Ultralight Vehicle Accident Report

Dived and Crashed While Turning
Songdo Flight Club
ULM COSMOS (Powered Ultralight Vehicle), S1045
Reclaimed Land of Lot No.6 in Songdo-dong,
Yeonsu-gu, Incheon-si
12 June 2012

June 2013

AVIATION AND RAILWAY ACCIDENT INVESTIGATION BOARD

According to the provisions of the Article 30 of the Aviation and Railway Accident Investigation Act, it is stipulated;

The accident investigation shall be conducted separately from any judicial, administrative disposition or administrative lawsuit proceedings associated with civil or criminal liability.

And in the Annex 13 to the Convention on International Civil Aviation, Paragraphs 3.1 and 5.4.1, it is stipulated as follows:

The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of the activity to apportion blame or liability. Any investigation conducted in accordance with the provision of this Annex shall be separate from any judicial or administrative proceedings to apportion blame or liability.

Thus, this investigation report issued as the result of the investigation on the basis of the Aviation and Railway Accident Investigation Act of the Republic of Korea shall not be used for any other purpose than to improve aviation safety.

In case of divergent interpretation of this report between the Korean and English languages, the Korean text shall prevail.

Ultralight Vehicle Accident Report

Aviation and Railway Accident Investigation Board. ***Dived and Crashed While Turning, Private Ownership, S1045 (Powered Ultralight Vehicle - Weight Shift Control), Reclaimed Land of Lot No.6 in Songdo-dong, Yeonsu-gu, Incheon-si, 12 June 2012.*** **Ultralight Vehicle Accident Report ARAIB/UAR1201. Sejong Special Self-governing City, Republic of Korea.**

The Aviation and Railway Accident Investigation Board (ARAIB), Republic of Korea, is a government organization established for independent investigation of aviation and railway accident, and the ARAIB conducts accident investigation in accordance with the provisions of the Aviation and Railway Accident Investigation Act of the Republic of Korea and Annex 13 to the Convention on International Civil Aviation.

The objective of the investigation by the ARAIB is not to apportion blame or liability but to prevent accidents and incidents.

The main office is located in Sejong Special Self-governing City.

Address: #94, Dasom 2-ro, Sejong Special Self-governing City, 339-012
Tel.: (82)-44-201-5447
Fax: (82)-44-201-5698
e-mail: araib@korea.kr
URL: http://www.araib.go.kr

Contents

Dived and Crashed While Turning

- ○ Operator: Songdo Flight Club
- ○ Manufacturer: OEM[1] by the Chinese Beijing International Unite Flight
  * Design : French Cosmos
- ○ Type: Weight-Shift, Powered Ultralight Vehicle (Top14.9+Phase Ⅲ)
- ○ Registration Mark: S1045
- ○ Location: Reclaimed Land of Lot No.6 adjacent to Jack Nicklaus Golf Club in Songdo-dong, Yeonsu-gu, Incheon-si
- ○ Date & Time: 12 June 2012, about 13:08 (Korean Standard Time[2])

Synopsis

On 12 June 2012 (Tue), about 13:08, a weight-shift powered ultralight vehicle, S1045, affiliated with Songdo Flight Club, crashed into the reclaimed land of lot No.6 adjacent to Jack Nicklaus Golf Club in Songdo-dong, Yeonsu-gu, Incheon-si while making a left turn during an experience flight.

Aboard the ultralight vehicle were one operator (male, age 40) and one passenger (female, age 44). They were fatally injured, and the vehicle was destroyed.

The Aviation and Railway Accident Investigation Board (ARAIB) determines that the probable cause of this accident was 「As the vehicle was affected by its tendency to drift towards the inside of the turn and a strong tailwind during a left descending turn at a low speed, it was put into a stall and a steep diving attitude, and while attempting a recovery maneuver at a low altitude, the vehicle entered a right spin and crashed.」

1) Original Equipment Manufacturing.
2) Unless otherwise indicated, all times in this report are Korean Standard Time, based on 24-hour clock.

Regarding this accident, the ARAIB addresses three recommendations to the Ministry of Land, Infrastructure and Transport (Civil Aviation Office), one recommendation to Regional Aviation Administrations, three recommendations to Korea Transportation Safety Authority, and two recommendations to Federation of Korea Aeronautics, Korea Sport Aviation Association, and Korea Light Aviation Association.

1. Factual Information

1.1 History of Flight

On the day of the accident, the operator and seven people[3] who desired to experience flight arrived at Songdo Airfield about 11:40 and 12:00, respectively. An actual owner[4] (hereafter referred to as the owner) of S1045, a weight-shift powered ultralight vehicle (hereafter referred to as the vehicle), took a test flight before all the people and gave an explanation[5] of S1045 to the operator. Then, he handed S1045 over to the operator, saying that the atmosphere was not good due to a west wind.

Beginning about 12:20, the operator who took over S1045 started an experience flight with one passenger seated in the back seat. Each flight lasted for about 12 minutes including five minutes of taxiing and passenger change and seven minutes of flight time. A passenger who had a third experience flight stated that the operator said during taxiing the wind was too strong. After a fourth takeoff, after which the accident occurred, the owner came to a group of passengers waiting for their turn and asked, "When did the vehicle take off? Refueling should be done." Several minutes later, he got a phone call about the accident occurrence.

3) They were all social gathering members, six of which work for the same company. They came to experience flight due to the suggestion of a fatally injured.
4) He became the owner of S1045 under an agreement, but ownership transfer was reported after the accident.
5) The weight-shift ultralight vehicle (Zoom 19+Phase II) owned by the operator on Anmyeon-do and S1045 (Top 14.9+Phase III) have a difference in performance of the engine and wings. The operator had previously flown S1045 three times.

A witness[6] doing exercise at Jack Nicklaus Golf Club stated that "the ultralight vehicle that was turning dived at a steeper angle and rotated as if it was overturning, then a litter later, there was a thump, so he determined the aircraft crashed and reported the accident to 112".

Another witness[7] riding a bicycle on the road adjacent to the crash point (reclaimed land)[8] stated that "as he heard the sound of the vehicle, he looked aside and saw it, and that a little later, the vehicle making a turn seemed to fall in a spiral vertically, then a litter later, there was a "thump", so he reported the accident to 119".

The Incheon 119 Safety Center and related rescue workers were dispatched to the accident site, and the operator and the passenger aboard were pronounced dead at the site and transported to a nearby hospital.

6) Located approximately 265 m east of the crash point.
7) Located approximately 150 m southeast of the crash point.
8) Located 4.1 km southwest (220°) of Songdo Airfield.

[Figure 1] S1045 Flight Path

1.2 Injuries to Persons

Injuries	Fatal	Serious	Minor/None
Operator	1	0	0
Passenger	1	0	0
Total	2	0	0

1.3 Damage to Ultralight Vehicle

S1045's landing gear, vertical and horizontal tubes, cockpit instrument panel, etc. were destroyed, and two of the three propeller blades were damaged. There was damage to the leading edge of the left wing at the nose plate as well as the cross bar.

1.4 Other Damage

None.

1.5 Personnel Information

1.5.1 Certificates

The operator held the (powered) ultralight vehicle pilot license[9], the (weight-shift) light sport aircraft pilot license[10], and the light sport aircraft[11] pilot training certificate[12], three of which were all issued by the Korea Transportation Safety Authority (KTSA).

1.5.2 Flight Experience

Club members and the operator's family members stated that since the operator had started hang gliding in 1994, he had accumulated more than 500 flights, and that he had participated in the World Championships for Hang Gliding twice. Since the operator had started a weight-shift powered ultralight vehicle in 2007, he had accumulated about 1,500 flight hours[13]. He obtained the light sport aircraft pilot license and the light sport aircraft pilot training certificate in 2010, and was undergoing private pilot license training in Australia. Also, he had two flights and one flight on S1045 in November 2011 and January 2012, respectively.

9) Acquisition Date: 17 Sep. 2007.
10) Acquisition Date: 22 Jul. 2010.
11) S1045 and the ultralight vehicle owned by the operator shall be operated as light sport aircraft beginning 10 September 2012, the expiry date of transitional measures concerning ultralight vehicle [Aviation Act, Addenda (No.9780), Article 2].
12) Acquisition Date: 22 Jul. 2010.
13) His flight log concerning flight hours was not managed.

1.5.3 Operator's Whereabouts in the 72 Hours before Flight

According to the statement of the operator's family members, on 9 June 2012 (Sat), about 06:00, he departed for Anmyeon-do, flew a weight-shift powered ultralight vehicle, then spent the night on Anmyeon-do. On 10 June (Sun), he also had a flight. On 11 June (Mon), from 11:00 to 19:00, he worked at his shop and went to bed about 21:00. On 12 June (Tue), about 08:00, he got up and had breakfast, and said to the family members that, after stopping by his shop at 09:00, then a fitness club, he would go to Songdo Airfield.

The operator was a positive person who was easy to get along with other people. He put emphasis on safety whenever he flew. When he flew a weight-shift powered ultralight vehicle, he never encountered an accident, but he made an emergency landing once in a non-powered hang glider. It was said that he tended to be calm in an emergency situation.

1.6 Ultralight Vehicle Information

1.6.1 General

S1045 was designed by the French COSMOS and OEMed by the Chinese Beijing International Unite Flight, and delivered on 20 April 2008. S1045 was equipped with the Top14.9 wing, a three blade propeller, and the ROTAX 912UL engine manufactured by ROTAX (BRP-Powertrain GmbH & Co KG).

Since delivered, S1045 has passed the KTSA's safety certification inspection three times[14]. The safety certificate[15] issued on 17 May 2012 was expired on 9 September 2012.

14) Inspection Date: 13 - 14 Jan. 2009, 15 - 17 Mar. 2011, and 16 May 2012.
15) Certificate No.: KQ12-102.

1.6.2 Wings

1.6.2.1 Wing Type of S1045 (Top14.9)

The safety certificate issued on 15 May 2012 recorded S1045's wing type as Top16.9, but the affected vehicle's wing type was Top14.9[16].

The KTSA actually inspected both types, Top16.9 and Top14.9, on 13 - 14 January 2009, and recorded S1045's wing type not only as Top16.9 in a safety certificate issued on 22 January 2009 but also as Top14.9 in a remarks column of the same certificate, thereby granting certification to both types in effect.

S1045's Top14.9 alone underwent safety inspection on 15 - 17 March 2011 and 16 May 2012, but the following safety certificates issued on 25 March 2011 and 17 May 2012 recorded S1045's wing type as Top16.9, whereas Top14.9 was not even recorded in their remarks column.

The KTSA inspects available types of wings that can be combined with a single fuselage of a weight-shift type among ultralight vehicles and light sport aircraft, and issues a safety certificate, but there were no specific relevant provisions in the safety certification inspection procedures.

1.6.2.2 Characteristics of Top14.9

Top14.9 was a wing type designed by the French COSMOS and OEMed by the Chinese Beijing International Unite Flight, but its manufacture and serial numbers were not managed, and whether safety inspection after its manufacture was performed was not verified, either.

Consultation with experts and club members who imported and flew the same

16) Top14.9 is a wing type designed by COSMOS, indicating the area of the wings (14.9 ㎡).

type wing manufactured in China revealed that, although this wing enables the aircraft to fly at a rapid speed, it cannot hold wind during turn and lets the wind leak through, and that as a result, failing to maintain centrifugal forces, ultralight vehicles tend to drift towards the inside of the turn.

1.6.3 Maintenance Records

Maintenance records of S1045's engine[17] and airframe were not managed.

1.6.4 Difference Between S1045 and the Operator's S1040

The operator established Leisure Hunter Inc.[18] on Anmyeon-do and operated a weight-shift powered ultralight vehicle (S1040[19]). Performance and specifications of and differences between S1045 and S1040 owned by the operator are shown in [Table 1].

17) During safety certification inspection, a significant difference was found between 273 engine service hours accumulated (Hour Meter) and 150 engine service hours claimed by the owner.

18) Leisure Hunter Inc. does leports business such as mountain bike rental, paintball game organization, and provision of flight experience.

19) S1040 is a weight-shift powered ultralight vehicle (Phase II-Zoom 19) registered as a non-commercial (for leisure).

Category		Operator's Ultralight Vehicle (S1040)	Affected Ultralight Vehicle (S1045)
Model	Airframe	Phase II	Phase III
	Wing	Zoom 19	Top 14.9
	Engine	ROTAX 582-UL	ROTAX 912-UL
	Instrument	SKYDAT GX1	SKYDAT GX2
Engine	Horse Power	64 hp	80 hp
	Fuel	High-Grade Gasoline (95 + octane rating)	High-Grade Gasoline (95 + octane rating)
Wing	Area	18.50 m^2	14.9 m^2
	Weight	44 kg	46 kg
	Width	10.6 m	9.87 m
	Fineness Ratio	6.07	6.44
	Nose Angle	130°	130°
Major Specifications	Acceleration Gravity Limit	+6G - 4G/350 kg	+6G - 4G/350 kg
	Stall Speed	38 km/hr	45 km/hr
	Cruising Speed	60 km/hr	100 km/hr
	Max. Speed	85 km/hr	145 km/hr
	Vne	76 km/hr	130 km/hr
	Length/Wingspan/ Height (unit: m)	2.5/1.92/2.45	2.5/2.7/1.86
	Weight/ Max. Takeoff Weight	185 kg/450 kg	225 kg/450 kg
	Advantage	Training, Aero Towing	High Speed, Short Distance Takeoff

[Table 1] Comparison Between S1040 and S1045

1.6.5 Engine Teardown Inspection

In November 2012, in the presence of investigators from Korea and Austria,

the engine underwent comprehensive teardown and testing at the engine manufacturer's premises (BRP-Powertrain GmbH & Co KG) in Wels, Austria. The results revealed that no anomaly was found with the engine's function, but whether the engine was in normal operation before crash was not verified.

Inspection results revealed that there were the following anomalies and defects with carburetor, oil return line, fuel pump, etc.

1.6.5.1 Carburetors

1.6.5.1.1 Throttle Valve Lever

The throttle valve lever, which determines the position of the throttle valve[20], was altered contrary to the delivery status prescribed by the engine manufacturer's installation manual as shown by the right carburetor in [Figure 2].

[Figure 2] Delivered Carburetor (left) & Modified Carburetor (right)

20) The throttle valve controls the thrust of an airplane, acting like an accelerator of a car.

The engine manufacturer set up a fail-safe[21] system that functions as follows: if the Bowden cable[22] is not connected or is fractured, the throttle valve will automatically move into full throttle position, but S1045's throttle valve lever was fitted contrary to the position prescribed by the manufacturer, the consequence of which is that the throttle valve will close to such an extent that the minimum thrust will be used.

In the case of ultralight vehicles that control the thrust level by using a foot, many vehicle manufacturers actually altered the throttle valve lever in a way that the throttle valve is closed as above.

One of the vehicle manufacturers replied that, "due to a foot's functional limit that force tends to be applied in a direction of pushing, the carburetor's spring acts in a way that the throttle valve is closed", which is contrary to the fail-safe mechanism, and that, since it had to add many mechanical devices to use a fail-safe system, it opted out".

1.6.5.1.2 External Contamination of the carburetor

As shown in [Figure 3], one[23] of the four carburetors displayed severe external contamination due to a loose banjo bolt that tightens a connecting nipple. The manufacturer's experts determined that contamination resulted from the accumulated deposits of oil and dirt caused by fuel leakage for a long period of time, and that this looseness existed even before the accident.

21) A fail-safe device is one that, in the event of failure, automatically responds in a way that will ensure safety.
22) A Bowden cable connected to a choke valve is a flexible cable that controls the engine thrust level.
23) Right forward one (2/4) out of the four carburetors when viewed from the back.

[Figure 3] Carburetor Contaminated by a Loose Banjo Bolt

1.6.5.2 Oil Return Line

The oil return line was fitted contrary to the position described in the ROTAX installation manual. The manufacturer, in consideration of the vehicle's attitude during flight, installed the oil return line at a relatively low position to ensure smooth oil circulation.

For such an aircraft type with a pusher configuration[24] as S1045, the oil return line should be installed on the right as shown below, but it was fitted on the left as in the case of a tractor configuration[25].

24) An aircraft constructed with a pusher configuration has the propeller(s) mounted behind their respective engine(s), so that the aircraft is "pushed" through the air.
25) An aircraft constructed with a tractor configuration has the engine mounted with the propeller facing forward, so that the aircraft is "pulled" through the air.

[Figure 4] Oil Return Line Installed at a different position

1.6.5.3 Fuel Pump

As shown in [Figure 5], dirt deposits, which formed a permanent build-up together with leaking fuel for a long period, were clearly visible on the cast housing, and thus the fuel pump was tested for fuel leakage and fuel pressure on the component test bed. As shown in [Figure 6], the test revealed that fuel leaked from the fuel pump, and that fuel pressure was measured at 0.3 bar, which was within tolerated pressure range from 0.15 bar to 0.4 bar. It was analyzed, however, that the leakage did not affect the function of the pump.

[Figure 5] Dirt Deposits Caused by Fuel Leakage

[Figure 6] Leakage of Fuel

1.7 Meteorological Information

1.7.1 Weather Conditions near the Accident Site

Weather conditions at Dongchun-dong and Incheon International Airport on 12 June 2012 about 13:08 (time of the accident) are as follows:

○ Weather observation system in Dongchun-dong, Yeonsu-gu, Incheon-si

-13:00: ceiling & visibility O.K., southwest wind, 255°/10.5 kts (5.4 m/sec), pressure 1,000 mb

○ A METAR weather report at Incheon International Airport[26)]

"METAR RKSI 120400Z 30009KT 9999 FEW030 26/13 Q1000"
-13:00: ceiling & visibility O.K., northwest wind, 300°/9 kts (4.6 m/sec), temperature 26℃, pressure 1,000 mb

26) Located 17 km northwest of the accident site.

1.7.2 Wind at the Time of the Accident

The average change of wind per minute around the time of the accident (13:08) at Incheon International Airport and Songdo is shown in [Table 2].

Weather Observation	Runway 33R at Incheon Airport		Songdo Sports Center in Dongchun-dong, Yeonsu-gu (AWS data[27])	
Date & Time (12 Jun. 2012)	One-min. Av. Wind Direction (degree)	One-min. Av. Wind Speed kts (m/s)	One-min. Av. Wind Direction (degree)	One-min. Av. Wind Speed kts (m/s)
13:00	330	9.4 (4.8)	256	10.5 (5.4)
13:01	320	9.1 (4.7)	257	10.1 (5.2)
13:02	310	9.0 (4.6)	254	10.1 (5.2)
13:03	310	9.1 (4.7)	255	10.1 (5.2)
13:04	320	9.7 (5.0)	253	9.9 (5.1)
13:05	320	8.8 (4.5)	255	10.7 (5.5)
13:06	320	8.2 (4.2)	254	10.3 (5.3)
13:07	320	9.0 (4.6)	254	10.1 (5.2)
13:08	300	9.4 (4.8)	253	9.7 (5.0)
13:09	300	9.0 (4.6)	252	10.1 (5.2)
13:10	310	9.5 (4.9)	255	10.1 (5.2)
13:11	310	10.2 (5.2)	255	11.1 (5.7)

[Table 2] Wind Data from Weather Observation Centers near Songdo

1.7.3 Statement on Weather Conditions

Passengers who desired to experience flight stated that the owner handed the vehicle over to the operator after a test flight, saying the atmosphere was not good due to a west wind. One of the passengers who had a third experience flight stated that the operator told her the wind was strong up there, and that when they flew toward the Incheon Bridge after takeoff, she felt like the vehicle was stopping in the air due to a headwind (west-south-west wind).

27) An automatic weather station (AWS) is an automated unmanned version of the traditional weather station, which operates weather observation equipment and collects weather data for the purpose of monitoring dangerous local weather conditions in real time.

Witnesses near the accident site stated that the wind was strong in Songdo area, and that, around the time of the accident, there was a gust of wind which blew off the signboard in the Namdong industrial complex.

1.8 Aids to Navigation

Not applied.

1.9 Communications

Not applied.

1.10 Airfield and Flight Area Information

1.10.1 Songdo Airfield

Since 1989, Songdo Airfield has been used by ultralight amphibious aircraft operated by individuals and club members to transport emergency patients in island areas and monitor the environment.

① Location/Address: N37 24 43, E126 38 39/Dongchun-dong #907, Yeonsu-gu, Incheon-si

② Runway: direction 130°/310°, altitude 10 ft, length and width 400 m × 20 m

③ Pavement: stone powder

1.10.2 Songdo Flight Area for Ultralight Vehicles

In June 1992, the area within a 3 km radius of Songdo Airfield, at an altitude of less than 500 ft AGL was designated as the Songdo flight area for ultralight vehicles, but beginning June 2010, it was reduced to a radius of 1.8 km.

In the aftermath of this accident, residents in Songdo, Incheon and the Incheon

Free Economic Zone Authority demanded the revocation of the flight area designation.

The Ministry of Land, Infrastructure and Transport (MOLIT) conducted investigation into the flight suitability of the Songdo flight area such as the flight environment, flight route, etc., collected relevant opinions, and held a briefing, then suggested the revocation of the designation to the Flight Area Working-Level Committee. This suggestion was passed in the committee on 24 September 2012, and as a result, the Songdo flight area was revoked.

1.10.3 Domestic Airfields for Ultralight Vehicles and Light Sport Aircraft

As of 1 July 2012, the number of ultralight vehicle operators and light sport aircraft pilots was annually increasing by about 200 to 1,752 and 661, respectively. As of 1 December 2012, the number of ultralight vehicles and light sport aircraft registered and reported was 600 and 191, respectively. As for private organizations, Federation of Korea Aeronautics has eight affiliated bodies, and under the Ministry of Culture, Sports and Tourism, Korea Sport Aviation Association is registered.

As of 1 December 2012, the number of airfields for ultralight vehicles and light sport aircraft (hereafter referred to as the airfields) was 7 in the metropolitan area, 9 in the Gyeongsang area, 6 in the Chungcheong area, and 6 in the Jeolla area, totalling 28 nationwide, but recently, the number has reduced to 25 since two airfields near Lake Sihwa and Songdo Airfield were closed.

The definition and standards of airfields are not specified in the Korean Aviation Act, and currently, airfields are located on three private lands, two local government sites, and 13 river sites, 10 of which were occupied by club members without permission.

Most of the domestic airfields including Songdo Airfield are not equipped with facilities necessary for the operation of ultralight vehicles and light sport aircraft, such as fueling facility, maintenance facility, fight information facility, flight preparation facility, etc.

1.10.4 Deviation from the Flight Area

As of 1 December 2012, 26 airspaces nationwide were designated as ultralight vehicle flight areas. Their horizontal range varies from minimum 0.7 km to maximum 7 km radius of the central point of the flight area, and their vertical range varies from ground to 500 ft AGL. Outside these areas, ultralight vehicles are restricted to fly, and to fly in the restricted areas, operators should submit their flight plans in advance and get an approval from the MOLIT Minister in accordance with Aviation Act, Article 23, Paragraph 2.

S1045, without an approval for its restricted area flight plan, deviated 1.8 km from the central point of the Songdo flight area and crashed 4.1 km southwest (220°) of the point.

After deviation from the Songdo flight area, the affected vehicle entered the restricted area, which meant it became beyond the nation's supervision and detection capacity.

1.11 Engine Data Storage Device

S1045 is not equipped with an engine data storage device.

1.12 Wreckage and Impact Information

1.12.1 General

As shown in [Figure 7], the fuselage tilted to the right at about 60° with its longitudinal axis in a north-north-west direction. Wings were located about 70° more to the right from the longitudinal axis in an east-east-north direction. The leading edge of the right wing was in touch with the ground, and its trailing edge was lifted towards the air at about 60° from the ground.

The wreckage was found on the accident site as follows: the left landing gear was found about 10 m west from the longitudinal axis of the fuselage; the forward landing gear and the right landing gear about 6 m west; the operator's seat about 4 m southwest; the forward landing gear cover about 5 m north-north-west; and the left shoe of the passenger about 8m north-north-west. A skid mark and a mark created when the vehicle was dragged on ground were not found on the site.

[Figure 7] Wreckage Distribution on the Accident Site

1.12.2 Landing Gear

As shown in [Figure 8], connecting rods were damaged, and the right landing gear went flat.

Left Landing Gear	Forward Landing Gear	Right Landing Gear
		

[Figure 8] Landing Gear Damage

1.12.3 Propeller

As shown in [Figure 9], two of the three propeller blades were damaged. The preceding blade was damaged mainly at the center from 1/3 point from the central axis of the propeller to the end of the inner wire, but the tip of the blade still remained attached. The succeeding blade sustained more severe damage, and the support rod inside the blade penetrated through it and bent about max. 40° in the opposite direction to the rotation and about 20° in the direction of the rear.

[Figure 9] Propeller Damage

1.12.4 Vertical and Horizontal Tubes

1.12.4.1 Vertical Tube

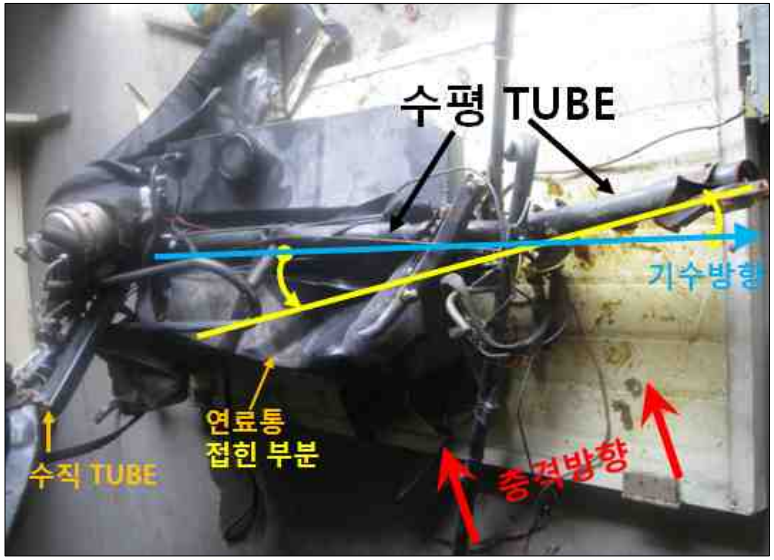
As shown in [Figure 10], the vertical tube was found broken at the bottom and attached. The upper portion of the tube was bent to the operator's right and

twisted clockwise.

[Figure 10] Broken Vertical Tube

1.12.4.2 Horizontal Tube

As shown in [Figure 11], the horizontal tube, which indicates the axial line in the direction of flight, bent at the point situated forward of the fuel tank, about 20° to the left and about 5° upwards. The direction of the bending almost coincided with the direction of the folding line of the distorted fuel tank immediately at the back.



[Figure 11] Bent Horizontal Tube

1.12.5 Fuel Tank

S1045 was equipped with a 60-liter fuel tank. As shown in [Figure 12], the upper right portion of the tank was crushed, resulting in about 12 cm tear at the top. The fuel tank tilted about 60° to the right and about 15° downwards. Approximately, 700 ml of fuel remained in the tank, and there was the evidence that 3 - 4 liters of liquid[28] flew on the ground below the tank.

As shown in the right images of [Figure 12], the fuel tank was cut in two pieces to investigate the inner structure. One fuel supply tube with a diameter of 1 cm was installed 6 cm forward from the rear center, and the tip of the pipe inside the tank was located about 2.5 cm from the bottom.

28) Fuel, oil, coolant, blood, etc.

[Figure 12] Damaged Fuel Tank (left) and the Tank Cut (right)

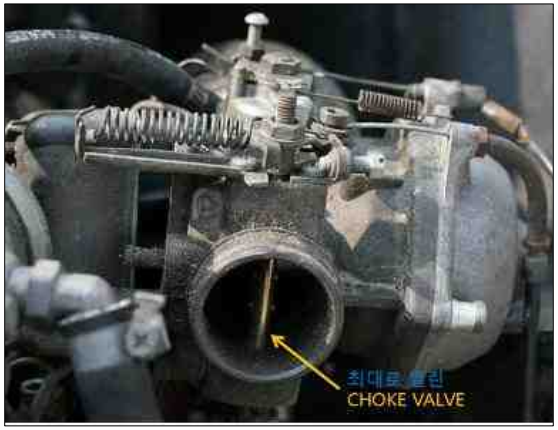
1.12.6 Carburetor's Choke Valve

As shown in [Figure 13], a choke valve[29], a throttle valve of the carburetor, was open to the full position, which means that the Bowden cable was not fractured and in full throttle position.

If the Bowden cable had been fractured, the choke valve of the affected vehicle should have been in the closed position because the fail-safe system was not in place as previously mentioned in 1.6.5.1.1.

29) A choke valve is a type of valve designed to control the flow of air, thereby controlling engine thrust.

Wreckage investigation revealed that the Bowden cable was not fractured and in normal operation, and thus, the throttle valve was in full throttle position during impact.



[Figure 13] Choke Valve in the Full Open Position

1.12.7 Wings

1.12.7.1 Exterior of the Wings

As shown in [Figure 14], the cross bar[30] on the left wing was separated from the leading edge due to the crash impact and penetrated through the sail. The battens[31] supporting the left wing sail were pushed towards the keel[32] at the center and bent like a bow.

30) A cross bar acts as a ridgepole, which forms a triangular frame along with leading edges of the left and right wings and a keel running along the longitudinal axis. It intersects with the keel in the shape of a cross with the ends of horizontal arms drooping downwards.
31) Battens are long, thin strips used to support wings.
32) A keel is a beam running in the middle of the wings, which intersects with a cross bar in the shape of a cross with the ends of horizontal arms drooping downwards, thereby forming the frame of the wings.

[Figure 14] Accident Site

1.12.7.2 Frame Damage inside the Wings

As shown in the blue triangle of [Figure 15], the left leading edge was fractured at the nose plate and remained attached. The keel was separated upon initial impact, and when it impacted the left leading edge again, its mouth was crushed to the right.

As shown in the orange rectangle of [Figure 15], the left cross bar was separated from the left leading edge, and as shown in the red circle, the center of the right cross bar was bent to the right. At the plate, intersection point of the cross bar and the keel, the left cross bar was connected to the keel and the right cross bar, with one bolt missing.

[Figure 15] Inner Structure of the Wings and its Damage

1.12.8 Control Bar and Wires

As shown in [Figure 15], the upright bar of the control bar in a triangular shape was bent at the center, and the left portion of the base bar at the bottom was separated. Four landing wires and six flying wires of the vehicle were connected with the wing frame and the control bar, and no functional anomaly was found.

1.12.9 Emergency Parachute

As shown in [Figure 16], S1045 was equipped with Galaxy 450 emergency parachute, but the parachute was not used.

According to the manufacturer manual, the area of the Galaxy 450 emergency parachute is 96 ㎡, and when the vehicle weighing the maximum 472.5 kg is

operated within the range between horizontal speed of 60 km/h and Vne, it takes 3.0 - 3.4 seconds for a parachute to open, and the minimum rescue altitude is 60 m.

[Figure 16] Ripcord Handle (above) and Emergency Parachute (below)

1.12.10 Instrument Panel

As shown in [Figure 17], S1045 was equipped with SKYDAT GX2 instrument panel manufactured by AMPtronic. On the LCD screen, indications of flight instruments including speedometer, altimeter, and variometer are displayed along with engine instrument indications such as RPM, EGT, and CHT.

There were also fuel instrument indications such as INST and ACCU on the LCD, but they were not usable since a fuel flow sensor was not installed.

[Figure 17] S1045's SKYDAT GX2 Instrument Panel

1.13 Medical and Pathological Information

Blood samples of the operator and the passenger were collected and sent to the National Forensic Service for drug and alcohol tests, and they tested negative for drugs and alcohol.

1.14 Fire

There was no evidence of fire on S1045.

1.15 Survival Factor

At 13:08, a witness reported the accident to Dongchun 119 Safety Center and Songdo 119 Safety Center under Incheon Gongdan Fire Station, and at 13:09, crews were dispatched and arrived at the scene at 13:18. So did officers of Songdo Community Policing Center and Incheon Yeonsu Police Station.

The operator and the passenger were pronounced dead at the scene by rescue workers of Songdo 119 Safety Center from whole-body multiple fractures and lacerations, and were transported to a nearby hospital.

1.16 Tests and Research

1.16.1 Fuel Element Analysis

A fuel sample collected from the scene was dark brown in color. The elements of the fuel sample and of deposits left after fuel evaporation were analyzed by using Fourier Transform Infrared Spectrometer (FTIR)[33] and Gas Chromatography-Mass Spectrometry (GC-MS)[34].

Fuel Sample before Evaporation

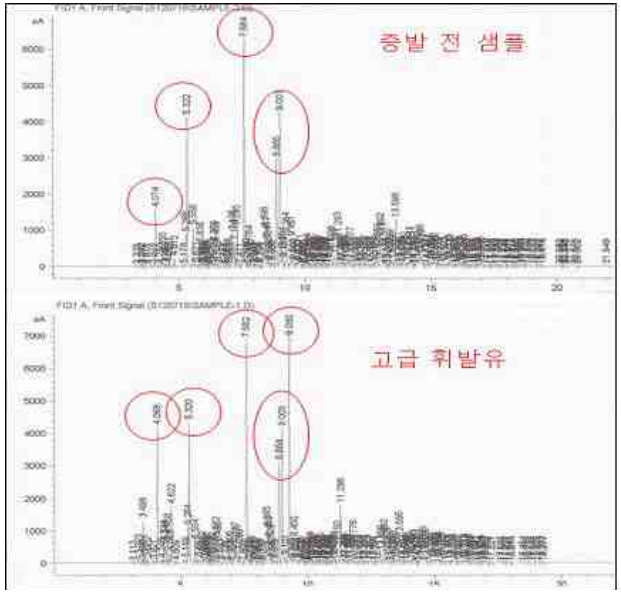
Fuel Sample after Evaporation

[Figure 18]

The fuel sample before evaporation was analyzed by FTIR and GC-MS. The analysis results revealed that as, shown in [Figure 19], elements of the fuel sample were similar to those of high-grade gasoline.

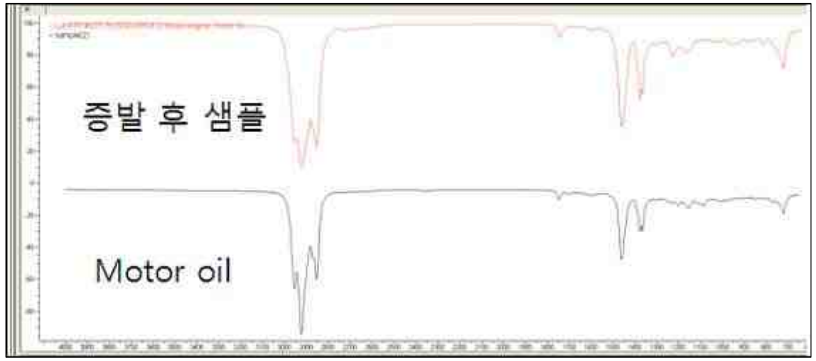
33) A device which conducts qualitative and quantitative analyses by obtaining an infrared spectrum of absorption and penetration.

34) A device which combines the features of gas-liquid chromatography and mass spectrometry to identify chemical structure, chemical reaction, and molecular weight of a test sample.



[Figure 19] Analysis Results of Fuel Sample before Evaporation (GC-MS)

A large quantity of deposits remained after fuel was evaporated, and they were analyzed by FT-IR, which revealed that, as shown in [Figure 20], elements of the deposits were similar to those of motor oil.



[Figure 20] Test

1.16.2 Close Inspection into Engine Operation During Ground Impact

1.16.2.1 Engine Gearbox Teardown Inspection

To inspect whether the engine was in operation during ground impact, the engine gearbox, which was connected with propellers, underwent teardown inspection for the presence of an impact mark[35]. The inspection found no impact mark on the rotor such as the gearbox axis.

1.16.2.2 Engine Manufacturer's Engine Teardown Inspection

BRP-Powertrain GmbH & Co KG, the Austrian engine manufacturer, disassembled the engine, and closely examined and tested it to check whether the engine was in normal operation before ground impact.

The fuel pump and the engine intake manifold displayed a compression damage caused by ground impact, but it was not confirmed that there was no rotation damage to other parts of the engine.

35) A mark on a rotor, which resulted from torsion and friction caused by inertial force produced when a rotor in operation is forcibly stopped by an external force.

The engine teardown inspection revealed that 「no functional anomaly was detected in the engine to such an extent that the engine malfunctioned, but the RPM of the engine crankshaft as well as whether the engine was in normal operation before ground impact were not verified.」

1.17 Organization and Management Information

1.17.1 Songdo Flight Club and Leisure Hunter

1.17.1.1 Songdo Flight Club

Songdo Flight Club which was run by the vehicle owner consists of a group of about 30 members who hold ultralight vehicle and light sport aircraft licenses for the purpose of leisure flights. The club has no regulations or articles of association, and was not affiliated with any particular organization home and abroad.

1.17.1.2 Leisure Hunter

The operator established Leisure Hunter Inc. in Taean, Chungcheongnam-do, and owned one weight-shift ultralight vehicle (S-1040), one hang glider, and one all-terrain vehicle (ATV)[36]. With the support of his friend, he did leports business for pleasure-seekers, such as mountain bike rental, paintball game organization, and provision of flight experience.

1.17.2 Government Activities in the Air Sports Area

1.17.2.1 Government's Plan to Promote Air Sports

36) All-Terrain Vehicle: a quad bike which handles a wide variety of terrain such as unpaved road, slope, sandy beach, wetland, etc.

In December 2012, the Korean government set up a short-term task force to promote the nation's air sports. The plan to promote air sports categorized into short- and mid-terms has been established and is being implemented in phases as follows: relevant framework and system will be improved between 2012 and 2013; a basis upon which to promote air sports will be formed between 2014 and 2017; and air sports activities will have been active by 2018.

1.17.2.2 Supervision of Songdo Airfield

Currently, the Korean government has no exclusive organization for the air sports area and thus, multiple agencies and departments simultaneously perform the relevant tasks, some of which are even overlapped, and there are less than 10 inspectors.

Between January 2012 and the day of the accident, the inspectors inspected Songdo Airfield twice, on 16 January and 13 April 2012.

They inspected the followings: pilot license; radio station license; safety certification; insurance purchase[37]; approval of flight plans; parking status of ultralight vehicles on the airfield; surrounding flight environment; and preparation for the transition of ultralight vehicles to light sport aircraft.

Also, they gave the following guidance: a thorough check-up on weather conditions before flying; compliance with the conditions of flight plan approval; safety management of the airfield; and a thorough maintenance check including recording of a flight log. They gave a briefing on light sport aircraft inspection activities in 2012 and distributed pamphlets about equipment for ultralight vehicle rescue support and light sport aircraft registration.

37) Applicable only to the vehicles registered as a commercial.

1.18 Additional Information

1.18.1 Major Statements

1.18.1.1 Witness Statements

[Witness A] He heard the sound of the affected vehicle and witnessed the accident while doing exercise at Jack Nicklaus Golf Club. The vehicle that was making a turn at about 100 m over the reclaimed land seemed to descend at first and soon thereafter, turned at a steeper angle and dived. It seemed to rotate with its nose upside down and flew towards the ground. After a moment, he heard a "thump", but could not witness the moment of the crash due to ground obstacles. He was not sure whether he heard the sound of the engine at the moment of the vehicle's turn and crash. He reported the accident to the police office and the Songdo police box, and in less than five minutes, heard the sirens of 119 fire trucks and police cars.

[Witness B] He witnessed the accident when he played golf. The vehicle seemed to fly from Incheon Bridge to Incheon University and to make a turn while descending, but suddenly, it seemed to overturn and crash into the open space. He heard a "thump" and reported the accident to 112.

[Witness C] When he was riding a bicycle on the road adjacent to a wire fence along the reclaimed land, he heard a sound and turned back. He was not sure whether the vehicle was diving while turning or was rotating, but saw the vehicle falling in an instant and heard a "thump". He immediately reported the accident to 119.

1.18.1.2 Passenger Statements

[Passenger A] The operator arranged an experience flight because he had a

business relationship with a fatally injured. A fee for flight was 40,000 won, and a total of 350,000 won, 50,000 won per person including lunch money, was collected but not paid to the operator.

As the vehicle flew to the sea after takeoff, she felt like the vehicle almost stopped in the air due to a strong wind. She was scared because she felt like she was riding a roller coaster when the vehicle made its first turn. Then, she was very scared again because the vehicle made its second turn at a steeper angle over the golf course.

[Passenger B] The vehicle made a left turn when it was flying to Incheon Bridge after takeoff. She was scared because the vehicle dropped sharply when it made a left turn over Jack Nicklaus Gold Club. A strong wind was blowing from the beach to such an extent that she could not turn her head well although she tried.

[Passenger C] The operator said before takeoff, "The wind is strong up there." She felt like the vehicle stopped in the air due to a headwind. She was frightened because the vehicle suddenly dropped with a lurch and climbed again while making a turn over Incheon Bridge.

When S1045 arrived at Incheon Bridge, where the accident occurred, after its fourth takeoff, the owner of the vehicle came to a tent where passengers were waiting for their turn and asked, "When did the vehicle take off? Refueling should be done." Several minutes later, he got a phone call about the accident occurrence.

1.18.1.3 Vehicle Owner's Statement

Three days before the accident, the owner filled 20 liters of fuel into the

empty fuel tank and flew for about 10 minutes. On the day of the accident, he personally took a test flight for about five minutes and handed the vehicle over to the operator, who started to help passengers experience a flight.

2. Analysis

2.1 Crash Sequence Analysis

It is determined that on the basis of damage to the fuel tank, vertical tube, and wings, the vehicle first impacted the ground at about 20° bank angle to the right and at about 5° descent angle, and that on the basis of the locations and directions of, and damage to the wings and keel, there were rolling moment to the right and strong yawing moment.

Secondly, the right leading edge contacted the ground due to the rolling moment to the right, and the vehicle turned to the right on an axis of the right leading edge. The vertical tube twisted and fractured due to strong yawing moment. As the left wing and battens were pushed towards the center, the nose plate sustained damage and the right cross bar was bent.

Therefore, the vehicle contacted the ground in the following order: right landing gear; forward landing gear; left landing gear; airframe; propellers; and wings.

It is analyzed that the vehicle impacted the ground while spinning to the right due to the stall given the following facts: overall debris such as landing gears, forward landing gear cover, a left shoe of the fatally injured, and wings were distributed clockwise within the right half circle from the airframe; the vehicle impacted the ground while descending with a slight nose-down attitude but was destroyed without a skid mark; and main frames of the vehicle sustained a certain type of damage.

2.2 Meteorological Factor

Weather conditions at Songdo at the time of the accident were ceiling &

visibility O.K., and west-south-west wind at 5.14 m/sec (10 kts). The owner, operator, and passengers all stated that a strong wind was blowing during flight. Also, the witnesses adjacent to the accident site stated that the wind was strong in Songdo area, and that around the time of the accident, there was a gust of wind which blew off the signboard in the Namdong industrial complex.

A gust of wind was not evidenced by the collected weather data, but it is determined that somewhat stronger west-south-west wind from the sea was blowing in the air with the unstable atmosphere.

At first, S1045 flew in a southwest direction and made a left turn. At the early stage of the left turn, it flew in a headwind. As the turn progressed, the vehicle flew in a crosswind from the right, at about 70° to the left, and afterwards, flew in a tailwind.

A strong tailwind has a negative influence on a weight-shift ultralight vehicle's ability to turn. In particular, a gust of wind combined with the operator's steep climbing/descending turn maneuver can cause a steep bank stall.

2.3 Ultralight Vehicle/Maintenance Factor

2.3.1 Wings (Top14.9)

S1045's wings cannot hold wind during turn and let the wind leak through, thereby failing to maintain centrifugal forces, and as a result, the vehicle tends to drift towards the inside of the turn, which was evidenced by the statement made by the passenger that the vehicle dropped sharply during turn before the accident.

The wings were OEMed by the Chinese company, which was a subcontractor of the original manufacturer, COSMOS. The manufacturer failed to provide data

on serial number, test flight to check performance and features, etc., and thus, the quality of the wings was not assured.

Problems with the certification and quality assurance of the wing are expected to be resolved[38] as the light sport aircraft system was currently introduced.

2.3.2 Possibility of Engine Malfunction

It is assumed that according to the statements of witnesses, S1045's engine was in operation at the early stage of the turn, but as bank and descent angles got steeper and steeper, insufficient fuel in the fuel tank moved forward to the left, and that as a result, the fuel supply to the engine stopped, thereby resulting in engine malfunction.

On the accident site, a choke valve was found open to the full position, which means that the Bowden cable controlling engine thrust was not fractured, and that the operator wanted maximum thrust.

If the engine had been in normal operation in maximum thrust position, all three propeller blades might have been damaged due to high speed rotation since they must have contacted the ground and part of the vehicle during crash. Yet, two blades sustained damage, whereas one was intact.

In addition, S1045's engine must have malfunctioned during ground impact given the following facts: the preceding blade was damaged mainly at the center, with the tip of the blade still remained attached; the succeeding blade sustained more damage than the preceding one; and the teardown inspection of the engine gearbox and the manufacturer's close examination of the engine found no impact mark caused by rotation.

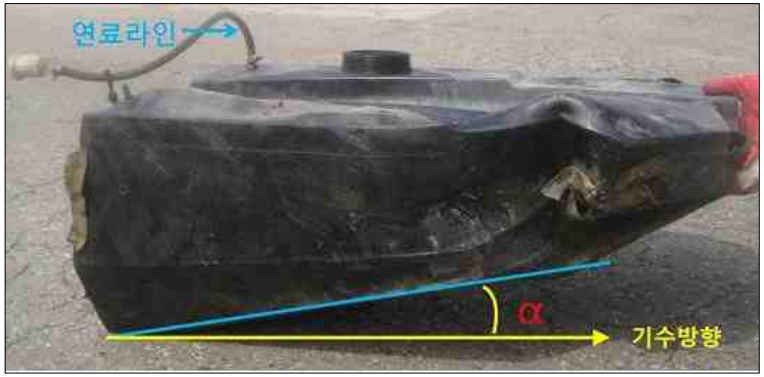
38) In accordance with the light sport aircraft's design and operations specifications (light sport aircraft flight safety regulations), aircraft parts manufacturers shall ensure that parts are compliant with the regulations, and complete aircraft manufacturers shall install such parts in the aircraft and assure their quality by testing them.

2.3.3 Fuel Analysis

2.3.3.1 Relation Among Engine Fuel Supply, Fuel Tank Structure, and Flight Attitude

In the case of S1045, fuel is pumped from the fuel tank below the engine and delivered to the carburetor. One fuel supply tube is inserted into the rear center of the fuel tank, and thus, in case of low fuel, as the vehicle's bank angle and descent angle get steeper, fuel will settle to the forward bottom of the tank that slants and not be fed to the fuel inlet.

As shown in [Figure 21], when S1045 maintains a level flight attitude, the base side of the fuel tank forms a dihedral angle of α(about 20°) with a virtual horizontal line running from the nose to the tail, and thus, fuel settles to the rear where the fuel supply tube is located. When the vehicle descends at an angle of α(about 20°), fuel is distributed evenly at the bottom, but when the vehicle descends at more than α, fuel settles to the front.

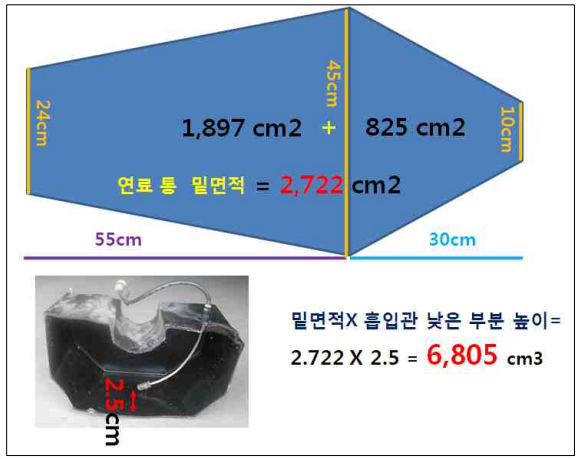


[Figure 21] Fuel Tank Viewed from the Side

2.3.3.2 Flight Attitude and Minimum Fuel Quantity

As shown in [Figure 22], the area of the fuel tank's base is approximately

2,722 ㎠. As the tip of the tube inside the tank was located about 2.5 cm from the bottom, there should be at least minimum 6.8 liters of fuel (2,722×2.5=6,805 ㎤) to be fed to the engine when the vehicle descends at about 20°. If the descent angle or bank angle of the vehicle increases in this flight attitude, there should be more fuel than 6.8 liters.



[Figure 22] Calculation of the Minimum Fuel Quantity When the Base of the Tank Is Horizontal

2.3.3.3 Owner's Statement and Calculation of the Remaining Fuel Quantity

The owner stated that three days before the accident, he filled 20 liters of fuel into the empty fuel tank, and that S1045 had a total of six flights from the time of refueling to the time of the accident, thereby accumulating a total flight time of about 43 minutes[39] and a total taxiing time of about 30 minutes. On the assumption that one minute flight at takeoff performance and the remaining flight at 75% continuous performance were conducted, the total quantity of fuel consumed during flight is estimated by referring to [Table 3] to be 12.39 liter

39) 10 min (owner's flight on the day of refueling) + 5 min (owner's test flight on the day of the accident) + 21 min (3 experience flights) + 7 min (accident flight) = 43 min = 1 min for takeoff × 6 times + 37 min.

s[40]. If the vehicle consumes 1 liter of fuel during 30-minute taxiing, the remaining fuel quantity at the time of the accident will be about 6.61 liters (20 - 12.39 - 1 = 6.61). With this fuel quantity, fuel will not be fed to the engine if the vehicle descends at more than 20°, regardless of a bank angle.

ENGINE - ROTAX 912 UL	**Fuel Consumption Rate** (unit: liter/h)
Takeoff Performance	24.0
Max. Continuous Performance	22.6
75% Continuous Performance	16.2

[Table 3] Fuel Consumption Rate of ROTAX 912 UL Engine

2.3.3.4 Remaining Fuel in the Wreckage

On the site, less than 1 liter of fuel remained in the fuel tank. There was the evidence that 3 - 4 liters of liquid[41] flew on the ground below the tank. If this liquid is assumed to be flown from a tear at the top of the tank, a total remaining fuel quantity will be less than 5 liters. With this fuel quantity, if the vehicle descends at more than 20° regardless of a bank angle, fuel will not fed to the engine

2.3.3.5 Fuel Analysis Results

2.3.3.5.1 Difficulty in Checking the Fuel Quantity During Flight

The operator should regularly check the fuel quantity during various flight stages, establish a fuel plan, and reflect it in a flight plan.

Since S1045 was not equipped with a fuel flow sensor, however, there was

40) (6×24+37×16.2)/60=12.39 liter.
41) Fuel, oil, coolant, blood, etc.

no instrument indicating fuel flow and accumulation quantity, and since the fuel tank was made of black opaque plastic, the operator was not able to check the fuel quantity during flight.

In the case of vehicles without a fuel instrument, various measures, including a use of a translucent fuel tank that enables a visual check, should be considered.

2.3.3.5.2 Detection of Oil in Fuel

Fuel analysis of the affected vehicle revealed that an element of oil was detected. A two-stroke-engine uses oil mixed in with fuel, but a four-stroke-engine like S1045 should not use oil.

It is unlikely that, after ground impact, leaked oil flew into a tear at the top of the fuel tank, and thus, how and when it flew into the tank was not determined.

2.4 Operation Factor

2.4.1 Diving Turn at a High Bank Angle at Low Altitude

Passengers all stated that the vehicle descended and climbed during turn as if they had ridden a roller coaster. It is determined that this was caused by the characteristics of the wings and by the operator's wingover[42] maneuver during each flight, which is a combination of climbing and descending turns.

In addition, witnesses stated that, as the vehicle making a turn dived, its bank

42) A wingover is an aerobatic maneuver, in which the aircraft makes a 180 degree change in heading, climb and descent, and thus, the aircraft's angles of bank, climb, and descent continue to change. Normally, the aircraft initially makes a climbing turn, allowing the airspeed to drop, then dives and raises airspeed as its angles of bank and descent increase.

angle got steep and the vehicle rotated. It is assumed that the operator attempted to dive while performing a wingover maneuver given the followings: the operator was already acquainted with the passenger due to their business relationship; and the accident occurred over the reclaimed land on the coast with no ground obstacles.

The operator gained a lot of experience in hang gliders and weight-shift ultralight vehicles, but since he flew S1045 only three times about five months ago, he was not familiar with the installed equipment, engine performance, and aerodynamic characteristics of the wings.

As a result, the operator failed to recognize lack of fuel during flight and to consider the performance of the engine and wings under high-wind conditions, and thus, performed excessive maneuvers including diving turn. It is assumed that a combination of these factors caused the vehicle to enter a stall with a diving attitude, followed by engine malfunction, which resulted in no use of an emergency parachute because an altitude was not high enough to recover from a stall and a descent angle, and that, as a result, the vehicle entered a spin during recovery maneuvers and crashed.

2.4.2 Analysis of the Event from Start of Turn to Ground Impact

The following is an analysis of the event from the start of turn to ground impact on the basis of the statements of witnesses and passengers, advice from experts on weight-shift ultralight vehicles, and wreckage analysis.

Witnesses stated that at the beginning of the turn, S1045's engine was functional. During a wingover maneuver, as shown in [Figure 23], the vehicle starts to make a left turn at location #1 and climb at location #2. It reached the maximum[43] climbing attitude at location #3, then reached the minimum speed at

43) In this paragraph, the "maximum" means "relatively highest" in the sections between the beginning and the end of the turn.

the maximum altitude at the maximum bank angle at location #4. As tailwind gets stronger due to a strong west-south-west wind from location #3, S1045 flies with a complete tailwind (0% crosswind) at location #4, so it is put at the biggest risk of entering a steep angle stall.

As S1045 maintains the maximum bank angle and gradually lowers its nose at location #5, the vehicle is supposed to take a flatter descent attitude and accelerate. Yet the vehicle's bank angle steepened and it took a diving attitude at locations #5, 6, and 7. At this point, the operator added the bank angle and increased the rate of turn by pushing forward the control column, thereby lowering the nose rapidly, but this maneuver decreased the vertical lift and increased the angle of attack. At this time, this was combined with the feature of the Top14.9 wing that cannot hold wind during turn and lets the vehicle drift towards the inside of the turn. As a result, as the descent angle of the vehicle steepened at location #6, it came to take an abnormal attitude.

As fuel in the fuel tank moved forward to the left due to a high left bank angle and steep descent rate at location #6, the engine might malfunction at location #7. As a result, the vehicle at a low speed entered a stall due to a strong tailwind, a high bank angle, a diving attitude, and the characteristics of Top14.9, at location #8, and finally lost the maneuverability.

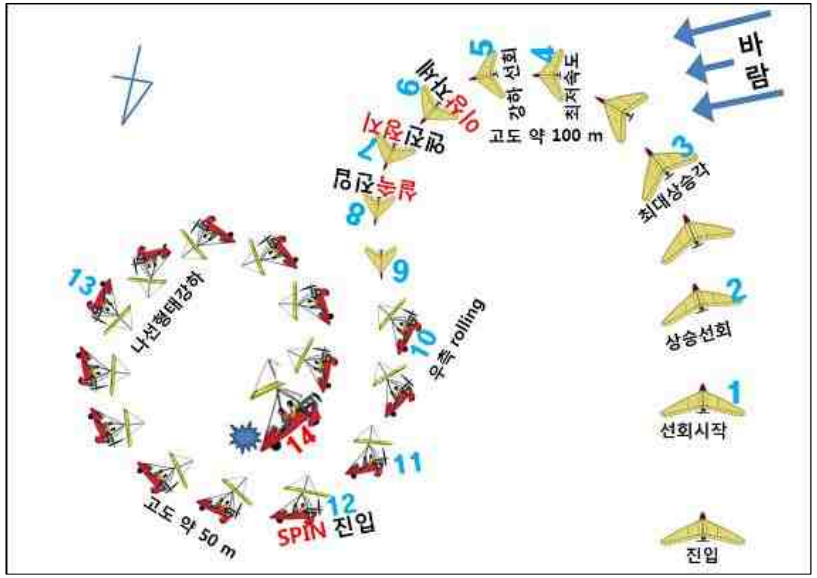
At location #9, the operator seemed to begin a recovery maneuver. At location #10, he started rolling to the right to reduce the left bank angle, using the maximum thrust, then executed maneuvers to recover from stall and reduce a descent rate. Stall recovery and descent rate reduction are opposite concepts, so at first, the operator was supposed to recover from stall by reducing the angle of attack and increasing speed, and as the vehicle recovered from stall, the operator was supposed to slowly increase the angle of attack, thereby reducing a descent rate.

Yet it would be difficult for the operator to execute these recovery maneuvers successively when the vehicle was in the stall at a steep descent angle at a low altitude with its engine unfunctional. Therefore, at location #11, the operator seemed to execute a maneuver to increase the angle of attack to reduce the descent angle when the stall recovery has yet to be completed.

When the vehicle was in a stall with its engine unfunctional, the rolling to the right and an increase in the angle of attack made the stall aggravated, and at location #12, it entered a spin[44] to the right wing, which was relatively more stalled.

It is assumed that, at location #13, the vehicle circled in a spiral as its bank and descent angles reduced, and that, at location #14, it was subjected to the roll moment due to the right spin and crashed into the ground at about 20° descent angle and about 5° right bank angle.

44) An aircraft falls into a spin when the both wings that are stalled are combined with a yawing motion. The aircraft autorotates in the direction of the more stalled wing based on the vertical axis, and descends downwards.



[Figure 23] Process from Entry into the Turn to the Impact

2.5 Legal and Regulatory/Procedural Requirements

2.5.1 Regulation on the Deviation from Restricted Areas and Necessity of Establishing an Exclusive Organization for Air Sports

In accordance with the Aviation Act, Article 23, Paragraph 2, a person who intends to fly in ultralight vehicle flight restricted areas shall get an approval from the MOLIT Minister. Yet the operator deviated from the Songdo flight area without a prior approval and entered the restricted area.

As air sports activities are diversifying and the air sports population is increasing, there are more and more cases that ultralight vehicles and light sport aircraft deviate from the approved altitude or areas, which becomes a significant risk factor for safety such as an accident in a densely populated area and the possibility of mid-air collision. These risk factors should be efficiently managed

and monitored by an exclusive organization for air sports, an air sports task force.

Currently, the Korean government has no such air sports task force, and there are only less than 10 inspectors. Multiple agencies and departments simultaneously perform the relevant tasks, some of which are even overlapped, and thus, it is hard for them to focus only on the air sports area and almost impossible for them to efficiently manage and monitor illegal flights that are sporadically occurring nationwide.

Increasing only the number of the inspectors to manage and monitor the air sports activities nationwide will produce an inefficient and limited result. Experts advised that it is desirable to devise the measures to utilize self-monitoring activities of operators, clubs, and organizations per each airfield.

Against this backdrop, it is determined that it is necessary to establish an air sports task force to resolve various problems and efficiently pursue a plan to promote air sports.

If the task force actively manages and monitors various safety risk factors including deviation from restricted areas by focusing on the air sports flights, and provides the safe flight environment equipped with the infrastructure including airfields, the air sports population will be more satisfied with and confident in the government and comply voluntarily with aviation laws, regulations and procedures, and further, this will lead to self-purification efforts by club members and organizations per airfield, thereby resulting in the efficient elimination of safety risk factors.

2.5.2 Creation of Infrastructure Including Standardized Airfields

Since the current aviation legislation fails to specify relevant provisions which

can be a legal basis for the definition and construction of airfields, there are no lawful and standardized airfields for the use of ultralight vehicles and light sport aircraft.

As most of the airfields are being expediently or illegally operated, the flight environment, including infrastructure, additional facilities, etc., is poor, and flights are being conducted according to the practices of each individual or club. As a result, operators are unable to learn systematic and standardized flights, thereby becoming a safety risk factor.

Also, since airfields are not constructed based on the legal foundation, regional aviation administrations or related associations are having difficulty giving guidance for safety.

The Korean government should enact regulations on the construction of airfields so that standardized airfields for ultralight vehicles and light sport aircraft can be provided. In addition, it should actively help those involved in air sports activities learn correct flight procedures, comply with laws, regulations, and procedures, and operate a safe flight in the standardized airfields equipped with fuel facility, maintenance facility, flight information facility, flight preparation facility, and ATC facility that are necessary for the operation of ultralight vehicles and light sport aircraft.

3. Conclusions

3.1 Findings

1. The operator held the valid ultralight vehicle pilot license and light sport aircraft pilot license.

2. S1045 was registered as a non-commercial (for leisure) and passed a safety certification inspection.

3. S1045's wing type is Top14.9, but was recorded as Top16.9 in its safety certificate.

4. The operator took a proper rest before flight and did not drink any alcohol or take any illegal medication. Health problems that might have affected the flight were not found.

5. Three days before the accident, the owner filled 20 liters of fuel into the empty fuel tank and had a 10-minute flight. On the day of the accident, he personally took a test flight for five minutes and handed S1045 over to the operator.

6. People who desire to experience flight collected 40,000 won per person for a fee for flight, which was not paid to the operator or the owner.

7. Without the approval, the operator entered the ultralight vehicle flight restricted area.

8. It is determined that, since the operator flew S1045 only three times about five months ago, he was not familiar with the installed equipment including an emergency parachute.

9. It is assumed that the operator made a diving turn without considering winds, characteristics of the wings, and fuel quantity.

10. The operator was unable to check the fuel quantity during flight because S1045 was not equipped with an instrument which allows a fuel quantity check and because the fuel tank was made of opaque plastic.

11. When S1045 maintains a level flight attitude, the base side of the fuel tank forms a dihedral angle of about 20° with a virtual horizontal line running from the nose to the tail.

12. An element of oil was detected in the fuel sample from S1045.

13. It is assumed that, as bank and descent angles of S1045 got steeper, insufficient fuel in the fuel tank moved forward to the left, thereby resulting in engine malfunction.

14. The vehicle manufacturer fitted the throttle valve lever and the oil return line contrary to the position described in the engine manufacturer's installation manual.

15. The engine gearbox teardown inspection found no impact mark caused by engine rotation.

16. During the engine manufacturer's teardown inspection, whether the engine was in normal operation before ground impact was not verified.

17. The engine manufacturer's teardown inspection and test revealed that no anomaly was found with the engine's function.

18. There is no evidence of an airframe defect that could have caused the loss

of flight control during flight.

19. There is no legal basis upon which to deal with airfields for ultralight vehicles and light sport aircraft.

20. The flight environment, including airfields for ultralight vehicles and light sport aircraft and addional facilities, was poor.

21. The Korean government has no exclusive organization for the air sports area.

22. Under the present circumstances, ultralight vehicles' deviation from their designated flight areas could not be managed and supervised.

3.2 Causes

The Aviation and Railway Accident Investigation Board determines the probable cause of this accident as follows:

「As the vehicle was affected by its tendency to drift towards the inside of the turn and a strong tailwind during a left descending turn at a low speed, it was put into a stall and a steep diving attitude, and while attempting a recovery maneuver at a low altitude, the vehicle entered a right spin and crashed.」

4. Safety Recommendations

As a result of the investigation of the accident that occurred to S1045 on 12 June 2012, the ARAIB issues the following recommendations.

4.1 To the MOLIT (Civil Aviation Office)

1. Establish an exclusive organization for the air sports sector (UAR1201-1).

2. Devise measures to manage and monitor ultralight vehicles' entry into the restricted areas (UAR1201-2).

3. Establish a legal basis upon which to provide standardized airfields for ultralight vehicles and light sport aircraft, and review support measures (UAR1201-3).

4.2 To Regional Aviation Administrations

1. Disseminate the information on safety concerns found during this accident investigation to the air sports population, and raise their awareness of compliance with laws, regulations, and procedures to ensure safe flight (UAR1201-4).

4.3 To the KTSA

1. Establish safety certification procedures for maintaining inspection records on available types of wings that can be installed on weight-shift ultralight vehicles and light sport aircraft (UAR1201-5).

2. Inform ultralight vehicle owners of the followings identified by the KTSA:

the reasons for, principles behind, and advantages/disadvantages of the ultralight vehicle manufacturer's installation of a component in the position different from that of the engine manufacturer's installation manual (UAR1201-6).

3. Strengthen inspection of fuel quantity checking methods during the safety certification inspection of the applicant's ultralight vehicle (UAR1201-7).

4.4 To Federation of Korea Aeronautics, Korea Sport Aviation Association, and Korea Light Aviation Association

1. Disseminate the accident information to members, and raise their awareness of compliance with the requirements for safe flight, including prohibition of reckless flight (UAR1201-8).

2. Raise members' awareness of management of maintenance history, use of prescribed fuel, and compliance with the procedures of the manufacturer's maintenance manual (UAR1201-9).