AI2022-4

AIRCRAFT SERIOUS INCIDENT

INVESTIGATION REPORT

The public foundation of Japan Student Aviation League
J A 0 1 K Y
J A 2 4 7 1

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

UNINTENTIONAL RELEASE OF OBJECT (TOW ROPE)
1. JAPAN STUDENT AVIATION LEAGUE
DIAMOND AIRCRAFT HK36TTC SUPER DIMONA, JA01KY
(TOW PLANE) (MOTOR GLIDER)
2. JAPAN STUDENT AVIATION LEAGUE
ALEXANDER SCHLEICHER ASK21, JA2471
(TOWED PLANE) (GLIDER)
AT AN ALTITUDE OF APPROX. 150 M OVER VICINITY
OF KOMATSU AIRPORT, ISHIKAWA PREFECTURE
AT ABOUT 12:03 JST, SEPTEMBER 16, 2019

June 10, 2022
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 SERIOUS INCIDENT INVESTIGATION

1.1 Summary of the Serious Incident	On September 16, 2019, a Diamond Aircraft HK36TTC Super Dimona, registered JA01KY and operated by the public foundation of Japan Student Aviation League with one person onboard, took off from Fukui Airport towing an Alexander Schleicher ASK21, registered JA2471 and operated by the same public foundation with two persons onboard, and was performing demonstration flight at Komatsu Airport. At about 12:03 Japan Standard Time (JST: UTC+9 hour; unless otherwise noted, all times are indicated in JST in this report on a 24-hour clock), part of a tow rope connecting both aircraft (7 mm diameter, approximately 61 m long, and approximate weight of 1.7 kg) dropped.
1.2 Outline of the Serious Incident Investigation	The occurrence covered by this report falls under the category of Article 166-4, item 15 of the Ordinance for Reinforcement of the Civil Aeronautics Act of Japan as “Case where a slung load, any other load carried external to an aircraft or an object being towed by an aircraft was released unintentionally or intentionally as an emergency measure” prior to the revision by the Ministerial Ordinance on Partial Revision of the Ordinance for Reinforcement of the Civil Aeronautics Act (Ordinance of Ministry of Land, Infrastructure, Transport, and Tourism No. 88 of 2020), and is classified as a serious incident. The Japan Transport Safety Board designated an investigator-in-charge

	and an investigator on September 16, 2019, to investigate the serious incident. Although the serious incident was notified to the Republic of Austria as the State of Design and Manufacture of the aircraft involved in the serious incident, Austria did not designate its accredited representative. Comments on the draft Final Report were invited from the parties relevant to the cause of the serious incident and the Relevant State.

2. FACTUAL INFORMATION

2.1 History of the Flight	According to the statements of the captains of JA01KY (hereinafter referred to as "the aircraft A") and JA2471 (hereinafter referred to as "the aircraft B"), and personnel of aerodrome control position of Komatsu Airport Control Tower (hereinafter referred to as "the Tower") and the aircraft operator of the general incorporated association of Tokai Kansai Student Aviation League (hereinafter referred to as "the League"), the history of the flight was summarized as follows: The aircraft A with the captain alone onboard took off from Fukui Airport at 11:23 on September 16, 2019, to attend an event held at Komatsu Airport (hereinafter referred to as "the Airport") towing the aircraft B where the captain and another pilot were onboard. Both captains obtained the meteorological information for the Airport prior to the flight, and confirmed that the northern wind blowing at the velocity of 16 to 18 kts in the demonstration flight airspace did not hinder the flight. According to the captain of the aircraft A, both aircraft planned to perform demonstration flight three times from 12:00 until 12:15, and had held short of over Kibagata in the southeast of the Airport (approximately 2.5 nm southeast of the Airport) until three minutes before the demonstration flight commenced. In the first round of the demonstration flight, both aircraft approached over runway 06 threshold at an altitude of 600 ft at 12:00 and flew straight along the runway at an altitude of 500 ft, and in the second round of the flight, performed meandering flight at the same altitude. Then, during left circling to perform the third round of the demonstration flight, the captain of the aircraft A felt impact like "boon" and confirmed that the tow rope was fractured. The captain of the aircraft A notified to the Tower that the aircraft B was going to land at the Airport and the aircraft A was returning to Fukui Airport, and landed at the airport at 12:20.

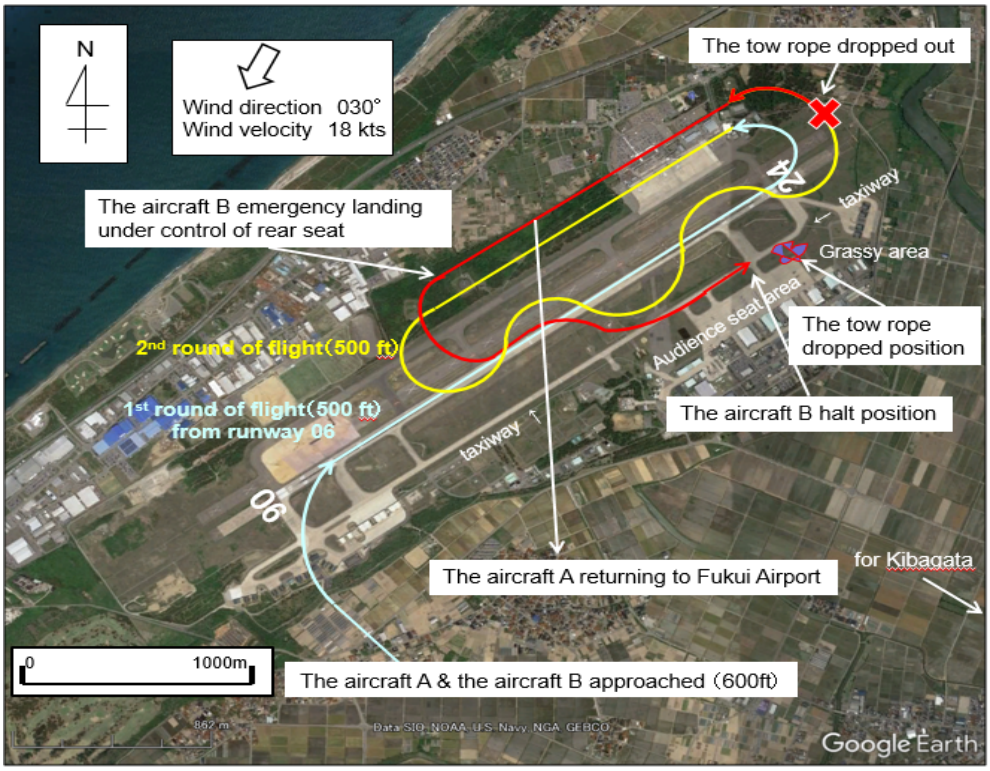


Figure 1 Estimated flight route

According to the captain in the front seat of the aircraft B, the aircraft B performed training flight five times in the morning launching by the aircraft A towing over surroundings of Fukui Airport. In the preflight check before 8 o'clock, the captain of the aircraft A checked appearance of the tow rope with the captain of the aircraft B, but they did not check the condition of the tow rope within the stop egg*1 (egg-shaped fitting). When the captain of the aircraft B felt the fracture and impact of the tow rope, the captain attempted to detach the tow rope that was thought to remain in the aircraft B. However, the captain was advised by the pilot in the rear seat not to do so to avoid damage to the ground that might occur if the tow rope dropped, and changed the control of the aircraft with the pilot in the rear seat. The aircraft B landed at taxiway of the Airport at 12:05. After that, part of the dropped tow rope (61 m long) was found in a grassy area on the side of the eastern taxiway shoulder in the vicinity of 310 m south of runway 24 threshold of the Airport.

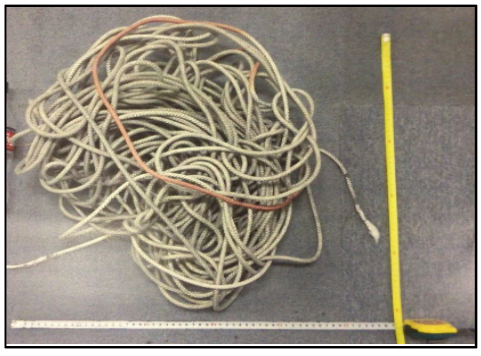


Figure 2 Dropped the tow rope

The serious incident occurred near the northeastern end of runway 24 of the Airport (36º23'52" N, 136º25' 12" E) at about 12:03 on September 16, 2019.

2.2 Injury to	None

*1 "stop egg" is an egg-shaped fitting attached to the tow plane side of the tow rope with a knot contained therein. The stop egg is to receive a load that generates in towing when a retracted tow rope is pulled out to capacity and strikes the stop egg detent.

Persons	
2.3 Damage	(1) Extent of damage to the aircraft: None (2) Damage to facilities on the ground: None (3) Others: Tow rope was fractured and dropped
2.4 Personnel Information	(1) Captain of the aircraft A: Age 57 Private pilot certificate (glider: High-class) October 27, 2000 Specific pilot competence Expiry of practicable period for flight: January 26, 2020 Type rating for motor glider Class 2 medical aviation certificate Validity: October 4, 2020 Total flight time 2,222 hours 14 minutes Flight time in the last 30 days 6 hours 05 minutes (2) Captain of the aircraft B: Age 64 Commercial pilot certificate (glider: High-class) November 9, 1977 Specific pilot competence Expiry of practicable period for flight: February 20, 2020 Class 1 aviation medical certificate Validity: June 17, 2020 Total flight time 874 hours 34 minutes Flight time in the last 30 days 31 hours 30 minutes (3) Another pilot onboard the aircraft B: Age 69 Commercial pilot certificate (glider: High-class) June 5, 1973 Specific pilot competence Expiry of practicable period for flight: April 9, 2020 Class 1 aviation medical certificate Validity: July 11, 2020 Total flight time 2,432 hours 40 minutes Flight time in the last 30 days 11 hours 25 minutes
2.5 Aircraft Information	(1) The aircraft A Aircraft type: Diamond Aircraft HK36TTC Super Dimona Serial number: 36609 Date of manufacture: April 12, 2000 Certificate of airworthiness: DAI-2019-33-14 Validity: April 22, 2020 Category of airworthiness: Motor glider Utility U Total flight time: 2,970 hours 35 minutes Flight time after the last periodical check (100-hour inspection conducted on April 23, 2019): 89 hours 15 minutes (2) The aircraft B Aircraft type: Alexander Schleicher ASK21 Serial number: 21488 Date of manufacture: January 21, 1991 Certificate of airworthiness: 2019-35-05 Validity: February 17, 2020 Category of airworthiness: Glider Utility U Total flight time: 4,516 hours 38 minutes Flight time after the last inspection (100-hour inspection conducted on September 5, 2019): 21 hours 51 minutes (3) When the serious incident occurred, the weight and center of gravity of both

aircraft were within the allowable ranges.

Figure 3 The aircraft A

Figure 4 The aircraft B

2.6 Meteorological Information

Aviation Routine Weather Report (METAR) for the Airport as of 12:00 on the day of the serious incident was as follows:

Wind direction 020º; Wind velocity 12 kts;
Prevailing visibility 10 km or more
Could amount 1/8; Cloud type Cumulus; Cloud base 2,000 ft;
Could amount 3/8; Cloud type Cumulus; Cloud base 3,500 ft;
Temperature 28º C; Dew point 22º C; Altimeter setting (QNH) 29.67 inHg

2.7Additional Information

(1) Situation at the time of the tow rope drop out

Footage taken by a witness on the ground recorded how the tow rope was dropped out during left circling in the second round of the demonstration flight. According to the footage, the tow rope, which was dropped out almost simultaneously from the Aircraft A and B sides, instantly retracted gathering in the center, and dropped like a bunch.

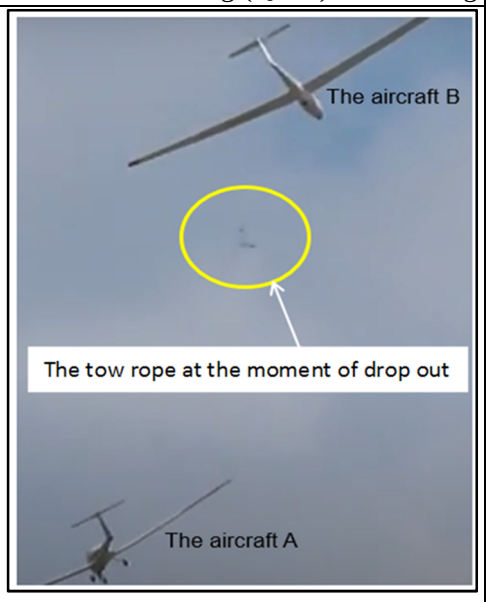


Figure 5 Footage showing the moment the tow rope dropped

(2) Conditions of the tow rope

The dropped tow rope was found in a grassy area on the side of the eastern taxiway shoulder in the vicinity of 310 m south of runway 24 threshold of the Airport. There was no damage to the ground as the grassy area was far from the audience seats. The length and weight of the dropped tow rope were approximately 61m and 1.7 kg, respectively.

The tow rope remained in the Aircraft A side (approximately 5.5m long) had a knot that was fractured like tearing off within the egg stop (see Figure 6).

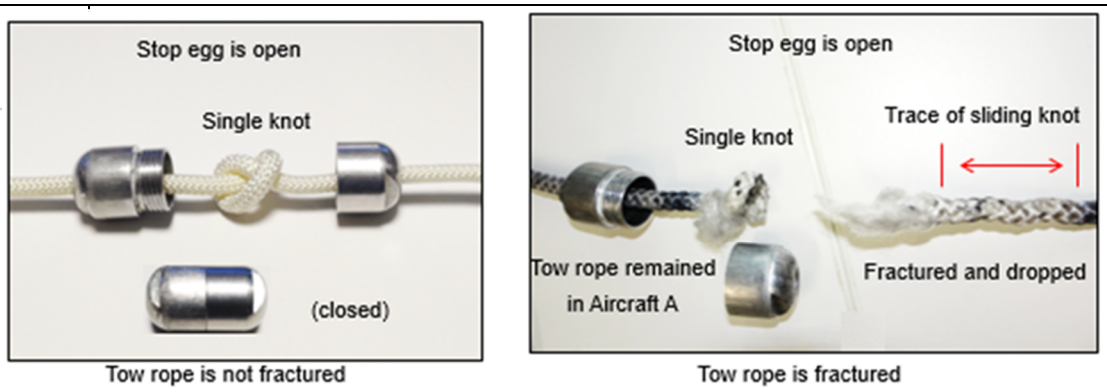


Figure 6 Fractured the tow rope (The aircraft A)

On the other hand, the tow rope went missing from the end piece*2 attached to the aircraft B, and only the end treatment tape was found in the protection cover. The braking piece*3 attached to the end piece was not cut. Besides, one end of the dropped tow rope was fractured like it was torn off (right photo in Figure 6) similar to the tow rope remained in the aircraft A side, and the tow rope on the aircraft B side had an untied knot (see Figure 7).

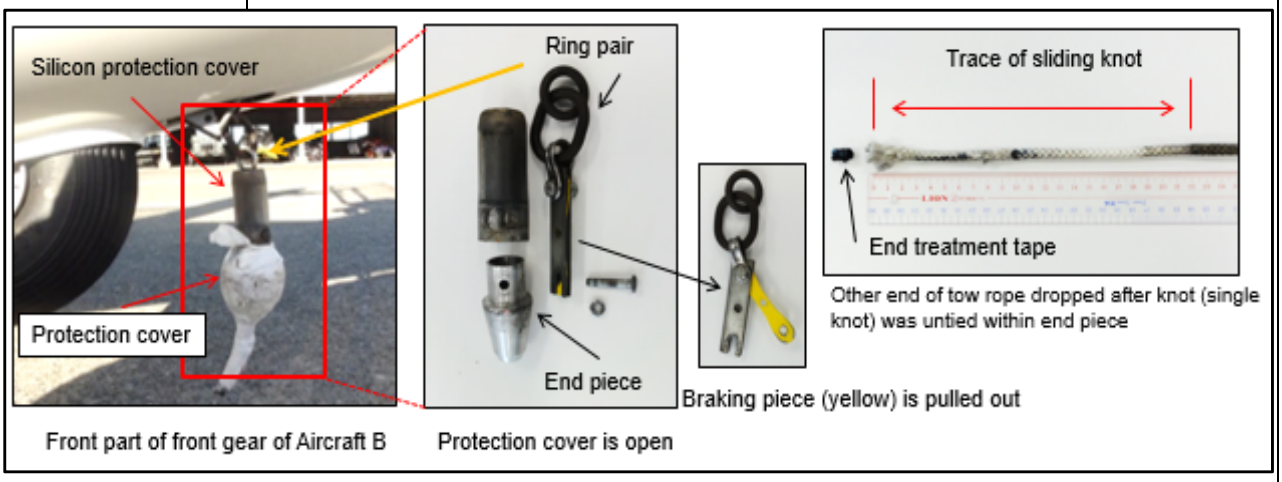


Figure 7 End piece and the tow rope with untied knot (The aircraft B side)

(3) Outline of the stop egg (on the aircraft A side) and end piece (on the aircraft B side)

The aircraft A was equipped with the tow rope retraction device to retract a tow rope after a glider has been released. The tow rope on the aircraft A side had the stop egg attached to prevent the tow rope from being pulled out from the tow rope retraction device over a certain length by tensile force acting during towing.

The end piece was attached to the tow rope end, and was attached to the aircraft B via the ring pair. Besides, the end piece was attached by the braking piece to automatically release a glider from the tow rope by cutting the braking

2 * "end piece" is a fitting attached to the tip of the tow rope on glider side, that connect to the glider via a ring pair and contains a knot made at the end of the tow rope threaded thereto.

3 * "braking piece" is a metal plate that fracturs when an excessive load is applied to the rope and separates the rope from the glider.

piece when an excessive tensile force (maximum load of 400 daN plus/minus 40) was applied during towing (see Figure 8).

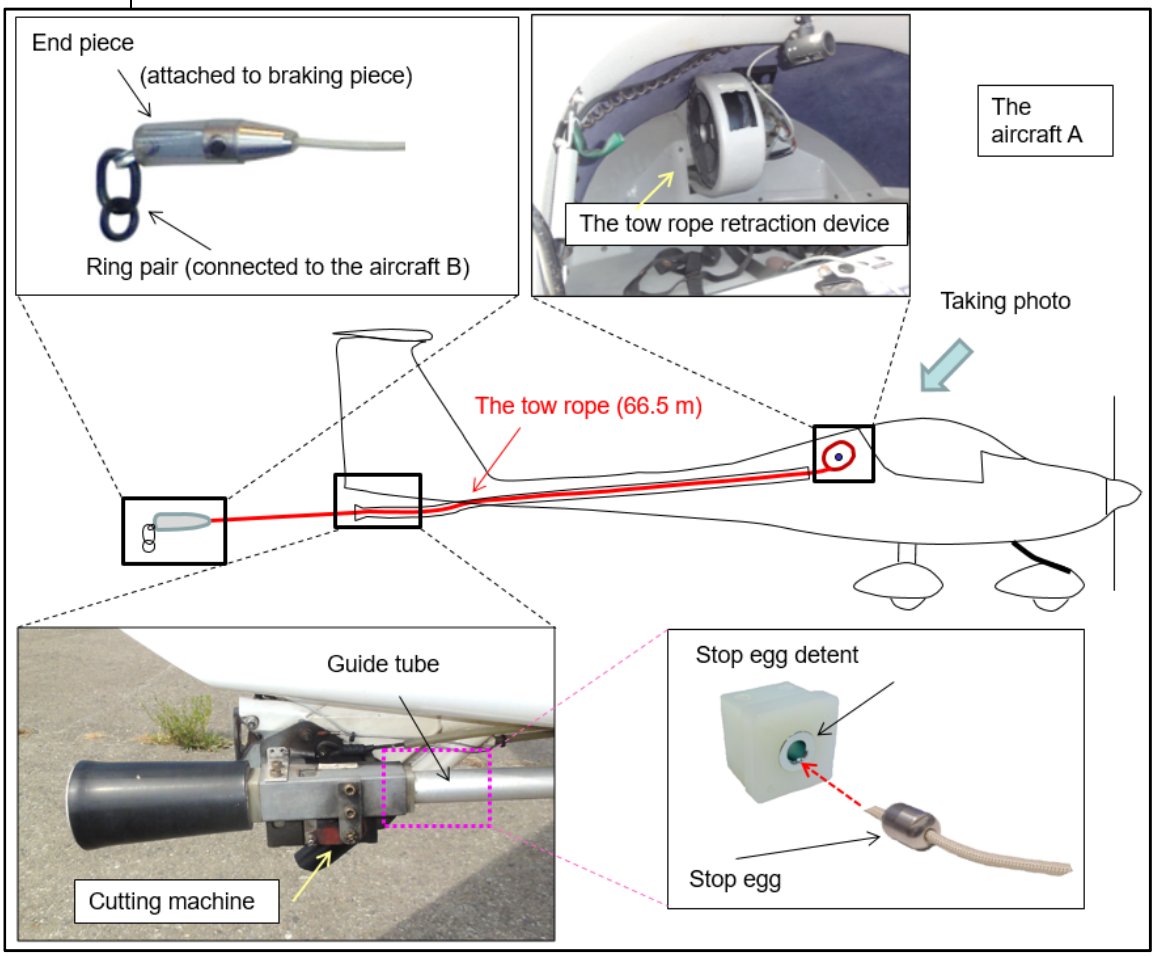


Figure 8 Installation of the tow rope

(4) Flight manual addendum and relevant engineering documents

i Flight manual addendum

The Flight manual individual addendum No. 9 “OPERATION WITH TOW-ROPE RETRACTION DEVICE” onboard the aircraft A described as follows regarding specifications and inspection periods of the tow rope. However, it did not contain descriptions regarding confirmation of damage to the tow rope within the stop egg and sliding of a knot in the tow rope within the end piece.

6.9 EQUIPMENT LIST

Tow rope at a length of 30 to 50 m (98 to 164 ft), made of PVC or polyamide with max diameter 6.3 mm (0.25 in.) with green marking of DAI-WI No. 27.

8.2 INSPECTION PERIODS

After 2,000 landings in tow-plane operation a new tow rope must be installed.

ii Relevant engineering documents

According to personnel of the League involved in inspection and maintenance of the aircraft A, they did not obtain DAI-WI (Work Instruction) No. 27, and accordingly, did not know what was described in

the WI. Besides, as a result of the inquiry to the Design and Manufacturer of the aircraft A about descriptions of DAI-WI No. 27 during the investigation, it was revealed that the number of DAI-WI No. 27 was incorrect, and the correct number was 28. DAI-WI No. 28 contained following descriptions regarding tow rope treatment (see Figure 9):

- Installation of the stop egg

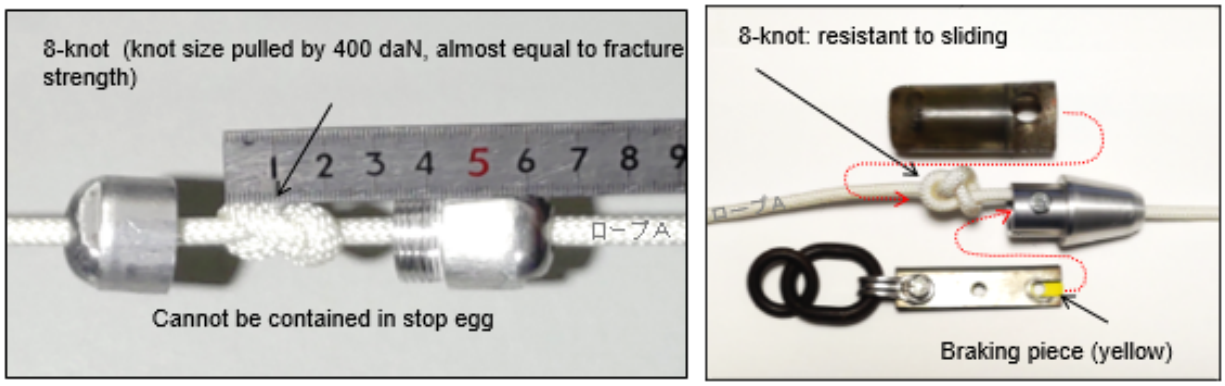
  Separate sleeve in two by twisting, and thread the half with the spherical inner surface onto rope. Make knot in the shape of a figure-eight. Screw to second half of sleeve so that the knot lies within the sleeve.

- Installation of the end piece

  Thread aluminum part of end piece onto rope. Make knot in the shape of an 8 within the end piece so that the knot lies within the end piece.

iii Treatment of the tow rope (how to make a knot)

In the investigation, figure-eight knot was made in a genuine tow rope of the design and manufacturer of the tow rope retraction device (hereinafter referred to as “the Rope A”) in an attempt to verify whether the knot could lie within the stop egg and end piece. As a result, it was confirmed that figure-eight knot was difficult to lie with the stop egg. A single knot could lie within the stop egg. Besides, figure-eight knot could lie within the end piece.



Stop egg is open (cannot contain)　　End piece is open

Figure 9　The tow-rope treatment based on DAI-WI No. 28(Rope A)

(5) Use record of the tow rope

The tow rope of the aircraft A was not the one originally installed in the tow rope retraction device, but was purchased in aftermarket in Japan, and was made of polyester at a length of approximately 66.5 m and maximum diameter of 7 ㎜. Strength test on the subject tow rope was conducted by the supplier and evaluated to be of sufficient strength by simply testing a straight-line strength without a knot, instead of the strength test of a knot in actual use conditions. The number of landings by tow flight was 669 since June 21, 2018, when the tow rope was first installed in the aircraft A.

(6) Tensile strength test of the tow rope

To compare tensile strength of a tow rope between without a knot

(straight-line strength) and with a knot (knot strength), the Rope A, the tow rope used in the serious incident (hereinafter referred to as "the Rope B"), and a brand-new Rope B (hereinafter referred to as "the Rope B New") were tested. The test was conducted with the knots lying within the stop egg or end piece used in towing except for the straight-line tensile strength test that does not have a knot.

Tensile test of the Rope A and Rope B with a single knot (simple overhand knot) was conducted to measure the load that led to knot fracture (strength of the knot: mean value of three-time measurement). The test result indicated that the Rope A had an approximately 500 daN*3, and the Rope B had an approximately 350 daN (approximately 70% of the Rope A). Besides, the Rope B New was also tested with a result that there was no significant difference from the Rope B in terms of the strength of the knot. Furthermore, a knot was made first by 10 daN followed by applying load less than endurable load of the fuse (100 to 300 daN). The result showed that the knot in every tow rope was confirmed to have slid (3 to 5 cm).

Tensile test by figure-eight knot in the manner as described in DAI-WI No. 28 was conducted with three tow ropes. The result showed that the tensile strength of the figure eight-knot of every tow rope deteriorated by almost 50% from the straight-line tensile strength likewise the single knot. Besides, a knot was made first by 10 daN to test sliding of the figure eight-knot per load. As a result, it was confirmed that sliding of every tow rope was stable staying 1 mm or less.

Table 1 Rope tensile strength test

Test items	Rope A	Rope B	Rope B New	Rope B/A	Rope B new/A
Straight-line strength (average of 3times: daN)	1108	649	610	59%	55%
Single knot strength (average of 3times: daN)	○517	▲351	▲374	68%	72%
Knot strength/straight-line strength	47%	54%	61%		
8-knot strength (average of 3times: daN)	○486	▲348	▲391	72%	80%
Knot strength/straight-line strength	44%	54%	64%		
Stop egg in normal direction (average of 3times: daN)	○447	▲348	▲361	78%	81%
Stop egg in reverse direction (average of 3times: daN)	○470	▲344	▲366	72%	78%
Stop egg in reverse direction/normal direction	105%	99%	101%		

○: used braking piece strength of 392 daN or more

▲: less than used braking piece strength of 392 daN

Table 2 Braking piece tensile strength test

New (daN)	Used (daN)
378	392

*3 1daN = 10N 1.02 kgf

Table 3 Knot sliding test (single knot)

Load	Rope A	Rope B	Rope B new
100 daN (average of 3times: mm)	32	26	34
200 daN (average of 3times: mm)	41	38	46
300 daN (average of 3times: mm)	49	46	55

Table 4 Knot sliding test (8-knot)

Load	Rope A	Rope B	Rope B new
100 daN (average of 3times: mm)	0.5	0.7	0.7
200 daN (average of 3times: mm)	0.7	0.8	0.8
300 daN (average of 3times: mm)	0.7	0.8	0.8

Furthermore, comparative tensile test by setting the stop egg in the direction as described in the procedure and in the reverse direction thereof was conducted with the result of no significant difference observed between both (see Table 1).

(7) Reference documents regarding strength of knot made in the tow rope

6-6 in "Glider Flying Handbook" published by FAA describes, "*A knot in the tow rope reduces its strength by up to 50 percent.*"

(8) Tow rope material test

Flight manual addendum specified the material of the tow rope to be "PVC or polyamide".

Fiber identification test conducted at a testing laboratory by Attenuated Total Reflection method (ATR method) determined that the material of the domestic-manufactured tow rope used in the serious incident, both Rope B and Rope B New, was polyester. On the other hand, the test result revealed that the Rope A had materials of polyester on the surface and middle layers and polyamide (nylon) only in the core (Figure 10). Besides, confirmation was made with the Design and Manufacturer of the aircraft A that a polyester make was also usable in addition to PVC and polyamide, which was reflected on the Flight manual addendum No.9 thereafter.

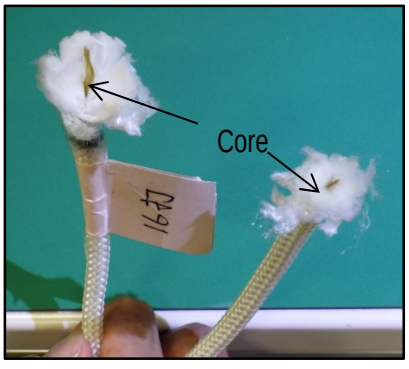


Figure10 Cross section of Rope A

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) Drop out conditions of the tow rope The aircraft A and B performed meandering flight and circling several times during tow flights. From the footage showing the moment of the tow rope drop out and the conditions of the recovered tow rope end, the JTSB concludes that it is highly probable that excessive tensile force was applied to the tow rope when the aircraft A circled to the left for the third demonstration flight, and the tow rope was fractured in the knot within the stop egg on the aircraft A side. Furthermore, due to the knot that was almost simultaneously untied within the end piece on the aircraft B side, it is highly probable that the tow rope was dropped when flying at an altitude of approximately 500 ft. (2) Fractured knot within the stop egg on the aircraft A side Tensile strength test of the tow rope revealed that the Rope A in conformity with the Flight manual kept a sufficient strength that was higher than the braking piece strength (400 daN) although the strength deteriorated due to a knot made in the tow rope. On the other hand, the Rope B was revealed to have deteriorated to less than the braking piece strength when a knot was made in the tow rope. The tow rope was used based on the evaluation of only the straight-line strength test without making a knot, instead of making a knot in actual use, when delivered to the League. The JTSB concludes that it is probable that this resulted in the insufficient strength due to a knot made within the stop egg and the fracture at less than the strength at which the braking piece acted. The League should have used a tow rope that held the strength in conformity with the Flight manual (a polyester-made genuine tow rope of the design and manufacturer of the tow-rope retraction device, or the equivalent). As described in 6.6 of "Glider Flying Handbook" published by FAA that "*A knot in the tow rope reduces its strength by up to 50 percent*", it is of importance that a tow rope be used with a knot that is tied by the installation method in accordance with the Flight manual, and have an enough allowance in the strength at which the braking piece acts. (3) Knot untied within the end piece on the aircraft B side The JTSB concludes that it is highly probable that a knot in the tow rope within the end piece attached to the aircraft B gradually moved toward the rope end by receiving repetitive tensile load while it had been used until the serious incident flight. Then, it is probable that the knot within the stop egg of the aircraft A was fractured since the rope remained in the aircraft B was untied from tensile force and rapidly began irregularly moving due to the fractured tow rope within the stop egg under the load of a large tensile force. According to DAI-WI No. 28, a knot in the tow rope was to be made in

figure-eight knot. However, the League did not obtain DAI-WI No. 27 and 28, and did not realize what was described therein. .

From the results of sliding tests of part of knots, it was confirmed that a single knot is easier to slide than a figure-eight knot. From this, the JTSB concludes that it is likely that the knot in the tow rope threaded onto the end piece on the aircraft B side and used in the serious incident was a single knot, not a figure-eight knot.

(4) Conformity of equipment installation and inspection based on the Flight manual

Attaching a tow rope to the stop egg is to be appropriately conducted in accordance with DAI-WI No. 28. However, through the investigation, it was revealed that figure-eight knot of the Rope A was too big to be contained within the stop egg. Inquiry on this point was made to the Design and Manufacturer of the aircraft A, which responded that DAI-WI No. 28 was revised to make a single knot within the stop egg according to DAI-WI No. 28.

Besides, when attaching a tow rope within the end piece, figure-eight knot is required to be securely made and be contained within the end piece.

It is of importance that personnel engaged in preparation and control of the Flight manual establish system to gather information necessary for safe flight, revise the Flight manual as appropriately, and forward information to owners of the type of the aircraft in a timely and appropriate manner.

According to the captain of the aircraft A, in the first preflight check of the day, the condition of the knot in the tow rope within the stop egg and end piece was not confirmed, and had not been confirmed in the past as far as the captain remembered.

Considering that a tow rope can be damaged within the stop egg, and a knot first tied in the tow rope is not maintained and is possibly untied by sliding while towing has repetitively been conducted, the JTSB concludes that it is of importance to check damage to the tow rope within the stop egg and inspect a knot position and tightening condition of the tow rope within the end piece at appropriate intervals depending on usage conditions of the tow rope.

4. PROBABLE CAUSES

The JTSB concludes that the probable cause of the serious incident was most likely that, when the aircraft A was flying towing the aircraft B in the serious incident, the tow rope connecting both aircraft was fractured on the aircraft A side, and the knot made within the end piece on the aircraft B side was untied almost simultaneously, which led to dropping of the tow rope on the grassy area of the Airport.

5. SAFETY ACTIONS

(1) Measures taken by the Design and Manufacturer of the aircraft A

Supplement Aircraft Flight Manual prepared by the Design and Manufacturer and cited in the Flight manual addendum No. 9 was revised reading “DAI-WI No. 28” from “DAI-WI No. 27”.

In 6.9 EQUIPMENT LIST of the Flight manual addendum No. 9 “OPERATION WITH TOW-ROPE RETRACTION DEVICE”, the materials used in the tow rope was revised reading

“polyester, PVC, or polyamide” from “PVC, or polyamide”.

Furthermore, the Design and Manufacturer revised DAI-WI No. 28 stipulating that a knot within the stop egg is to be a single knot.

(2) Major measures taken by the League

After the serious incident, the League decided to take safety measures as described below, and is set to review the safety measures as needed. Besides, the measures i. and ii. described below were released in association with taking the measures iii. through vi. described below:

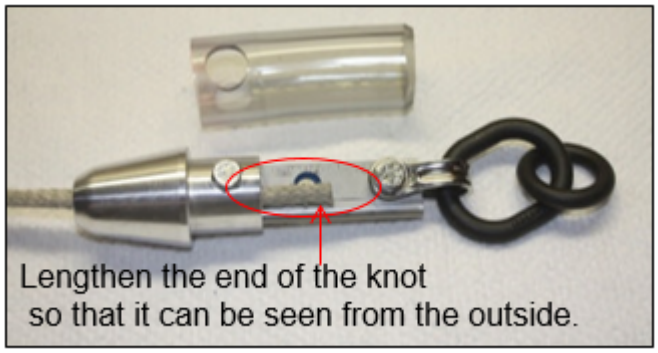
i. Level flight in towing and meandering flight are suspended until the cause of the serious incident is determined since towing in level flight such as demonstration flight within an airport and meandering flight are prone to generate loosened tow rope compared to towing at launching.

ii. Tow rope retraction device is suspended until the cause of the serious incident is determined.

iii. Tow rope used in the aircraft A is to be a genuine one of the design and manufacturer of the tow rope retraction device, which meets the requirements of the Flight manual addendum No. 9.

iv. Knots within the stop egg and end piece are appropriately made in accordance with DAI-WI No. 28-/3.

v. A knot within the end piece has a longer remainder of the rope after knotted so that sliding of the knot can be visually confirmed.



vi. Latest engineering information (AFM, and WI, etc.) is confirmed for reflecting on the Flight manual. Besides, safe flight in accordance with the Flight manual is performed.