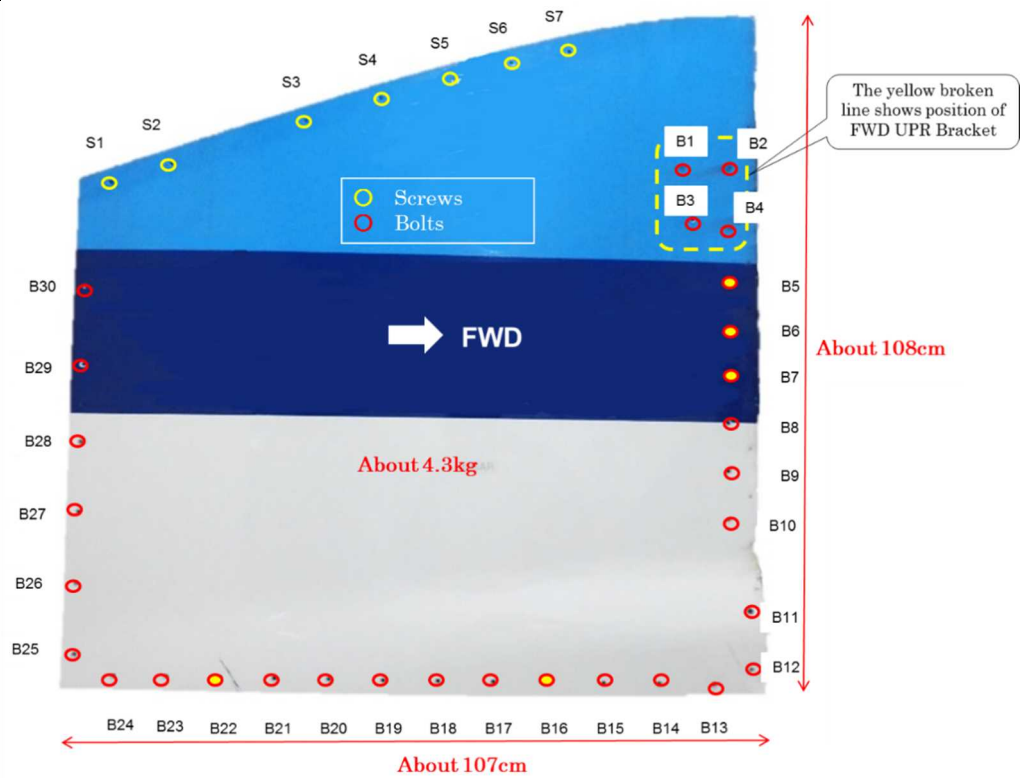


Photo 2 Dropped Panel

(3) Regarding the Bolts

Actual measurements of the bolts that attached to the Aircraft were taken. As result, it was found that the Improper Bolt (BACB30XD3K5) has a longer grip length, shorter thread length, and smaller outside diameter of head than the Proper Bolt (BACB30LH3-4). (Figure 3)

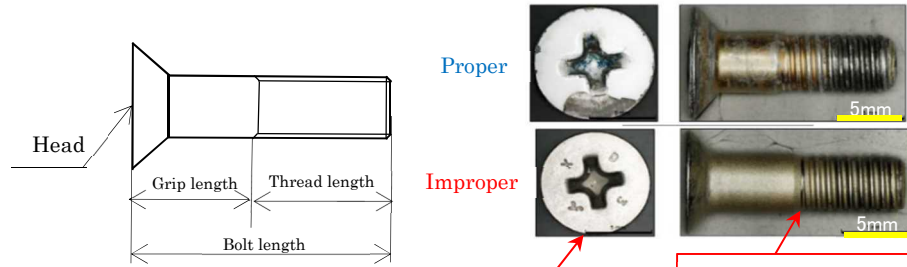


Figure 2 Name of Each Part of the Bolt

Photo 3 Proper Bolt (Top) and Improper Bolt (Bottom)

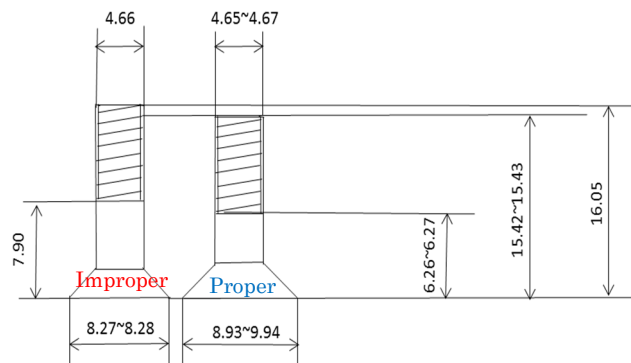


Figure 3 Actual Measured Values of the Bolts Attached to the Aircraft (mm)

(4) Effect Created by Use of the Improper Bolts

It was found that if the Panel is attached using the Improper Bolts, the bolts torqued at the end of thread because the grip length is longer and creates a situation in which the Panel is not fully secured, and that a maximum 0.7 mm gap can be formed between the Panel and the Bracket. The Improper Bolts were not used in the positions of the damaged forward upper Bracket; however, three were used in the positions just below the upper forward Bracket location. (Figure 4) Marks remained where the bolt was torqued at the end of thread of the Improper Bolts. (Photo 3)

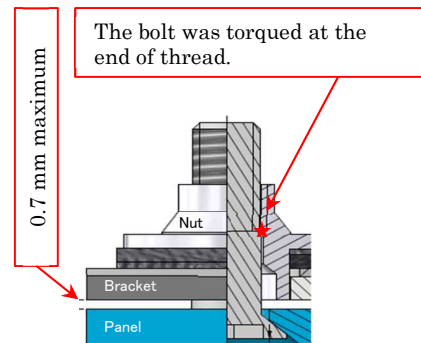


Figure 4 Tightening by Improper Bolt

The Operator conducted a simultaneous inspection of the installation conditions of the similar panel in all of its aircraft of the same type to determine whether the Improper Bolts were also installed in other aircraft. The inspection did not find any use of the Improper Bolts in other aircraft. It also found that the installation conditions of similar panels were good.

(5) Conditions of Bolt Stock Management

Bolts are ordinarily reused when the similar panel is installed on the fuselage. However, when they must be replaced, the mechanic typically takes and uses the necessary amount of bolts from fastener cabinets. Several fastener cabinets exist and their stock is regularly managed by specialized staff members. At the time of the investigation, no instances in which Improper Bolts were mixed into boxes for Proper Bolts in fastener cabinets were observed at the KLM maintenance facility.

(6) Regarding the Bracket

The Bracket that secures the forward upper corner of the similar panels (positions B1 to B4 in Photo 2) comes in a pre-enhancement design and an enhanced design. The pre-enhancement Bracket has a part number of 149W5913-3/-4 and is installed in aircraft with line



Broken bracket Enhanced design bracket

Photo4 Comparison of Brackets

numbers between 1 and 699. The enhanced Bracket has a part number of 149W5913-15/-16 or part number 149W5913-23/-24 and is installed in aircraft with line numbers of 700 or higher. The pre-enhancement Bracket is manufactured using a bending process from plate material with thickness of 1.6 mm and has dimension accuracy of ± 1.52 mm. On the other hand, the enhanced Bracket is manufactured using machine processing and is reinforced with increased thickness of 2.54 mm. It has dimension accuracy of ± 0.25 mm. (Photo 4)

The Aircraft's line number is 461, and its Brackets were the pre-enhancement Brackets that were installed when it was manufactured.

The Aircraft's Bracket was broken and its upper flanges remained in the Panel, and evidence of fatigue fracture was observed in the Bracket's fractured surface. (Appendix Figure 1)

(7) Pre-Flight Inspection

According to the Operator, on the day of the serious incident, an ordinary visual inspection of the aircraft's exterior was conducted during the Aircraft's pre-flight inspection by a qualified ground engineer, and no abnormalities with the Aircraft's external appearance, including the area around the Panel, were observed in this inspection.

(8) History of Work on the Panel

According to the Aircraft's maintenance record, the Operator conducted work to remove and reinstall the Panel for the purpose of conducting a visual inspection of the Aircraft's structure at the time of routine maintenance that was conducted in Amsterdam in September 2015. No other work records concerning the Panel other than the aforementioned work remained.

At the time of the aforementioned routine maintenance, the Aircraft's total

fight time was 63,475 hours and total number of flights was 7,320.

(9) Similar Incidents

According to a study by the Aircraft's manufacturer, there have been eleven reports of the 777 fleet similar panel coming off aircraft during flight, including this serious incident. Of them, ten occurred on Boeing 777-200 aircraft (hereinafter referred to as "-200 Aircraft") and one occurred on a Boeing 777-300 aircraft (hereinafter referred to as "-300 Aircraft"). The total numbers of flight cycles of these aircraft were between 1,899 and 18,748.

(10) Service Bulletin

The Aircraft's manufacturer issued two service bulletins concerning the falling of similar panels. Their content is excerpted and summarized as follows.

1) Service Bulletin (SB) 777-53-0049 Issued April 5, 2007

Several operators of 777 aircraft have reported that screws that secure the aft wing-to-body fairings were found to be loose. Loose screws could result in damage to the fairing panel or the fuselage skin due to vibration or the departure of a fairing panel. Accordingly, inspect attachment screws (126 screws per aircraft) and replace them if necessary. This applies to -300 Aircraft and Boeing 777-300ER (hereinafter referred to as "-300ER Aircraft") with a line number between 94 and 524.

2) SB 777-53-0056 Issued May 29, 2008

-200 Aircraft operator reported that the right aft wing-to-body fuselage panel departed the airplane during flight. Subsequent manufacturer review of other airplanes revealed that the panel on some -300 and -300ER airplanes had misfair, eliminating required panel preload. If the unevenness grows larger, air can flow to the panel's inboard side and result in damage to the fairing panel or Brackets caused by vibration and may also result in departure of the panel. Accordingly, check misfair between the aft wing-to-body fairing and the fuselage and confirm that it is within the specified value. If misfair less than or equal to 0.09 inches and no gap, apply sealant. If misfair is greater than 0.09 inches and/or with gap, replace the panel with a new one. This applies to -300 Aircraft and -300ER Aircraft with line numbers from 508 to 543. Aircraft after line number 543 were determined in production to have properly contoured fairing panel. (See Figure 5)

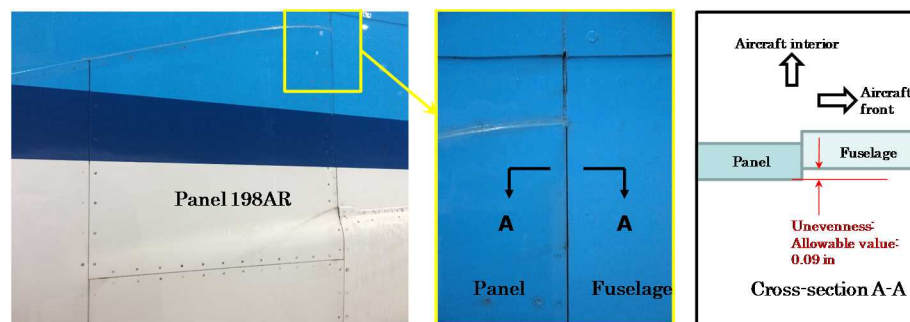


Figure 5 Location where Unevenness between the Panel and Fuselage was Confirmed

	<p>(11) Service Letter (SL)</p> <p>In addition to the SBs mentioned in the previous paragraphs, the Aircraft’s manufacturer provided information to operators by issuing service letters (SL). The content is excerpted and summarized as follows.</p> <p>1) SL 777-53-009 Issued September 24, 2009</p> <p>There have been six reported occurrences of cracks in Brackets that attach to the aft wing-to-body fairings (part number 149W5913-3/-4) from operators of 777. Some operators reported hearing unusual wind and flapping noises in the cabin during flight, and during subsequent inspection after landing, the operators found cracks in the Brackets.</p> <p>The manufacturer developed an enhanced Bracket (part number 149W5913-15/-16) made with thicker material compared to the current Bracket and tighter dimensional tolerance. The pre-enhancement Bracket can be replaced by the enhanced Bracket on aircraft with line numbers from 1 to 699. The enhanced Brackets have been installed in aircraft with a line number of 700 or higher from the time of their manufacture. Their Brackets must not be replaced with the pre-enhancement Brackets.</p> <p>(12) Implementation of the SBs and SL</p> <p>The Operator did not implement the content of the two aforementioned SBs because they did not apply to its aircraft. Regarding the aforementioned SL, the Operator did not replace Brackets with the enhanced Brackets, even though the SL did apply to its aircraft, because no failures had occurred.</p> <p>According to the Aircraft’s manufacturer, there were no reports from any operator regarding broken enhanced brackets or departed similar panels on aircraft on which the enhanced Brackets had been installed.</p> <p>(13) Response of the Operator and Conditions of other Aircraft</p> <p>Following this serious incident, the Operator prepared a plan to replace Brackets with the enhanced Brackets on the aircraft having a line number of 699 or lower that it operates (total of 16 aircraft). While the operator was implementing the replacement program, Brackets with cracks were found in two aircraft (one Bracket each, total of two Brackets).</p>
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3. ANALYSIS

3.1 Involvement of Weather	None
3.2 Involvement of Pilot	None
3.3 Involvement of Aircraft	Yes
3.4 Analysis of Findings	<p>(1) Bracket Damage and Panel Departure</p> <p>It is probable that the Panel was not fitted tightly to the fuselage because the preload that forces the forward upper corner of the Panel down was weak or had weakened because the Bracket was a pre-enhancement Bracket that was manufactured with a bending process and its dimension accuracy was</p>

insufficient, meaning that it also had insufficient strength. It is probable that, because of this, a gap was created between the forward upper corner of the Panel and the fuselage and air flowed in behind the Panel. It is probable that protective film on the inboard side of the forward upper corner of the Panel was peeled off by the inflowing air.

Given that marks caused by fatigue fracture were left on the broken Bracket's fractured surfaces, it is probable that load was placed on the Bracket and bolts by the air flowing inside the Panel that was in addition to the load caused by ordinary aerodynamic force from the Panel's exterior, and that repetition of this force to create repeated bending stress on the Bracket's flanges and led to fatigue fracture.

From the above, it is highly probable that the Bracket broke and an even larger gap formed between the forward upper corner of the Panel and fuselage, and the Panel departed due to the pressure of inflowing air and vibration.

(2) Replacement with Enhanced Brackets

Given that the enhanced Brackets have greater strength and higher dimension accuracy, it is probable that replacement with the enhanced Brackets is an effective means of preventing the departure of similar panels. Moreover, thus far, there have been no reports of damage to the Brackets or departure by similar panels on aircraft on which the enhanced Brackets were installed.

As was described in 2.7 (10), the Aircraft's manufacturer received reports of damage to the pre-enhancement Brackets and departure of similar panels, and it issued two service bulletins (SB) providing prevention measures. However, these SBs applied to -300 Aircraft and -300 ER Aircraft. It is somewhat likely that they did not apply to -200 Aircraft because noticeable failures were discovered on -300 Aircraft and -300ER Aircraft in inspections conducted by the Aircraft's manufacturer.

Moreover, as was described in 2.7 (11), the Aircraft's manufacturer received reports of damage to the Brackets from operators of aircraft of the same type and series, and it developed an enhanced Bracket and provided information on it to operators via a service letter (SL). However, because no SB providing instructions replacement to the enhanced Brackets was issued, the Operator did not make plans to make replacements to the enhanced Brackets

When the similar panel departs the aircraft, it could result in damage to the airplane or a potential hazard to persons or property on the ground. Thus, in order to prevent the occurrence of similar cases, the Aircraft's manufacturer must require operators of aircraft of the same type and series to make replacements to the enhanced Brackets or take similar measures to prevent panels from departing the aircraft.

(3) Effects of the Improper Bolts

Given that paint was not applied to the heads of the Improper Bolts only, it is probable that the bolts were mistakenly installed at the time of routine maintenance at the Operator. However, given that no marks indicating air flowed in behind the Panel assembly that was secured with the Improper Bolts

were observed, and that the Improper Bolts were not used in other aircraft in which cracks in Brackets were found, it is probable that the possibility that use of the Improper Bolts was a direct factor in this serious incident is negligible.

(4) Preventing Use of Improper Bolts

Depending on the Improper Bolts' specifications and installation place, the attachment of similar panels using the Improper Bolts can be a direct factor in the similar panel's departure. From the standpoint of preventing the occurrence of similar incidents, it is desirable that the Operator reviews its maintenance procedures (Compliance with the Maintenance Manual) and parts management and takes preventive measures concerning use of Improper Bolts so that the installation of Improper Bolts in aircraft does not occur.

(5) Regarding the Site where the Panel Landed or Impacted

Given that the Panel arrived at the impact site at around 10:57, it is probable that, from the relationship with the Aircraft's estimated flight route and times shown in Figure 1, the Panel likely departed from the Aircraft between points a and d and within a time period of about seven to ten minutes. Regarding the path the departed Panel took, this could not be clarified due to factors that include difficulty in estimating the precise point and time that the Panel departed from the Aircraft, the fact that the wind direction and wind speed were changing with the altitude along the Aircraft's estimated flight route, the fact that the Panel was a thin plate that is easily influenced by the wind, and, further, the possibility that the Panel was blown by the wake turbulence of the Aircraft after it departed.

4. PROBABLE CAUSES

It is certain that this serious incident occurred when the departed right aft wing-to-body fairing panel struck and damaged a moving vehicle, while the aircraft was climbing and passing over the city of Osaka after takeoff.

Regarding the departure of the Panel, it is highly probable that the Bracket that secured the Panel's forward upper corner by holding it to the Aircraft's side broke, a gap was occurred between the Panel's forward upper corner and the fuselage, and the Panel departed due to the pressure of inflowing air and vibration.

5. SAFETY ACTIONS

- (1) The Aircraft's manufacturer provided information to operators by issuing a service bulletin that instructed them to make replacements to the enhanced Brackets as a measure to prevent recurrence of panels departing from airplanes. (SB 777-53-0088 Issued March 8, 2018)

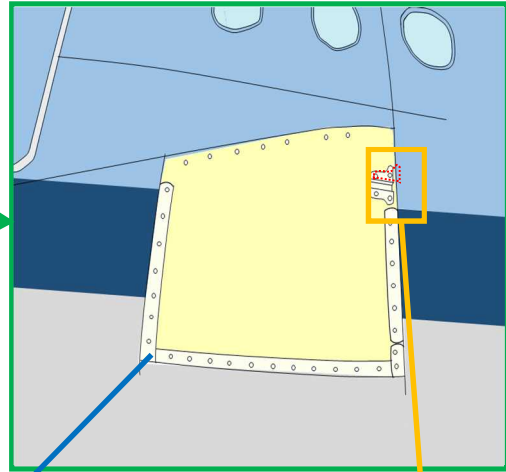
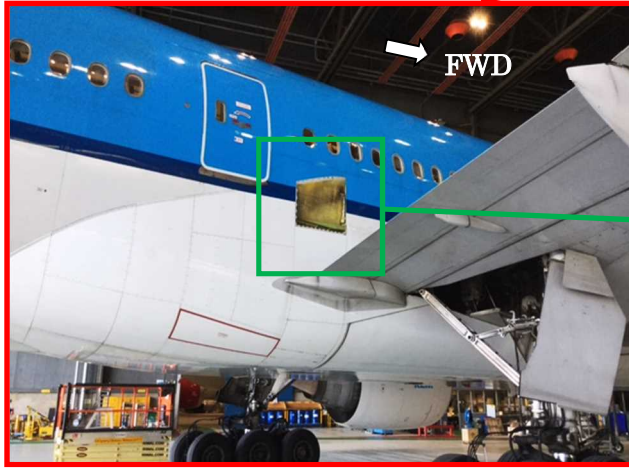
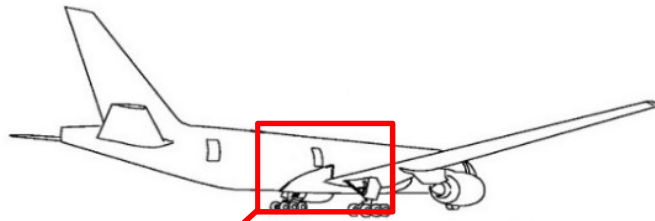
Since 2000, there have been eleven reports in which an aft wing-to-body fairing panel on aircraft of the same type and series departed. Such incidents pose a risk to people and property on the ground. It is probable that the cause of the fairing panels' departure was damage to their Brackets.

Operators can prevent the departure of this fairing panel by replacing Brackets with the enhanced Brackets in accordance with this service bulletin.

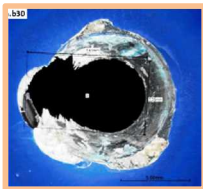
The service bulletin applies to aircraft installed with the pre-enhancement Brackets, line numbers 1 to 699.

- (2) The Operator completed replacing the Brackets in aircraft of the same type of aircraft with the enhanced Brackets by December 2017.
- (3) The Operator checked the installation conditions of similar panels and confirmed that the Improper Bolts are not used in any of its aircraft.
- (4) The Operator improved fastener cabinets so that Improper Bolts are not mixed in or erroneously taken.

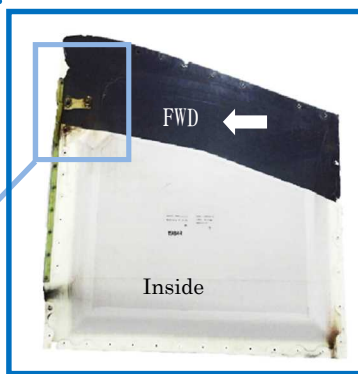
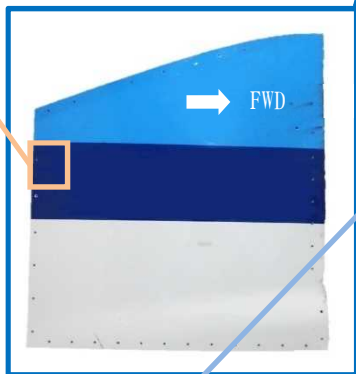
Appendix Figure 1 The Conditions of the Panel and Brackets



The part shown by the red line broke and remained on the panel side.

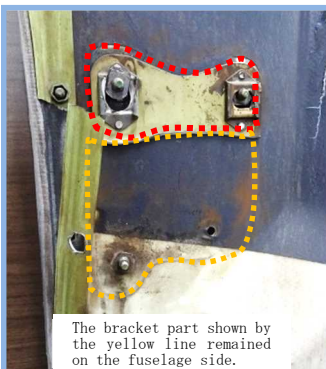


Enlarged bolt hole

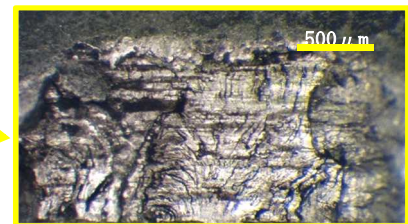


A bracket that broke and remained on the fuselage side

The part shown by the red line broke and remained on the panel side.



The bracket part shown by the yellow line remained on the fuselage side.



Evidence of fatigue fracture was observed when the broken brackets' fractured surfaces were enlarged.

The broken bracket was removed from the Aircraft and its fractured surface was matched with the bracket remaining on the panel.

Appendix Figure 2 Conditions of the Screws and Bolts Remaining on the Aircraft

