AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

THE ENGINE IS STOPPED CONTINUOUSLY IN FLIGHT

OKAYAMA AIR SERVICE CO., LTD.

CESSNA 172R, JA10AZ

NEAR KOHNAN AIRFIELD,

OKAYAMA CITY, OKAYAMA PREFECTURE

AT ABOUT 15:06 JST, JULY 14, 2023

July 19, 2024

Adopted by the Japan Transport Safety Board

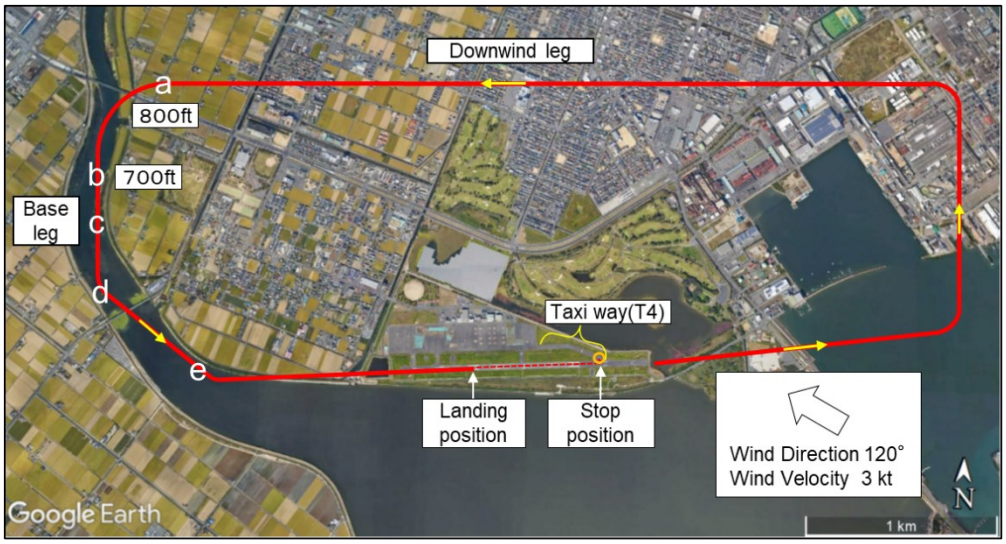
Chairperson TAKEDA Nobuo
Member SHIMAMURA Atsushi
Member MARUI Yuichi
Member SODA Hisako
Member NAKANISHI Miwa
Member TSUDA Hiroka

1. PROCESS AND PROGRESS OF THE AIRCRAFT SERIOUS INCIDENT INVESTIGATION

1.1 Summary of the Serious Incident	On Friday, July 14, 2023, a Cessna 172R, JA10AZ, operated by Okayama Air Service Co., Ltd., was approaching Runway 09 at Kohnan Airfield when its engine was stopped. The aircraft continued to approach and stopped on the taxiway after landing on the runway. There were three persons on board the aircraft, consisting of the captain, a trainee, and a passenger, but no one was injured.
1.2 Outline of the Serious Incident Investigation	The occurrence covered by this report falls under the category of "the engine is stopped continuously in flight" as stipulated in item (viii), Article166-4 of the Regulation for Enforcement of Civil Aeronautics Act of Japan (Order of Ministry of Transport No.56 of 1952) and is classified as a serious incident. On July 14, 2023, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and an investigator to investigate this serious incident. An accredited representative and an adviser of the United States of America, as the State of Design and Manufacture of the aircraft and the engine of the aircraft involved in this serious incident, participated in the investigation. Comments on the draft Final Report from parties relevant to the cause of the serious incident and the Relevant State were invited.

2. FACTUAL INFORMATION

2.1 History of the Flight	According to the statements of the captain, the trainee, and the passenger, the history of the serious incident is summarized as follows: On Friday, July 14, 2023, at 13:07 Japan Standard Time (JST: UTC+9hr, unless otherwise stated all times are indicated in JST on a 24-hour clock), a Cessna 172R, JA10AZ, operated by Okayama Air Service Co., Ltd., took off from Kohnan Airfield for training to acquire a commercial pilot certificate, with the trainee sitting in the left pilot seat, the captain as an instructor in the right pilot seat and the passenger in the right rear seat, being piloted by the trainee. The aircraft returned Kohnan Airfield after the continuous touch-and-go training at Hiroshima Airport, and from about 14:50, it conducted the continuous touch-and-go training three times using the south side traffic pattern for Runway 09 at Kohnan Airfield. After that, for landing, the aircraft entered the north side traffic pattern for the runway. Before the aircraft entered the base leg from the downwind leg at an altitude of about 800 ft, the trainee set the engine revolution to 1,500 rpm, then the trainee checked again the tachometer and noticed that it had fallen to approximately 1,000 rpm. When the trainee operated the throttle to raise the engine revolution, it was raised to approximately 2,000 rpm, therefore, the trainee adjusted it at 1,500 rpm (Figure 1, a). The aircraft continued to fly, however, when lowering the flap from 10° to 20°, the trainee confirmed that the revolution had fallen below 1,000 rpm again (Figure 1, b). In addition, the trainee did not feel any thrust force and felt as if the propeller was windmilling. At about 15:06, the captain judged the engine had stopped, and took over the control of the aircraft from the trainee (Figure 1, c). The captain tried to start the engine two times, the engine was not started (Figure 1, d). Judging that it was able to land on the runway from the altitude and the speed at that point by gliding in that way, the captain raised the flap, which had been lowered to 20°, to 0°, and continued to approach at a speed of about 65 kts (Figure 1, e). The aircraft touched down near the aiming point marking. The propeller stopped to rotate during the landing roll. At 15:08, the aircraft vacated the runway via Taxiway (T4) and stopped at the taxiway. There was no damage to the aircraft, and none of the three persons on board the aircraft were injured.

	This serious incident occurred at about 15:06 on July 14, 2023, at about 700 ft about 2.5 km west-northwest of Kohnan Airfield (34° 36' 01" N, 133° 54' 24" E).  Figure 1: Estimated Flight Route
2.2 Injuries to Persons	None
2.3 Damage to the Aircraft	None
2.4 Personnel Information	(1) Captain Age: 41 Commercial pilot certificate (Airplane) October 21, 2004 Specific pilot competence Expiration date of piloting capable period: January 26, 2025 Type rating for single-engine (Land) January 26, 2023 Class 1 Aviation Medical Certificate Validity: March 31, 2024 Total flight time 2,132 hours 38 minutes Flight time in the last 30 days 19 hours 31 minutes Total flight time on the type of aircraft 71 hours 36 minutes Flight time in the last 30 days 17 hours 33 minutes (2) Trainee Age: 48 Private pilot certificate (Airplane) December 4, 2008 Type rating for single-engine (land) December 4, 2008 Class 2 Aviation Medical Certificate Validity: March 4, 2025 Total flight time 223 hours 37 minutes Flight time in the last 30 days 6 hours 41 minutes Total flight time on the type of aircraft 203 hours 30 minutes Flight time in the last 30 days 6 hours 41 minutes
2.5 Aircraft Information	(1) Aircraft Aircraft type: Cessna 172R Category of Airworthiness: Airplane, Normal N Serial number: 17281142 Date of manufacture: December 16, 2002  Figure 2: The aircraft

	Airworthiness certificate: Dai-2022-698 Validity: March 7, 2024 Total flight time: 3,247 hours 19 minutes When the serious incident occurred, the weight and the center of gravity of the aircraft, both of which were within the allowable ranges. (2) Engine Model: Lycoming IO-360-L2A Serial Number: L-31495-51E Date of total disassembly inspection of the engine: March 23, 2020 Total time in service: 4,039 hours 29 minutes Time in service since last periodical check (50-hr check on July 6, 2023): 3 hours 11 minutes
2.6 Meteorological Information	Aviation weather observations for Kohnan Airfield around the time of this serious incident were as follows: 15:00 Wind direction: 120°, Wind velocity: 3 kt Wind direction fluctuation: 060° to 160° Prevailing visibility: 15 km Clouds: Amount 1/8 to 2/8, Type Cumulus, Cloud base Unknown Temperature: 28℃, Dew point: 25℃ Altimeter setting (QNH) 29.77 inHg
2.7 Additional Information	(1) Engine and Fuel System a) The examination of the airframe and engine condition conducted after the serious incident found no failure. There was no abnormality with the engine during the operation test of engine on the ground. b) The fuel tanks of the aircraft are installed in the left and right wings, and on each side of leading and trailing edges of the main wing, there are fuel tank supply outlets leading to the engine. The fuel from the fuel tanks flows through the fuel selector valve that allows selection of both tanks, or either of the left or right one, and through the fuel reservoir tank, and then, the fuel is boosted by the engine driven fuel pump. And the FUEL INJECTION SERVO injects the amount of fuel adjusted depending upon the position of the mixture and the throttle from the injector to the engine cylinder. The auxiliary fuel pump is used for engine starting or restarting (Figure 3 to Figure 8). According to the engine design and manufacturer, if air is mixed in the fuel line or the FUEL INJECTION SERVO, the proper amount of fuel is unable to be delivered to the engine, which may result in engine shutdown. In this case, for restarting the engine, it is necessary to remove the air mixed in the fuel line. c) Fuel Reservoir Tank The fuel reservoir tank capacity is about 0.45 U.S. Gallons (about 1.7 liters), which is equivalent to the fuel quantity enable to deliver to the engine for about 10 to 15 minutes in the case of the engine revolution of about 1,500 rpm, even though the fuel from the fuel tanks is interrupted.

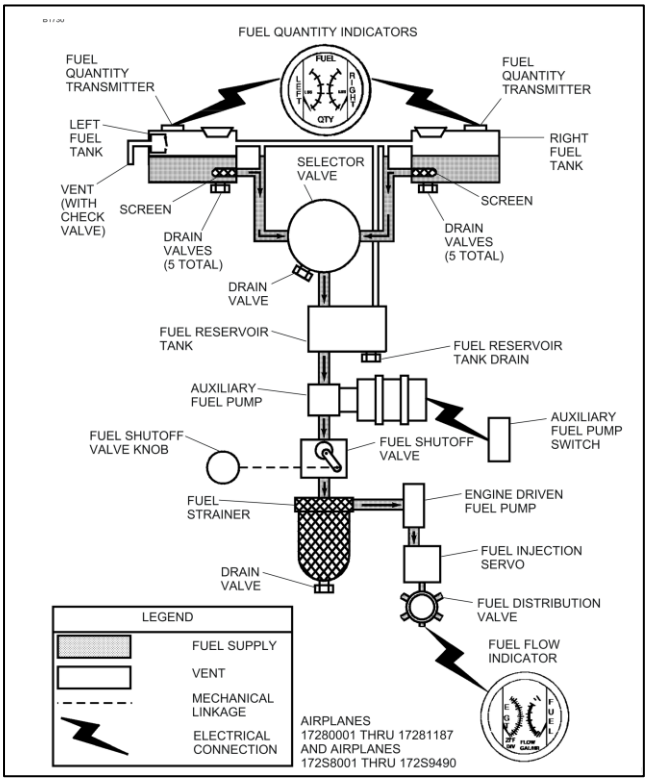


Figure 3: Fuel System (Extracted from Aircraft Maintenance Manual)

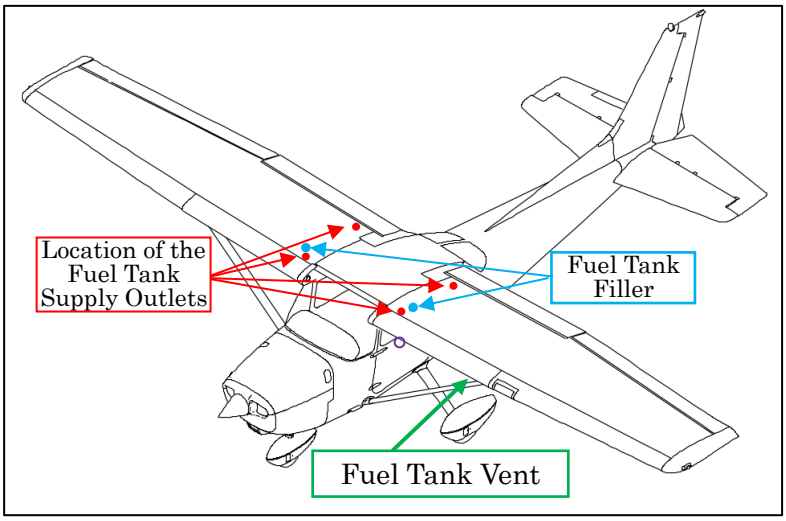


Figure 4: Location of the Fuel Tank Supply Outlets
(Added the excerpt from the Aircraft Maintenance Manual)

Figure 5: Fuel Tank Supply Outlet
(Taken from the Fuel Tank Supply Outlet on the Right Main Wing)

Figure 6: Fuel Tank Vent

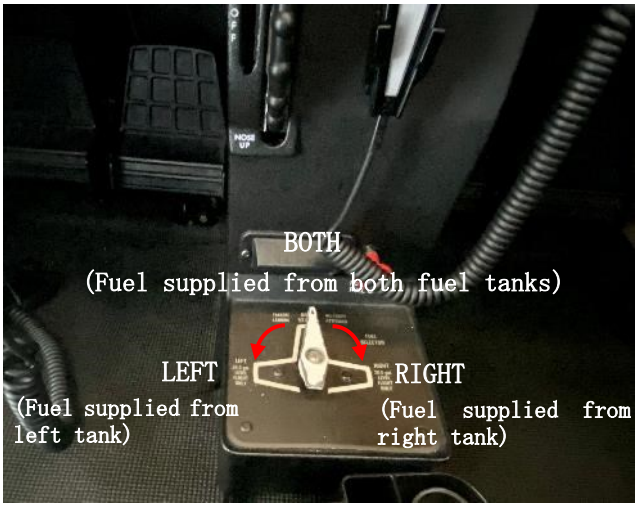


Figure 7: Fuel Selector Valve Handle

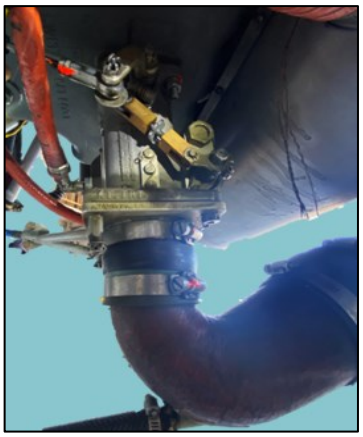


Figure 8: Fuel Injection Servo

(2) Aircraft Flight Manual

a) The aircraft flight manual for the aircraft contains the following descriptions in Section 2 LIMITATIONS.

FUEL LIMITATIONS

Total Fuel: 56 U.S. gallons (2 tanks at 28.0 U.S. gallons each).

Usable Fuel (all flight conditions): 53.0 U.S. gallons.

Unusable Fuel: 3.0 U.S. gallons (1.5 U.S. gallons each tank).

(Omitted)

ADDITIONAL FUEL LIMITATIONS

Takeoff and land with the fuel selector valve handle in the BOTH position.

Maximum slip or skid duration with one tank dry: 30 seconds.

Operation on either LEFT or RIGHT tank limited to level flight only.

With 1/4 tank or less, prolonged uncoordinated flight is prohibited when operating on either left or right tank.

Fuel remaining in the tank after the fuel quantity indicator reads 0 (red line) cannot be safely used in flight.

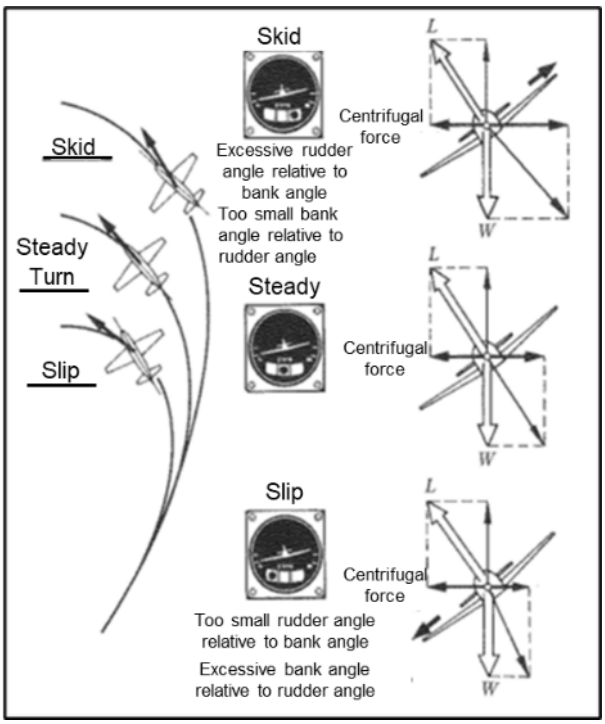


Figure 9: Slip and Skid
(Extracted from Aeronautical Engineering Course, Vol.1, Aerodynamics Theory", published by the Japan Aeronautical Engineers Association)

The “Uncoordinated Flight” includes slip or skid, as well as flight in an imbalance state due to changes in attitude for ascending, descending and others.

b) The aircraft flight manual for the aircraft contains the following descriptions in Section 3 EMERGENCY PROCEDURES.

Engine Failures

(Omitted)

ENGINE FAILUERE DURING FLIGHT (Restart procedures)

1. Airspeed--65 KIAS

2. Fuel Shut-off Valve--ON (push full in)

3. Fuel Selector Valve--BOTH

4. Auxiliary fuel pump switch--ON

5. Mixture--Rich (if restart has not occurred)

6. Ignition Switch--BOTH (or START if propeller is stopped)

Note

If the propeller is windmilling, the engine will restart automatically within a few seconds. If the propeller has stopped (possible at low speeds), turn the ignition switch to START, advance the throttle slowly from idle and lean the mixture from full rich as required for smooth operation.

7. Auxiliary Fuel Pump Switch--OFF

(Omitted)

*EXCESSIVE FUEL VAPOR*1 INDICATIONS*

Excessive fuel vapor is most likely to be generated during ground operations when operations at higher altitudes, in unusually warm temperatures or with more volatile fuel blends. Operation at or near idle RPM (low fuel flow) for extended periods will increase the chances of fuel vapor generation. (see "Leaning For Ground Operation's", Section 4.)

Indicated fuel flow that is not stable (sudden changes greater than 1 gal/hr) is a sign that fuel vapor may be present in the system. Fuel flow indications that become less stable (increasing changes) may lead to power surges and power loss if not corrected.

According to the engine design and manufacturer, when the fuel rate and flow in the fuel line are low as in the state of engine operation at near idle RPM during ground operations or operations at high altitude, the time to absorb the heat by the engine cowling will be prolonged, the fuel vaporizes in the fuel line, fuel vapor is generated, which can allow air to get stuck in the fuel line (vapor lock), probably causing the engine to shut down.

(3) Pilot's Operating Handbook and Others

a) The FUEL SELECTOR VALVE in Section 7 FUEL SYSTEM of the aircraft's Pilot's Operating Handbook (Part Number: 172RPHUS09, Revision 9, issued on July 19, 2004) contains the following descriptions.

(Omitted)

・ *When the fuel tanks are 1/4 full or less, prolonged uncoordinated flight such as slips or skids can uncover the fuel tank outlets.*

(Omitted)

b) Section 6 FUEL MANAGEMENT in the Cessna Pilot Safety and Warning Supplements (Reissue 2, published by Textron Aviation on September 28, 2018) contains the following descriptions.

FLIGHT COORDINATION VS. FUEL FLOW

The shape of most airplane wing fuel tanks is such that, in certain flight maneuvers, the fuel may move away from the fuel tank supply outlet. If the outlet is uncovered, fuel flow to the engine may be interrupted and a temporary loss of power might result. Pilots can prevent inadvertent uncovering of the tank outlet by having adequate fuel in the tank selected and avoiding maneuvers such as prolonged uncoordinated flight or sideslips which move fuel away from the feed lines. It is important to observe the uncoordinated flight or sideslip limitations listed in the respective operating handbook. As a general rule, limit uncoordinated flight or sideslip to 30 seconds in duration when the fuel level in the selected fuel tank is 1/4 full or less. Airplanes are usually considered in a sideslip anytime the turn and bank "ball" is more than one quarter ball out of the center (coordinated flight) position. The amount of usable fuel decreases with the severity of the

*1 "Fuel Vapor" refers to the fuel in a vapor state. The state where a vaporized fuel bubble blocks the flow of fuel is also called "Vapor Lock".

sideslip in all cases.

According to the engine design and manufacturer, as the condition of uncovering of the fuel tank supply outlet is different depending on the amount of remaining fuel or the flight attitude, "prolonged uncoordinated flight" does not define a certain amount of time. And even with fuel filled in both tanks, depending on a combination of low remaining fuel flow and uncoordinated flight, the fuel tank supply outlets being uncovered may affect the engine.

(4) Fuel Quantity in Left and Right Fuel Tanks

Before the flight, the captain and the trainee confirmed that the total of about 35 gallons (about 132L) enough to fly for about three hours 30 minutes was equally loaded in left and right tanks. According to the statement of the captain, when the aircraft started the continuous touch-and-go training after returning Kohnan Airfield, the fuel quantity indication was about 5 to 8 gallons (about 19 to 30 L) for the left tank and about 10 gallons (about 38 L) for the right tank. In addition, the fuel selector valve had been in the BOTH position from take-off to landing (Figure 7). After the landing, the fuel quantity indication was about 5 gallons (about 19 L) for the left tank and about 10 gallons (about 38 L) for the right tank. As to an unbalanced fuel load between the left and right tanks, according to the company operating the aircraft, difference in the fuel quantity between the left and right tanks can occur, as the Cessna 172R airplane has a vent outlet on the left fuel tank, when the fuel selector valve is on the BOTH position, the fuel in the left tank, which allows air to escape easier than that in the right tank, tends to be consumed more. With fuel selector valve on BOTH, during parking on the ground or continuing uncoordinated flight, the fuel may be transferred between fuel tanks by the fuel selector valve. When there is amount of fuel loaded, fuel may transfer through the vent line.

(5) Flight Operations by the Trainee

The captain noticed about the flight operations by the trainee, especially when the engine power was increased, the aircraft skidded to the left a few times, however, the captain intended to point it out after the flight training as this training was a simulation of the practical examination. Regarding whether the aircraft made an uncoordinated flight while turning toward the base leg before the engine shutdown, even if the trainee had made an uncoordinated flight, the captain did not care about it especially, because it was within the extent the captain would be able to handle. Besides, since concentrating on landing after the engine shut down in the air, the captain did not check the fuel flow indicator.

(6) Past Similar Serious Incidents

On October 6 , 2017, occurred the serious incident where a privately owned Cessna 172K, JA3500 took off from Sapporo Airport, but its engine stopped during the flight, because the fuel in the right fuel tank was exhausted due to the one-sided reduction in fuel between tanks that allowed air to enter the fuel system, which resulted in not allowing the fuel to reach the engine and the engine shutdown. (See AI-2019-3 Aircraft Serious Incident Investigation

	Report.)

3. ANALYSIS

(1) Fuel Quantity in Left and Right Fuel Tanks

The JTSB concludes as follows:

A total of about 35 gallons of fuel on the left and right tanks on the aircraft before the flight. The fuel quantity indicator read about 5 gallons for the left fuel tank and about 10 gallons for the right fuel tank after the landing when the aircraft had flown for about two hours. As to an unbalanced fuel load between the left and right tanks, it likely occurred because the fuel in the left tank tends to be consumed more as the aircraft has a vent outlet on the left fuel tank, and because fuel transferred between fuel tanks occurred due to uncoordinated flight including skidding.

(2) Engine Shutdown

The JTSB concludes as follows:

a) When the engine revolution had fallen below 1,000 rpm, no thrust force was felt and the propeller stopped to rotate, therefore, the engine had been most likely stopped as the captain judged.

b) Regarding the engine shutdown of the aircraft, it is highly probable that there was no failure in the engine itself at the time of the serious incident because examination of the airframe found no anomalies and the engine operated without any problems during the operation test of engine on the ground. On the other hand, the engine did not restart after following the operations procedures described in Engine failure in flight (Restart procedures) in the aircraft flight manual, therefore, the fuel to the engine was probably interrupted, resulting in the engine shutdown. According to the engine design and manufacturer, in case of fuel starvation, or interruption of fuel to the engine due to the fuel tank outlets being uncovered, decrease in engine revolution or engine vibrations can be observed as sign of the engine shutdown. Therefore, the engine revolution set at 1,500 rpm had fallen to approximately 1,000 rpm before the aircraft's engine shut down was probably the sign that the fuel supply from the fuel tanks would be interrupted.

(3) Interruption of Fuel Flow to the Engine

The JTSB concludes as follows:

a) Regarding the interruption of fuel flow to the aircraft's engine, as in the aircraft flight manual, Pilot's Operating Handbook and others that mention the possibility that uncoordinated flight with low remaining fuel flow can uncover the fuel tank outlets, it is possible that a similar case occurred in this serious incident, and the fuel tank outlet was uncovered, resulting in decrease in fuel supply to the engine.

b) As to the fuel tank outlets being uncovered, they were uncovered possibly because the aircraft prolonged uncoordinated flight while conducting the continuous touch-and-go on the south side traffic pattern. There are four fuel tank outlets, and even if one outlet is uncovered and interrupts the fuel flow, it is unlikely to directly affect the engine. However, the aircraft prolonged uncoordinated flight with low remaining fuel flow in the left tank during the continuous touch-and-go training, which likely caused several fuel tank outlets to be exposed. Due to the fuel tank outlets being uncovered, the fuel supply flow to the engine decreased, the fuel in the fuel reservoir tank was consumed, which allowed air to enter the fuel system that delivers the fuel from the tank to the engine, resulting in the engine possibly shutdown.

c) It is most likely that with the aircraft was flying with the engine revolution set at 1,500 rpm,

fuel vapor was not present there. In the event of engine malfunction, not just fuel vapor, it is desirable to also check the fuel flow indicator as described in the aircraft flight manual.

d) It is necessary for the engine restarting not only to fill the fuel to the fuel outlets and feed the fuel but also to remove air entered in the fuel line, however, the air cannot be removed only by the engine driven fuel pump due to insufficient pressure to remove it. In this case, if it is performed maintenance work, or in flight it is necessary to remove air entered in the fuel line by activating auxiliary fuel pump according to section 3 emergency procedure in the aircraft flight manual.

Regarding the failure to restart the engine when the captain tried to do it, it is likely that the captain placed priority on the landing procedures when attempting to restart the engine while going through the landing procedures, which made the operation time of auxiliary fuel pump short, resulting in the failure to remove air entered in the fuel line.

(4) The JTSB concludes that the reason the aircraft was able to land safely at the time of the engine shutdown was most likely because of the levelheaded judgement and appropriate flight operation made by the captain from the engine shutdown to the landing.

(5) The JTSB concludes that if the Cessna 172R airplane is flown with low remaining fuel flow, depending on the position selected by the fuel selector valve, the fuel tank outlets could be uncovered and the fuel supply flow to the engine may be interrupted, resulting in possible loss of engine power. Therefore, it is important to load the sufficient fuel before flight according to the purpose and duration of the flight, and it is necessary to ensure that an aircraft does not prolong uncoordinated flight when the amount of remaining fuel was low in the fuel tanks.

4. PROBABLE CAUSES

The JTSB concludes that the probable cause of this serious incident was most likely that when the aircraft was flying, the fuel supply flow to the engine was interrupted, resulting in the engine shutdown. Regarding the interruption of fuel supply flow to the engine, it is possible that with the low remaining fuel flow in the fuel tanks, its fuel tank outlets were uncovered due to the change in flight attitude and the fuel flow to the engine decreased, which allowed air entered in the fuel line to interrupt the fuel flow to the engine.

5. SAFETY ACTIONS

5.1 Safety Actions Considered Necessary	As described in "3. ANALYSIS", it is important to load the sufficient fuel before flight according to the purpose and duration of the flight, and it is necessary to ensure that an aircraft does not prolong uncoordinated flight with low remaining fuel in the fuel tanks.

5.2 Safety Actions Taken after the Serious Incident	After the serious incident, the company disseminated this serious incident to all staff in the Flight Operations Department. And the company delivered the Operation Information to all staff in the Flight Operations Department to call their attention to the issue that prolonged uncoordinated flight including slip or skid with low fuel may result in the engine shutdown. Besides, on August 1, 2023, the company published the internal document specifying the minimum fuel for training and decided that the captain shall interrupt the training and land as soon as possible if the fuel reserve is expected to be lower than the minimum fuel. In addition, the company instructed them to ensure thorough that sufficient fuel is on board in accordance with the flight plan.

For more information for prevention of accidents involving small aircraft and others, please refer to the following JTSB document and website.

"For Prevention of Accidents of Small Aircraft - Do you know flight data monitoring device (FDM)? "
(https://jtsb.mlit.go.jp/bunseki-kankoubutu/jtsbdigests_e/jtsbdigests_No42/No42_pdf/jtsbdi-42_all.pdf)