AI2022-4

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

KAWASAKI HEAVY INDUSTRIES, LTD.
7 0 3 3

June 30, 2022

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.

《Reference》

The terms used to describe the results of the analysis in "3. ANALYSIS" of this report are as follows.

i) In case of being able to determine, the term "certain" or "certainly" is used.
ii) In case of being unable to determine but being almost certain, the term "highly probable" or "most likely" is used.
iii) In case of higher possibility, the term "probable" or "more likely" is used.
iv) In a case that there is a possibility, the term "likely" or "possible" is used.

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

RUNNING OFF THE SIDE OF A RUNWAY
KAWASAKI HEAVY INDUSTRIES, LTD.
P-1 FIXED WING PATROL AIRCRAFT, 7033
GIFU AIRFIELD
AT ABOUT 16:00, SEPTEMBER 7, 2021

June 10, 2022
Adopted by the Japan Transport Safety Board
Chairperson TAKEDA Nobuo
Member SHIMAMURA Jun
Member MARUI Yuichi
Member SODA Hisako
Member NAKANISHI Miwa
Member TSUDA Hiroka

1. PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the serious incident	On Tuesday, September 7, 2021, a P-1 fixed-wing patrol aircraft 7033, operated by Kawasaki Heavy Industries, Ltd., ran off to the right side (north side) of Runway 28 at Gifu Airfield when landing, and was disabled to perform taxiing after stopping in a grassy area. There were ten persons on board in total, consisting of the captain and nine other crew members, and no one was injured.
1.2 Outline of the serious incident investigation	The occurrence covered by this report falls under the category of "Running off the side of runway (limited to when an aircraft is disabled to perform taxiing)" as stipulated in Article 166-4, item (4) of the Ordinance for Reinforcement of the Civil Aeronautics Act of Japan (Ministry of Transport Ordinance No. 56, 1952), and is classified as a serious incident. On September 7, 2021, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and three other investigators to investigate this serious incident. Comments were invited from the parties relevant to the cause of the serious incident.

2. FACTUAL INFORMATION

2.1 History of the Flight	On September 7, 2021, a P-1 fixed-wing patrol aircraft, serial number 7033, operated by Kawasaki Heavy Industries, Ltd., made a test flight at the time of new manufacturing before delivery to the Ministry of Defense, with the captain in the left pilot seat as PF*1 and the first officer (FO) in the right pilot seat as PM*1 in the cockpit.

*1 "PF" and "PM" are terms used to identify pilots by their different roles in aircraft operated by two persons. The PF abbreviates Pilot Flying and is mainly responsible for maneuvering the aircraft. The PM abbreviates Pilot Monitoring and mainly responsible for monitoring the flight status of the aircraft and cross-checking of the PF's maneuvering and undertakes other non-operational duties.

After landing on Runway 28 (runway direction: 281°) at Gifu Airfield at about 15:59JST (JST: UTC+9 hours; unless otherwise noted, all times are indicated in JST in this report on a 24-hour clock), the Aircraft came to stop in the grassy area located on the right side (north side) of the runway and was disabled to perform taxiing. The crew members disembarked the Aircraft by themselves, and no one was injured.

Figure 1:Serious Incident Aircraft

The history of the flight up until the Aircraft stopped after its landing is summarized as follows:

(1) Records of flight data and voice in the cockpit of Flight Recorder, and records of Onboard Maintenance Computer (OMC*2)
(Note) As for OMC records were corrected by using the time information from the records of the Flight Recorder.

Time	Flight Recorder	OMC
15:59:20	・The WOW* 3 of main landing gear changed to the Ground Mode. ・The reverser levers for No.2 and No. 3 engines were in the interlock position*4. (See (a) in Appended Figure). ・Heading: 278° ・Ground speed: 102 kt	
15:59:26	・The WOW of nose landing gear changed to the Ground Mode. (See (b) in Appended Figure) ・Heading: 279° ・Ground speed: 87 kt	
15:59:27	・The position of the reverser levers for No.2 and No. 3 engines were set at the maximum. ・The left rudder pedal input increased. (See (c) in Appended Figure.) ・Heading: 279° ・Ground speed: 84 kt	
15:59:28	・Heading: 280° ・Ground speed: 80 kt	・Steering angle: Right 4°
15:59:30	・The left rudder pedal input and the rudder position	・Steering angle: Right 5°

*2 "OMC" stands for Onboard Maintenance Computer, which is an onboard device to monitor the operation status of the aircraft systems and others.

*3 "WOW" stands for Weight On Wheel, which refers to the data indicating whether the aircraft is on the ground or in the air by signals from a sensor which works if loads are put on the nose landing gear and the main landing gear.

*4 "Interlock position" means a position where the reverse levers' movement is restricted to limit the thrust until the thrust reversers meet the conditions to be available after the reverser levers are operated.

	change to the left were almost maximized. (See (d) in Appended Figure.) ・Heading: 279° ・Ground speed: 73 kt	
15:59:31	"It's veering awfully." (Captain)	
15:59:33	・The acceleration to the right continued. (~ 15:59:40) (See (e) in Appended Figure.) ・The no.4 engine throttle lever angle increased in the direction to enlarge the thrust. (See (f) in Appended Figure.) ・Heading: 279° ・Ground speed: 67 kt	・Steering angle: Right 6°
15:59:35	・Heading: 282° ・Ground speed: 62 kt	・The status of autobrake selection was set to "OFF". ・The steering wheel angle for the right pilot seat changed to the left. (See (g) in Appended Figure.) ・Steering angle: Right 7°
15:59:37	・Heading: 287° ・Ground speed: 61 kt	・The operation to the left on the steering wheel of the right seat pilot side became its maximum. (See (h) in Appended Figure.) ・Steering angle: Right 8°
15:59:40	・Heading: 291° ・Ground speed: 61 kt	・The right brake pressure rose. (~ 15:59:42) ・Steering angle: Right 10°
15:59:51	・Ground speed became zero. (See (i) in Appended Figure.) ・Heading: 256°	

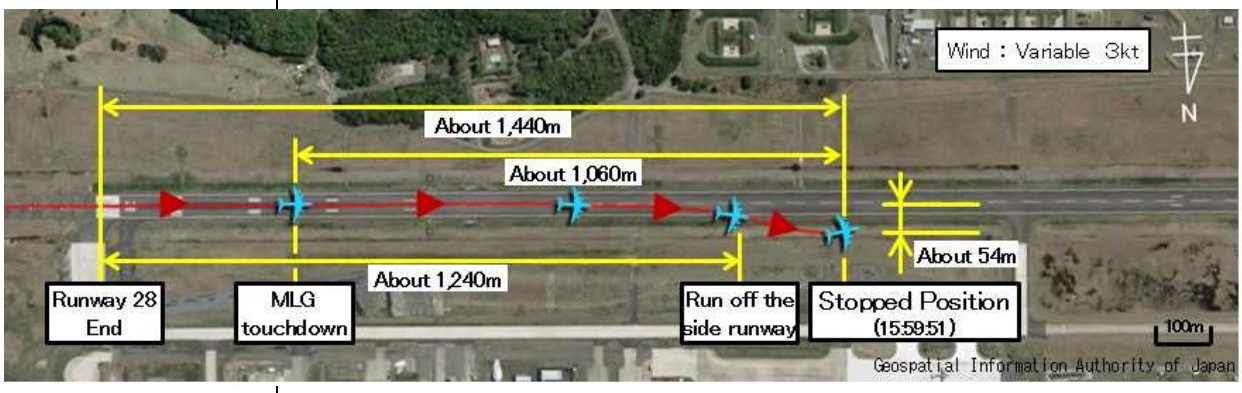


Figure 2: Estimated ground track

(2) Statements of the captain, the FO and the flight engineer

Although the captain recognized that the travel direction of the Aircraft changed to the right around the time when the reverser levers had

	become at their maximum position and tried to correct it with the left rudder pedal, he was unable to correct it. And the captain advanced the No.4 throttle lever and tried to correct the travel direction of the Aircraft by the asymmetric thrust. The FO noticed there was an abnormality in the function of steering by the rudder pedals on the left pilot seat side because the captain tried to correct the travel direction of the Aircraft by the asymmetric thrust while trying to correct it with the left rudder pedal. Therefore, the FO tried to change the travel direction by the steering wheel and the rudder pedals on the right pilot seat side. However, the travel direction did not change, thus the FO applied the brakes judging the Aircraft would not be able to avoid deviating from the runway. The flight engineer, who was sitting facing the center instrument panel in the aft cockpit, did not notice the veering of the Aircraft until just before it departed the runway because he was monitoring the systems with the instruments. The captain and the FO had not recognized abnormality in the steering system until the Aircraft started veering to the right because they had not felt any abnormalities in its behavior and there had not been any warning and others had appeared about its steering system. In addition, there was no record in the OMC of the Aircraft to indicate any abnormality had occurred in its steering system. This serious incident occurred at Gifu Airfield (35º23'41" N, 136º52'07" E) on September 7, 2021, at about 16:00.
2.2 Injuries to Persons	None
2.3 Damage to the Aircraft	Minor damage 1. Nose landing gear doors: Partial fracture of its components 2. Tires: Damaged 3. Fuselage and main wings: Scratch marks and dents 4. No. 2 and No.3 engines: Partial deformation of its fan blades
2.4 Personnel Information	At the time of the occurrence of the serious incident, the Aircraft was performing a test flight by the crew members who held the following competence certificate on qualifications while obtaining the permission in compliance with Article 28, paragraph (3) of Civil Aeronautics Act (Permission for the acts outside of the scope of service). (1) Captain: Age 40 Pilot certificate (Ministry of Defense) March 25, 2005 Type rating for P-1 September 12, 2014 Aviation medical examination certificate (Ministry of Defense) Validity September 7, 2022 Total flight time 5,468 hours 24 minutes Flight time in the last 30 days 15 hours 06 minutes Flight time on the type of aircraft 1,409 hours 36 minutes Flight time in the last 30 days 12 hours 48 minutes (2) First Officer: Age 41 Pilot certificate (Ministry of Defense) July 18, 2003 Type rating for P-1 February 7, 2018 Aviation medical examination certificate (Ministry of Defense) Validity August 1, 2022 Total flight time 5,745 hours 36 minutes Flight time in the last 30 days 23 hours 00 minute Flight time on the same type of aircraft 1,340 hours 54 minutes Flight time in the last 30 days 22 hours 24 minutes (3) Flight Engineer: Age 51

	Senior Aviator (Ministry of Defense) April 12, 2005 Type rating for P-1 May 11, 2011 Aviation medical examination certificate (Ministry of Defense) Validity September 7, 2022 Total flight time 9,849 hours 30 minutes Flight time in the last 30 days 5 hours 06 minutes Flight time on the same type of aircraft 3,365 hours 30 minutes Flight time in the last 30 days 4 hours 30 minutes
2.5 Aircraft information	(1) Aircraft type: P-1 Fixed wing patrol aircraft (Airplane) Serial number: 7033, Total flight time: 14 hours 26 minutes (2) The permission (Permission for test flights and others) under proviso for paragraph (1) in Article 11 of the Civil Aviation Act had been obtained. (3) When the serious incident occurred, the weight of the aircraft is estimated to have been 117,600 lb and the position of the center of gravity is estimated to have been 29.8% MAC*5, both of which have been within the allowable range.
2.6 Meteorological information	(1) The aviation routine weather report for Gifu Airfield around the time of the serious incident was as follows: 16:00 Wind direction and velocity VRB*6 03 kt Visibility 10 km or more Cloud: Amount 1/8; Type Cumulus; Cloud base 2,000 ft Cloud: Amount 6/8; Type Stratocumulus; Cloud base 4 ,500 ft Temperature 24℃, Dew point 19℃ Altimeter setting (QNH) 1,015 hPa
2.7 Additional information	(1) Situation of the serious incident site Gifu Airfield has a runway with magnetic bearing 101º/281º, 2,700 m long and 45 m wide. From the Aircraft's tire marks found during the on-site investigation, the Aircraft entered the grassy area located on the right side (north side) of the runway after passing the runway side stripe marking at approximately 1,240 m from runway 28 threshold, and it came to a stop approximately at 1,440 m from runway 28 threshold with the head bent forward, the all landing gears sinking in the grassy area, and its heading 256°. (2) Damage to the Aircraft The mounting part for nose landing gear doors was partially fractured. In addition, there were scratch marks and dents found on the fuselage and main wings. Furthermore, some deformations were found on part of No.2 and No.3 engine fan blades. (3) Steering Systems The outline of the steering systems is shown in Figure 3. The nose landing gear steering can be operated to the left or right up to 60° by the steering wheels equipped on the side consoles of both pilot seats and to the left or right up to 6° by the rudder pedals equipped on the floor in front of both pilots' seats. Besides, when the steering wheels are operated at the same time by both pilots in the left and right seats, the sum of the amount operated by both steering wheels controls the steering angle.

*5 "MAC" means the mean aerodynamic chord, which is the wing chord representing aerodynamic characteristics of the wings and indicates the representative wing chord when the wing chord is not constant such as a sweptback wing, etc. 29.8 % MAC indicates the position of 29.8 % from the forward edge of the MAC.

*6 "VRB" means the condition the mean wind velocity is less than 3 kt and the wind direction is variable less than 60º, or the mean wind velocity is more than 3 kt and the wind direction is variable at or more than 180º, and or the wind direction is not possible to determine.

In addition, the steering angle, which is controlled by each operation, such as the steering wheel operation, the rudder pedal operation, or simultaneous operation with the steering wheel and the rudder pedal, changes the maximum operation angle corresponding to the speed of the aircraft.

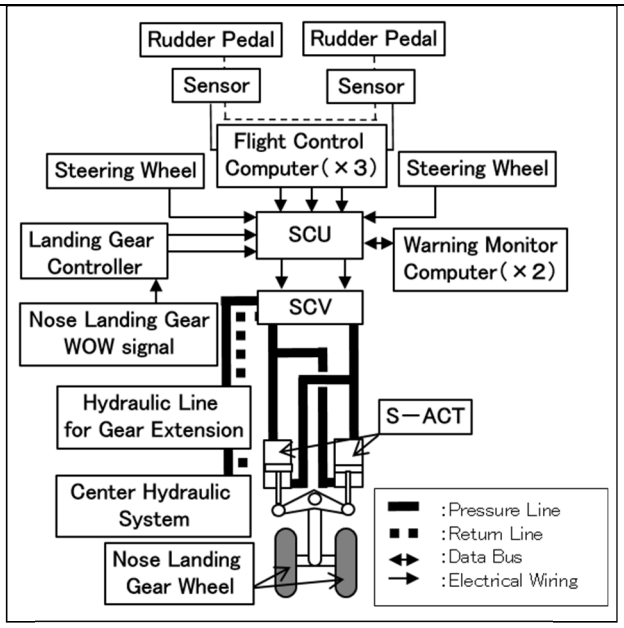
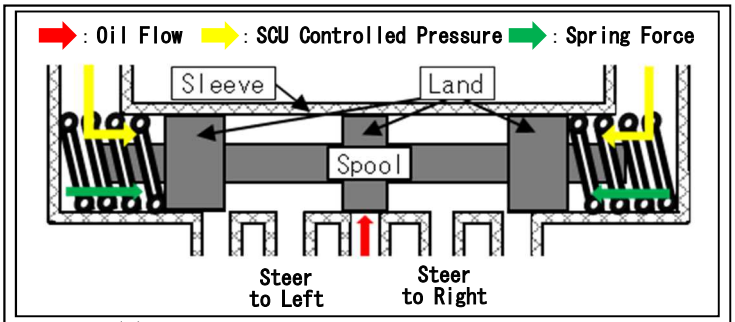


Figure 3: Outline of steering systems

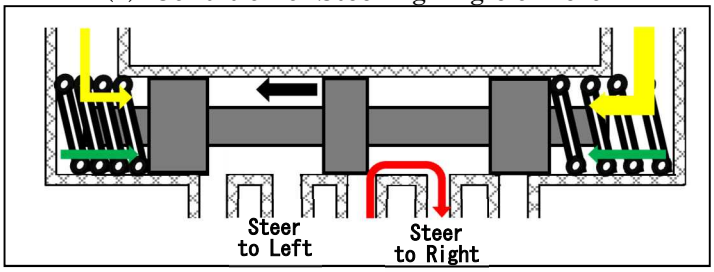
The steering system controls the travel direction by operating the steering actuator (S-ACT) mounted on the nose landing gear by the hydraulic pressure of the line to let landing gears down by a multiplexed electric control system.

The input amount on a steering a wheel and a rudder pedal is converted into electrical signals and entered into the steering controller (SCU).

The SCU controls the steering angles through S-ACT by changing the hydraulic oil pressure in the steering control valve (SCV) in order to drive the spool*7 in the SCV main stage and switch the oil passage so that the steering angle can be formed according to the electric control signals (see Figure 4).



(1) Condition of Steering Angle of Zero



(2) Condition of Steering Angle of Right

Figure 4: Status of SCV main stage (conceptual)

The steering systems are controlled by the WOW signals of nose landing gear so as to maintain the Caster Mode*8 in flight and for about one second after touchdown, and are not activated. About one second after the WOW signal of the nose landing gear changes to the Ground Mode, the steering systems activate and the SCU controls the oil pressure in the SCV so that the steering angle is changed in correspondence with a pilot input and a speed.

*7 "Spool", which is used mainly as a direction switching valve, means an internal structure part to switch oil flow. It is skewer-shaped and the part, which largely spreads in the radial direction, is called "Land" (see Figure 4).

*8 "Caster Mode" refers to the mode to make the nose landing gear steering "Free" status.

The SCU carries out the monitor for a failure in each device, and the over-angle monitor*9 in order to prevent a steering malfunction. When detecting a failure in a control channel in the steering systems, the SCU issues an alert and automatically switches the control to the unaffected control channel so that the steering can continue to operate. In addition, when detecting any failure in the two control channels of the steering systems, the SCU shuts off the hydraulic system supply and changes to the Caster Mode.

Furthermore, a pilot can switch the steering mode to the Caster Mode by operating the "STEER MODE" switch installed in the steering wheel.

(4) Actions for the steering systems failure

The Flight Handbook, which describes information on the systems for the same type of aircraft, performance data, and necessary aircraft control procedures, does not include any procedures to respond to the steering system failures.

On the other hand, regarding how to respond to cases where the steering systems become uncontrollable during taxiing, the Manufacturer designs as follows:

At low speed:	The aircraft shall be stopped at pilot's judgement.
At high speed:	When the over-angle monitor detects an anomaly, the steering mode shall be automatically switched to the Caster Mode, and then, the pilot shall control the travel direction of the Aircraft by applying asymmetrical brakes and asymmetrical thrust.

(5) Autobrakes

The autobrakes of the Aircraft can be disengaged under one of the following conditions.

1. Place the autobrake selector to "OFF".
2. Depress the brake pedal and add pressure to either right or left manual brake pressure so that it could become a specified value or more.
3. Move either throttle lever 10° or more from the most aft position.
4. Operate the speed brake lever*10 to retract the inboard spoilers of both main wings.

(6) Detailed Examination of Steering Systems

Foreign materials such as aluminum alloy, low alloy steel, copper alloy, cress and others were found in hydraulic oil in the SCV and S-ACT in the detailed examination of the steering systems component. Among these objects, the copper alloy was the material not used for steering systems accessories.

The size of found foreign materials was larger than the filtration grain size of the filter installed in SCV.

The observation with an optical microscope found several scratch marks on the spool (material: stainless steel 440 C) in the SCV, however, it was not able to identify the material which had made the scratches because they were too small.

Besides, it was confirmed that there was no sticking in moving parts of SCV.

On the other hand, it was confirmed that the spool in the SCV remained in the position in which there was an opening angle to steer the aircraft to the right even with no electric signals from the SCU that

*9 "Over-angle Monitor" refers to the monitor function to determine the failure of the steering controller and stop the control when the actual steering angle exceeds a threshold angle relative to the steering angle limits varied according to the speed of the aircraft.

*10 "Speed brake lever" refers to the lever to control a device (spoiler) which is installed on the surface of main wings and used to reduce the lift.

	controls the steering angle. This opening angle is within the allowable range, but is almost equivalent to that of where the steering angle changes 0.45° per second. (7) Circumstances when Manufacturing the Aircraft In order to prevent foreign objects from mixing into the products including SCV and others, the manufacturers of the parts were taking measures such as performing cleaning, inspection and assembling of each component in a semi-clean room. The aircraft manufacturer had executed the SCV and S-ACT joining and the installation in the aircraft in the comprehensive aircraft assembling facility wherein a hole is mechanically formed using a drill.

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	(1) Running off the Side of Runway The JTSB concludes that judging from the flight record on the flight recorder, the Aircraft more likely touched down within the aiming point marking of Runway 28. As having noticed the Aircraft was veering to the right during the landing roll, the captain most likely tried to control the travel direction of the Aircraft by applying the left rudder pedal and fully depressing it to the maximum eventually. However, contrary to his effort of the rudder pedal operation, the steering angle continued to change to the right (see (j) in Appended Figure). The captain increased the No.4 engine thrust and tried to stop the Aircraft from veering by the asymmetric thrust force, however, it is probable that No.4 engine, which was in idle condition, could not provide enough engine thrust to enable the Aircraft stop veering inside the runway. Besides, although the autobrakes were disengaged by advancing the No.4 engine throttle lever, the captain, who was depressing the left rudder pedal to the maximum and trying to stop the veering by the asymmetric thrust, likely had difficulty depressing the brake pedals. The FO operated the steering wheel and the rudder pedal to the left, but it is highly probable that he could not change the steering angle to the left because the Aircraft's steering angle continued to change to the right. It is most likely that the Aircraft veered to the right (north side), run off the runway (see (k) in Appended Figure), came to stop in a grassy area and was disabled to perform taxiing because it failed to control the travel direction since the steering angle continuously changed to the right and the aerodynamic influence of the rudders had been reduced as the ground speed decreased. (2) Change of Steering Angle The OMC records showed that the steering angle of the Aircraft continuously changed to the right (see actual steering angle shown in Appended Figure) after the steering systems started to operate. On the other hand, the flight record in the flight recorder showed that around the time when the steering systems started to operate, the operation amount of the left rudder pedal continuously increased, eventually to the maximum, and the rudder had also changed to the left at the maximum. The captain most likely continued to input to the left rudder pedal since around the time when the steering systems started to operate.

Besides, the FO stated that he noticed the captain tried to correct the travel direction of the Aircraft with the left rudder pedal, but it did not change, thus the FO tried to change it with the steering wheel and the left rudder pedal, and the OMC recorded the amount of the steering operation had increased.

From the above, the JTSB concludes that the steering angle of the Aircraft was most likely changing to the right continuously despite the steering operation made by the pilots to change the direction to the left.

(3) Status of Steering Systems

The captain and the FO found no anomalies in the behavior of the Aircraft and did not recognize any warnings related to the steering systems of the Aircraft until the Aircraft started veering to the right. In addition, the OMC records showed no anomalies in the steering systems of the Aircraft. Therefore, the JTSB concludes that it is highly probable that the captain and the FO were not able to recognize failures occurred in the steering systems even after the Aircraft veered to the right.

As the result of the detailed examination of the parts related to the steering systems, it was able to identify no abnormality except for the contamination in the oil in the SCV and the S-ACT and several scratches on the spool of the SCV.

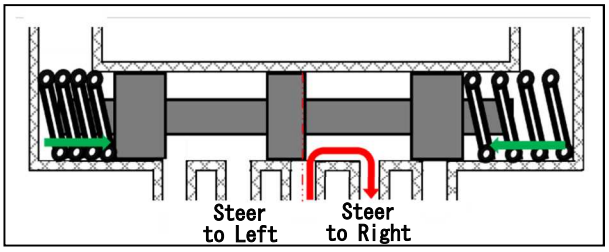


Figure 5: Null Position of the Spool of the Aircraft

On the other hand, the JTSB concludes that the neutral position of the spool most likely remained the position where the hydraulic oil would flow in the right steering direction because it was confirmed that the hydraulic oil would flow in the right steering direction with no electric signals from the SCU (see Figure 5).

Furthermore, part of the scratch marks on the right side of both the left land and the central land of the spool (see Figure6) likely resulted from foreign objects caught between the sleeve and the spool when the spool moved in the right direction (in the left steering direction).

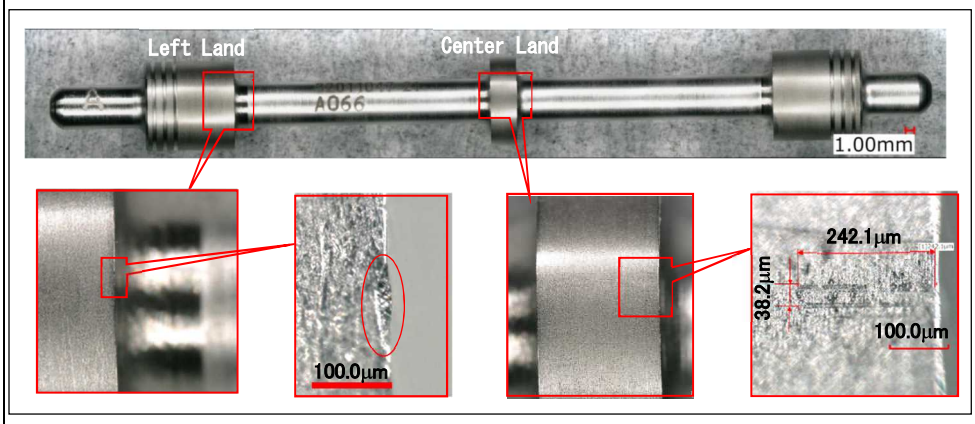


Figure 6: Scratch Marks on the Spool

From the above, the JTSB concludes that regardless of the pilots' operations, the steering angle more likely continued to change to the right because the foreign materials caught between the sleeve and the spool of the SCV and restricted the spool movement while the neutral position of the spool had remained the position where hydraulic oil would flow in the right steering direction.

Regarding the instant when the foreign materials were caught between the sleeve and the spool, the instant was likely when the SCU sent the electrical signal to move the spool in the right direction about one second after the WOW of the nose landing gear had sensed the ground mode. However, it could not be determined when foreign objects became caught between the sleeve and spool because the OMC recorded the steering angle with one second interval, and there was no record before the steering systems started to operate.

(4) Damage to the Aircraft

The JTSB concludes that the partial fracture of the nose landing gear doors most likely occurred because the doors made contact with the ground when the nose landing gear sank in the grassy area. In addition, it is highly probable that the Aircraft rolled up soil and pebbles in the grassy area after running off the side of the runway, which caused many scratch marks and dents on the fuselage and main wings as well as deformation of the engine blades.

(5) Contamination of foreign objects

The scratch marks found in the detailed examination of the steering systems after this serious incident were too small to determine the materials of foreign objects that caused the scratch marks on the spool.

The foreign objects most likely got mixed into the SCV during the SCV manufacturing process or an aircraft assembly process because the Aircraft was brand-new immediately after production.

Because during the SVC manufacturing process, the manufacturer of the parts was taking measures such as performing cleaning, inspection and assembling of each component in a semi-clean room in order to prevent foreign objects from mixing into the products, it is less likely that foreign objects got mixed into the products, though it does not exclude the possibility.

On the other hand, since the materials not used in the steering systems were found in the mixed foreign objects, they most likely got mixed during the aircraft assembly process such as jointing between the SCV and S-ACT joining.

It is probable that it is necessary for manufacturers to verify operational procedures such as the component manufacturing stage and the periodical maintenance, and work environment in order to prevent similar incidents.

(6) Response of crew members

When the Aircraft started veering to the right, the captain said, "It's awfully veering", but afterwards he tried to correct the travel direction of the Aircraft by using the left rudder pedal and the asymmetric thrust without saying a single word.

On the other hand, although the FO, who noticed the corrective action by the captain and the veering of the Aircraft to the right, tried to correct the travel direction of the Aircraft but did not share the situation awareness with the captain verbally.

Although the JTSB views it is important for crew members to try to share the operational intention and the aircraft condition with each other and make efforts to prepare responses, it is probable that it was difficult for the crew members of the Aircraft to accurately grasp and share the situation because there were no warnings to indicate a system failure at the time of the occurrence of this serious incident, thus, the JTSB concludes that the captain and the FO more likely had no choice but to pay attention to controlling the travel direction of the Aircraft.

In addition, the Flight Handbook does not describe a specific response to be taken when a steering system malfunction occurs, but since the pilot is required to recognize the situation, make judgments, and operate in a

	short time if a steering system malfunction occurs during a takeoff and a landing, it is probable that it is necessary to provide the pilot with a standard response method after providing information on related events that occur in response to the defect.

4. PROBABLE CAUSES

The JTSB concludes that the probable cause of this serious incident was that the Aircraft most likely veered to the right (north side), ran off the runway, stopped in a grassy area, and was disabled to perform taxiing because it was not able to control the travel direction during landing roll.

The reason why the Aircraft failed to control the travel direction, was the foreign materials mixed into the SCV were more likely caught between the sleeve and the spool of the SCV and then restricted the spool movement while the neutral position of the spool had remained in the position where the hydraulic oil would flow in the right steering direction.

5. SAFETY ACTIONS

Measures taken by the Manufacturer

(1) Measures to protect steering systems from contamination caused by foreign objects

1. They requested the Manufacturer of the Parts to clearly specify in the work instructions about the cleaning operation for each component performed in production job site.
2. They implemented education for persons in charge of work so as to fully enforce preventive measures against contamination by foreign objects when those related works are performed during aircraft manufacture and regular maintenance.

(2) Removal of foreign objects

In order to ensure capturing of foreign objects in the function test of steering systems during the manufacturing process, they increased the number of times of steering operation with the SCV return port filter removed.

(3) Clarification of procedures to respond to steering system failure

They clarified the Emergency Operation Procedures to switch the steering mode using the "STEER MODE" switch to the Caster Mode when a failure is found in the steering systems.

Appended Figure　Records of Flight Recorder and OMC